AVIFAUNAL WALK-THROUGH REPORT

PROPOSED KOUP 1 WIND ENERGY FACILITY AND ASSOCIATED INFRASTRUCTURE NEAR BEAUFORT WEST IN THE WESTERN CAPE PROVINCE

May 2023

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EXECUTIVE SUMMARY

Genesis Koup 1 Wind Farm (Pty) Ltd received an Environmental Authorisation (EA) (DFFE Ref: 12/14/16/3/3/1/2120) dated (12/09/2022), for the development of up to 184MW Koup 1 Wind Energy Facility (WEF) and associated infrastructure near Beaufort West which falls within the Beaufort West Local Municipality which falls within the jurisdiction in the Western Cape Province.

Arcus Consultancy Services South Africa (Pty) Ltd ('Arcus'), a South African based environmental consultancy, as part of the Environmental Resources Management ('ERM') Group of Companies has been commissioned to undertake the Final Layout plan and EMPr associated with the authorised WEF, and it's authorised grid infrastructure. As per the conditions of the relevant EAs various specialist pre-construction walkthroughs have been undertaken to inform the placement of infrastructure for the Final Layout.

This report presents the results and recommendations of the avifaunal walk-through exercise.

METHODOLOGY

Site inspections were conducted on 03 February 2023 with a vehicle and a drone to record all avifaunal sensitivities on, and in the immediate vicinity of the project site, which could influence the lay-out of the turbines. Emphasis was placed on locating nests of priority species, particularly species of conservation concern (SCC), which may be impacted by the proposed WEF. The data gathered during the 12-months monitoring from October 2019 to July 2020 was also taken into account. Priority species were defined as species included on the list of priority species of the Avian Wind Farm Sensitivity Map of South Africa compiled by Birdlife South Africa (Retief *et al.* 2012).

RESULTS

Appendix 3 lists the species Van Rooyen *et al*. (2021) recorded the period of pre-construction monitoring from October 2019 to 2020. The 29 species that were recorded on and around the project site during the site surveys in February 2023 are listed in Table 1.

RECOMMENDATIONS

The recommendations below are put forward for inclusion in the Final Environmental Management Programme (EMPr). These recommendations are based on the pre-construction monitoring conducted from October 2019 to July 2020 and the walk-through exercise in February 2023 (Van Rooyen *et al*. 2021):

Design phase

- It is recommended that a 5km turbine exclusion zone is implemented around the Martial Eagle nest a Tower 108 on the Droërivier – Protheus 400kV transmission line (see Figure 4). The current 28 turbine lay-out has taken this into account.
- It is recommended that a 150m turbine exclusion zone is implemented around all drainage lines at the project site, and a 200m turbine exclusion zone around dams and water troughs as a pre-cautionary measure against SCC and other priority species collisions (Figure 4). The current 28 turbine lay-out has taken this into account.

- It is recommended that all internal medium voltage cables are buried if technically possible.
- Those sections where the 33kV medium voltage cable cannot be trenched due to technical or environmental reasons, but needs run on overhead poles, the proposed pole designs must be approved by the avifaunal specialist, to ensure that the designs are raptor-friendly.
- It is recommended that bird flight diverters are fitted to all internal 33kV overhead lines according to the applicable Eskom engineering standard at the time.
- Consideration should be given to painting one third of one blade on each turbine signal red as a mitigation measure against avifaunal collisions, if feasible. While this mitigation measure is still considered experimental, data from Norway indicates a high level of effectiveness, even up to 100% for large raptors. If this can be done during the manufacturing phase, it can be done inexpensively.

Construction phase

- Construction activity should be restricted to the immediate footprint of the infrastructure as far as possible, and in particular to the proposed road network. Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of SCC.
- Removal of vegetation must be restricted to a minimum.
- Construction of new roads should only be considered if existing roads cannot be upgraded.
- The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the activity footprint is concerned.

Operational phase

- Vehicle and pedestrian access to the site should be controlled and restricted to access roads to prevent unnecessary disturbance of SCC.
- Formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition (2015) of the best practice guidelines (Jenkins *et al.* 2011). The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the site operator once these timelines and a commercial operational date have been finalised.
- As a minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in Year 5, and again every five years thereafter for the operational lifetime of the facility. The exact scope and nature of the post-construction monitoring will be determined on an ongoing basis by the results of the monitoring through a process of adaptive management.
- Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels of SCC turn out to be biologically significant, including Shutdown on Demand (SDoD).

1.1 Operational phase

- Dismantling activity should be restricted to the immediate footprint of the infrastructure as far as possible. Access to the remainder of the area should be strictly controlled to prevent unnecessary disturbance of priority species.
- Measures to control noise and dust should be applied according to current best practice in the industry.

IMPACT STATEMENT

It is recommended that the lay-out is approved, subject to the implementation of the mitigation measures as detailed in the updated Environmental Management Programme (EMPr).

DETAILS OF THE SPECIALIST AND EXPERTISE TO COMPILE A WALK-THROUGH REPORT

Chris van Rooyen (Avifaunal Specialist)

Chris has decades of experience in the management of wildlife interactions with electricity infrastructure. He was head of the Eskom-Endangered Wildlife Trust (EWT) Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has worked in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. Chris also has extensive project management experience and has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author of 15 academic papers (some with co-authors), co-author of two book chapters and several research reports. He has been involved as ornithological consultant in numerous power line and wind generation projects. Chris is also co-author of the Best Practice for Avian Monitoring and Impact Mitigation at Wind Development Sites in Southern Africa, which is the industry standard. Chris also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Albert Froneman (Avifaunal Specialist)

Albert has a Master of Science degree in Conservation Biology from the University of Cape Town and started his career in the natural sciences as a Geographic Information Systems (GIS) specialist at Council for Scientific and Industrial Research (CSIR). In 1998, he joined the Endangered Wildlife Trust where he headed up the Airports Company South Africa – EWT Strategic Partnership, a position he held until he resigned in 2008 to work as a private ornithological consultant. Albert's specialist field is the management of wildlife, especially bird related hazards at airports. His expertise is recognized internationally; in 2005 he was elected as Vice Chairman of the International Bird Strike Committee. Since 2010, Albert has worked closely with Chris van Rooyen in developing a protocol for pre-construction monitoring at wind energy facilities, and he is currently jointly coordinating pre-construction monitoring programmes at several wind farm facilities. Albert also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

DECLARATION BY THE SPECIALIST

I, Chris van Rooyen, declare that –

- I act as the independent specialist 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 the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- 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;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

Afrimage Photography t/a Chris van Rooyen Consulting

Name of Company:

22 May 2023

Date

DECLARATION BY THE SPECIALIST

I, Albert Froneman, declare that –

- I act as the independent specialist 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 the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
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- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

Afrimage Photography (Pty) Ltd ta Chris van Rooyen Consulting

Name of Company:

22 May 2023

Date

1 BACKGROUND

Genesis Koup 1 Wind Farm (Pty) Ltd received an Environmental Authorisation (EA) (DFFE Ref: 12/14/16/3/3/1/2120) dated (12/09/2022), for the development of up to 184MW Koup 1 Wind Energy Facility (WEF) and associated infrastructure near Beaufort West which falls within the Beaufort West Local Municipality which falls within the jurisdiction in the Western Cape Province.

The project will include (as authorised):

- Up to 28 wind turbines, each between 5.6MW and 6.6MW, with a maximum export capacity of approximately 184MW;
- Each wind turbine will have a hub height and rotor diameter of up to approximately of up to 200m and rotor diameter of up to 200m.
- Permanent compacted hardstanding areas / platforms (also known as crane pads) of approximately 90m x 50m (total footprint of approx. 4 500m^2) per turbine during construction and for no-going maintenance purposes for the lifetime of the proposed development. A crane hardstand at each turbine position where the main lifting crane will be erected and/or disassembled;
- Temporary laydown areas will be established for the storage of wind turbine components, including the cranes required for tower/turbine assembly and civil engineering construction equipment. Laydown areas will also accommodate building materials and equipment associated with the construction of buildings;
- Each wind turbine will consist of a foundation with dimensions of approximately 30m x 30m x 5m in diameter;
- Electrical transformers adjacent to each wind turbine (typical footprint of up to approximately 2m x 2m) to step up the voltage to 33kV;
- One (1) new 33/132kV on-site substation and/or combined collector substation, occupying an area of approximately 1.5ha;
- The wind turbines will be connected to the proposed substation via medium voltage (33kV) cables will be buried along access roads wherever technically feasible;
- A Batter Energy Storage System (BESS) will be located next to the onsite 33/132kV substation. Up to 40MW of batteries using solid state/ liquid flow batteries with hazardous material of more than 80m^3 will be used;
- The wind turbines will be connected to the proposed substation via medium voltage (33kV) cables. Cables will be buried along access roads wherever technically another by means of medium voltage cable.
- Internal roads with a width of between 8m and 10m will provide access to each wind turbine. Existing site roads will e used wherever possible, although new site roads will be constructed where necessary. Turns will have a radius of up to 50m for abnormal loads (especially turbine blades) to access the various wind turbine positions;
- Site will be accessed via an existing gravel road from the N12 National Route (±25km of existing road, 31.27km of new roads to be constructed);
- One permanent Operational and Maintenance (O&M) Building including an on-site spares storage building, a workshop and an operations building to be located on the site identified for the construction laydown area;
- A wind measuring lattice mast (approximately 120m in height);
- An internal gravel road network will be constructed to facilitate movement between turbines on site. These roads will include drainage and cabling.
- A hard standing laydown area of a maximum of 10 000 m2 will be constructed; and
- A temporary site office will be constructed on site for all contractors, this would be approximately 5000m^2 in size.

The properties associated with the Koup 1 Wind Energy Facility include:

- The Farm Riet Poort No. 231;
- Portion 11 of the Farm Brits Eigendom No. 374;
- Portion 15 of the Farm Brits Eigendon no. 374;
- Portion 5 of the Farm Kaatjies Klaar No. 380
- Portion 10 of the Farm Kaatjies Kraal No. 380; and
- Portion 11 of the Farm Kaatjies Kraal No. 380.

The Genesis Koup 1 Wind Farm (Pty) Ltd will also share the on-site substation located on the adjacent Koup 2 WEF site.

The Koup 1 Wind Farm (Pty) Ltd also received EA's for a new proposed onsite Switching Station/ Collector Substation and associated 132kV power line was issued on 26 October 2022 to support the Koup 1 WEF in the Western Cape Province of South Africa, EA Reference 14/12/16/3/3/1/2538. Both will be included in the layout for the Koup 1 WEF for completeness and demonstrate its connection to the National Grid. The authorised Koup 1 WEF and Koup 2 WEF are located adjacent to each other and will operate as a cluster.

The infrastructure associated with the Switching Station portion of the on-site substation and 132kV Powerline located on Remaining Extent of Nooitgedacht Farm 148 (DFFE Ref: 14/12/16/3/3/1/2457/AM1) includes:

- Switching Station portion of the on-site substation:
- One new 33/132kV on-site substation and/or collector substation, occupying an area of up to approximately 1.5ha. the proposed substation will be a step-up substation and will include an Eskom portion and IPP portion; and
- One new 132 kV overhead power line connecting the on-site substation to an off-site collector substation, or via a direct tie-in to the existing 400kV overhead power line, thereby feeding into the grid. The power line tower being considered for this development include self-supporting suspensions monopole structures for relatively straight sections of the line and angle strain towers where the route alignment bends to a significant degree. Maximum tower height is expected to be approximately 25m.

The Koup 1 Wind Energy Facility will also consider the Environmental Authorisation for Electrical Grid Infrastructure that supports the Koup 1 WEF and Koup 2 WEF, Western Cape Provinces (Ref; 14/12/16/3/3/1/2077/AM2) authorised within a 500m grid corridor.

The properties associated with the Electrical Grid Infrastructure to support the Koup 1 WEF includes:

- Remaining extent of Hartebeeste Fontein Farm 147;
- Remaining Extent of Nooitgedacht Farm 148;
- Remaining Extent of Beeren Valley Farm 150;

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2 METHODOLOGY

Site inspections were conducted on 03 February 2023 with a vehicle and a drone to record all avifaunal sensitivities on, and in the immediate vicinity of the project site, which could influence the lay-out of the turbines. Emphasis was placed on locating nests of priority species, particularly species of conservation concern (SCC), which may be impacted by the proposed WEF. The data gathered during the 12-months monitoring from October 2019 to July 2020 was also taken into account. Priority species were defined as species included on the list of priority species of the Avian Wind Farm Sensitivity Map of South Africa compiled by Birdlife South Africa (Retief *et al.* 2012).

See Figure 1 for the 28 turbine lay-out.

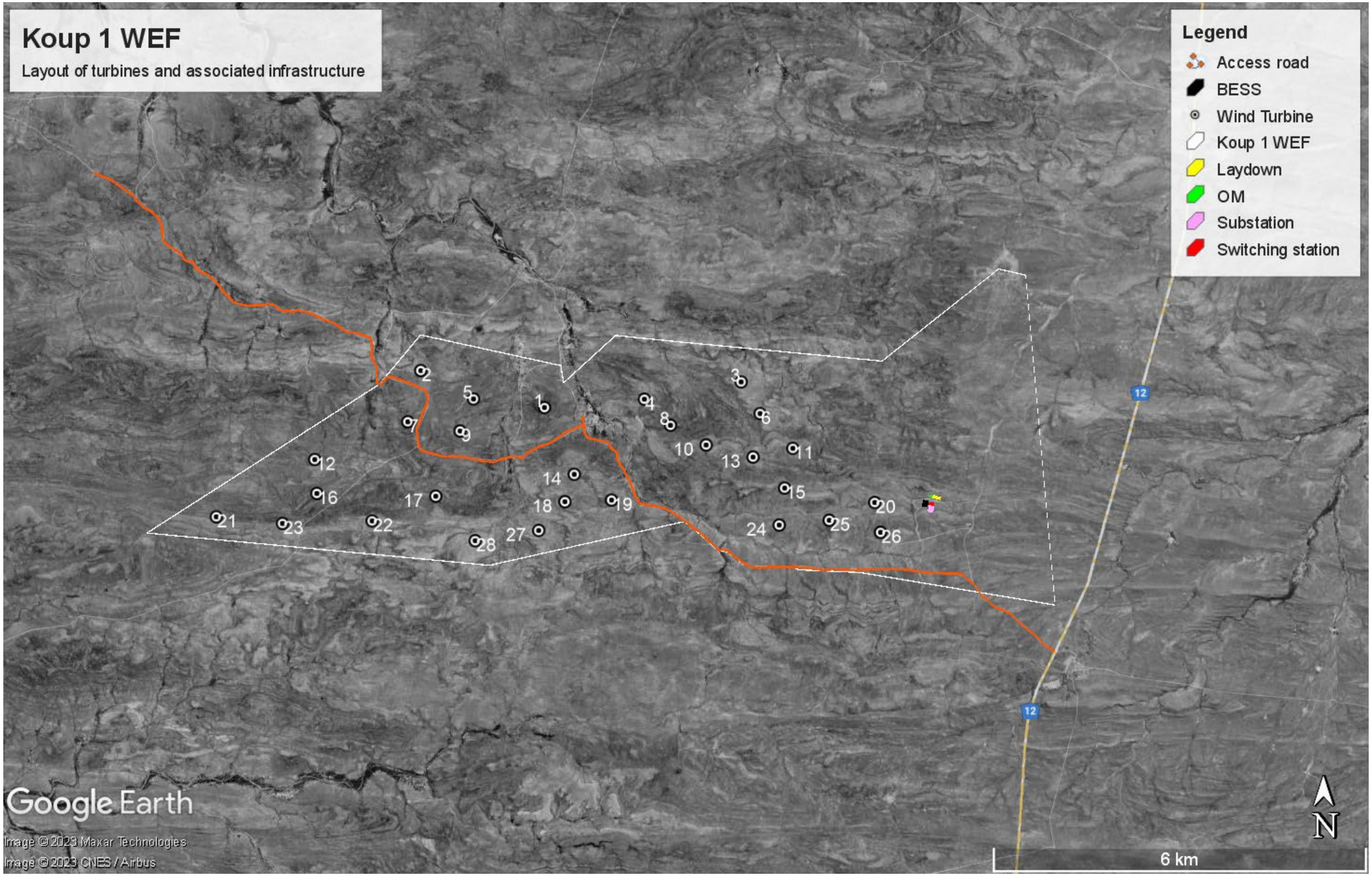


Figure 1: The proposed lay-out of 28 turbines

3 RECEIVING ENVIRONMENT

3.1 DFFE National Screening Tool

The study area and immediate environment is classified as **Medium and High** sensitivity for avifauna, according to the DFFE online screening tool. The development sites contain confirmed habitat for species of conservation concern (SCC), as defined in the Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855, 30 October 2020)[1], namely listed on the IUCN Red List of Threatened Species or South Africa's National Red List website as Critically Endangered, Endangered, Vulnerable, Near-threatened or Data Deficient. The occurrence of SCC was confirmed during the surveys i.e. Ludwig's Bustard (Globally and Regionally Endangered) was recorded in the study area. This classification is assessed to be accurate as far as the impact of the proposed WEF and associated infrastructure is concerned, based on actual conditions recorded on the ground during the site visits in February 2023, and the 12-months of pre-construction monitoring which was conducted from October 2019 to July 2020 (Van Rooyen *et al*. 2021).

See Appendix 1 for the DFFE screening report.

3.2 Bird habitat

3.2.1 The natural environment

The turbine and control sites are located in Gamka Karoo, which is one of most arid vegetation units of the Nama Karoo biome. It consists of undulating plains covered with dwarf spiny shrubland dominated by Karoo dwarf shrubs, with sparse low trees. Dense stands of drought-resistant grasses cover broad sandy bottomlands, especially after abundant rains (Mucina & Rutherford 2006). The turbine site contains a few ephemeral drainage lines which are characterised by sandy channels with *Vachellia* karoo shrubs and small trees growing on the edges. This region is in the rain shadow of the Cape Fold Belt mountains in the south, with mean annual precipitation ranging from 100 – 240mm, mostly between December and April. Mean maximum and minimum monthly temperatures in Beaufort West are 38.7˚C and -3.2˚C for January (summer) and July (winter) respectively (Mucina & Rutherford 2006). Strong north-westerly winds occur in winter (Mucina & Rutherford 2006). The only longer-term surface water at the turbine site consists of a couple of dams and boreholes with reservoirs. Drainage lines flow only briefly after good rains, when pools of standing water may last for several weeks. The land is used for sheep and game farming.

3.2.2 The modified environment

Whilst the distribution and abundance of the bird species in the broader area are mostly associated with natural vegetation, as this comprises virtually all the habitat, it is also necessary to examine the few external modifications to the environment that have relevance for birds.

The following avifaunal-relevant anthropogenic habitat modifications were recorded within the broader area:

[1] The wind theme is only applicable to developments that are located in Renewable Energy Development Zones.

- **Water points:** The land use in the broader area is mostly small stock and game farming. The entire area is divided into grazing camps, with associated boreholes and drinking troughs. In this arid environment, open water is a big draw card for birds which use the open water troughs to bath and drink.
- **Dams:** The development site contains a few ground dams located in drainage lines. When these dams fill up after good rains, they contain standing surface water for several months, which attracts birds to bath and drink.
- **Transmission lines:** The application site is bisected by the Droërivier – Proteus 1 400kV transmission line. The transmission towers are used by raptors for perching and roosting, and also for breeding. A Martial Eagle nest is present tower 108, 5km from the closest proposed turbine location, and approximately 850m from the closest border of the proposed development site. In May 2020, both adult birds were observed perching on the towers around the nest, indicating that the territory is active. In August 2021, an adult bird as observed at the nest. In February 2023, the nest was inspected with a drone and found to be structurally in good shape, indicating an active territory. No birds were recorded at the time, but it is outside the breeding season.

Appendix 4 provides a photographic record of the habitat at the application site.

4 RESULTS AND CONCLUSIONS

4.1 Avifauna

Appendix 3 lists the species Van Rooyen *et al*. (2021) recorded the period of pre-construction monitoring from October 2019 to 2020. The 29 species that were recorded on and around the Koup 1 and 2 project sites during the site surveys in February 2023 are listed in Table 1.

Table 1: Avifauna recorded during surveys at the project site on 03 February 2023. Priority species are shaded.

Species name	Scientific Name
Black-winged Kite	*Elanus caeruleus*
Booted Eagle	*Aquila pennatus*
Pale Chanting Goshawk	*Melierax canorus*
Greater Kestrel	*Falco rupicoloides*
Lesser Kestrel	*Falco naumanni*
Speckled Pigeon	*Columba guinea*
Cape Turtle-Dove	*Streptopelia capicola*
Laughing Dove	*Streptopelia senegalensis*
Namaqua Dove	*Oena capensis*
Common Swift	*Apus apus*
White-backed Mousebird	*Colius colius*
Acacia Pied Barbet	*Tricholaema leucomelas*
Spike-heeled Lark	*Chersomanes albofasciata*
Grey-backed Sparrowlark	*Eremopterix verticalis*
Barn Swallow	*Hirundo rustica*
Pied Crow	*Corvus albus*
Southern Grey Tit	*Parus afer*
Familiar Chat	*Cercomela familiaris*

Karoo Chat	*Cercomela schlegelii*
Karoo Scrub-Robin	*Cercotrichas coryphoeus*
Karoo Prinia	*Prinia maculosa*
Rufous-eared Warbler	*Malcorus pectoralis*
Dusky Sunbird	*Cinnyris fuscus*
Cape Sparrow	*Passer melanurus*
Black-headed Canary	*Serinus alario*
Yellow Canary	*Crithagra flaviventris*
White-throated Canary	*Crithagra albogularis*
Lark-like Bunting	*Emberiza impetuani*
Karoo Long-billed Lark	*Certhilauda subcoronata*

4.2 Nests

The following nests were recorded during the site surveys on 03 February 2023. All the nests were recorded on the Droërivier-Proteus 400kV HV line:

1. Martial Eagle nest Tower 108 (Figure 2)
2. Black-winged Kite Tower 114 (Figure 3)

The Martial Eagle nest is 5km from the closest turbine and will therefore not impact on the lay-out, as the recommended turbine exclusion zone around a Martial Eagle nest is 5km (see Figure 4). The Black-winged Kite nest is 2.4km away from the closest turbine, therefore the construction activities should not impact on the birds through disturbance (Figure 4).

Figure 2: A Martial Eagle nest recorded during the walk-through exercise on 03 February 2023 on Tower 108 of the Droërivier-Proteus 400kV.

Figure 3: A Black-winged Kite nest recorded during the walk-through exercise on 03 February 2023 on Tower 114 of the Droërivier-Proteus 400kV.

4.3 Other sensitivities

Surface water (drainage lines and water troughs) is crucially important for priority avifauna including all SCC. It is important to leave open space with no obstructions for birds to access and leave the surface water area unhindered (see Figure 4).

5 RECOMMENDATIONS

The recommendations below are put forward for inclusion in the Final Environmental Management Programme (EMPr). These recommendations are based on the pre-construction monitoring conducted from October 2019 to July 2020 and the walk-through exercise in February 2023 (Van Rooyen *et al*. 2021):

5.1 Design phase

- It is recommended that a 5km turbine exclusion zone is implemented around the Martial Eagle nest a Tower 108 on the Droërivier – Protheus 400kV transmission line (see Figure 4). The current 28 turbine lay-out has taken this into account.
- It is recommended that a 150m turbine exclusion zone is implemented around all drainage lines at the project site, and a 200m turbine exclusion zone around dams and water troughs as a pre-cautionary

measure against SCC and other priority species collisions (Figure 4). The current 28 turbine lay-out has taken this into account.

- It is recommended that all internal medium voltage cables are buried if technically possible.
- Those sections where the 33kV medium voltage cable cannot be trenched due to technical or environmental reasons, but needs run on overhead poles, the proposed pole designs must be approved by the avifaunal specialist, to ensure that the designs are raptor-friendly.
- It is recommended that bird flight diverters are fitted to all internal 33kV overhead lines according to the applicable Eskom engineering standard at the time.
- Consideration should be given to painting one third of one blade on each turbine signal red as a mitigation measure against avifaunal collisions, if feasible. While this mitigation measure is still considered experimental, data from Norway indicates a high level of effectiveness, even up to 100% for large raptors. If this can be done during the manufacturing phase, it can be done inexpensively.

5.2 Construction phase

- Construction activity should be restricted to the immediate footprint of the infrastructure as far as possible, and in particular to the proposed road network. Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of SCC.
- Removal of vegetation must be restricted to a minimum.
- Construction of new roads should only be considered if existing roads cannot be upgraded.
- The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the activity footprint is concerned.

5.3 Operational phase

- Vehicle and pedestrian access to the site should be controlled and restricted to access roads to prevent unnecessary disturbance of SCC.
- Formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition (2015) of the best practice guidelines (Jenkins *et al.* 2011). The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the site operator once these timelines and a commercial operational date have been finalised.
- As a minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in Year 5, and again every five years thereafter for the operational lifetime of the facility. The exact scope and nature of the post-construction monitoring will be determined on an ongoing basis by the results of the monitoring through a process of adaptive management.
- Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels of SCC turn out to be biologically significant, including Shutdown on Demand (SDoD).

5.4 Operational phase

- Dismantling activity should be restricted to the immediate footprint of the infrastructure as far as possible. Access to the remainder of the area should be strictly controlled to prevent unnecessary disturbance of priority species.
- Measures to control noise and dust should be applied according to current best practice in the industry.

6 IMPACT STATEMENT

It is recommended that the lay-out is approved, subject to the implementation of the mitigation measures as detailed in the updated Environmental Management Programme (EMPr).

7 REFERENCES

- Van Rooyen, C. & Froneman, A . 2021. Proposed construction of the Koup 1 wind energy facility and associated grid infrastructure, near Beaufort West, Western Cape Province, South Africa. Avifaunal Specialist Assessment Report. Unpublished report to SiVEST, July 2021.

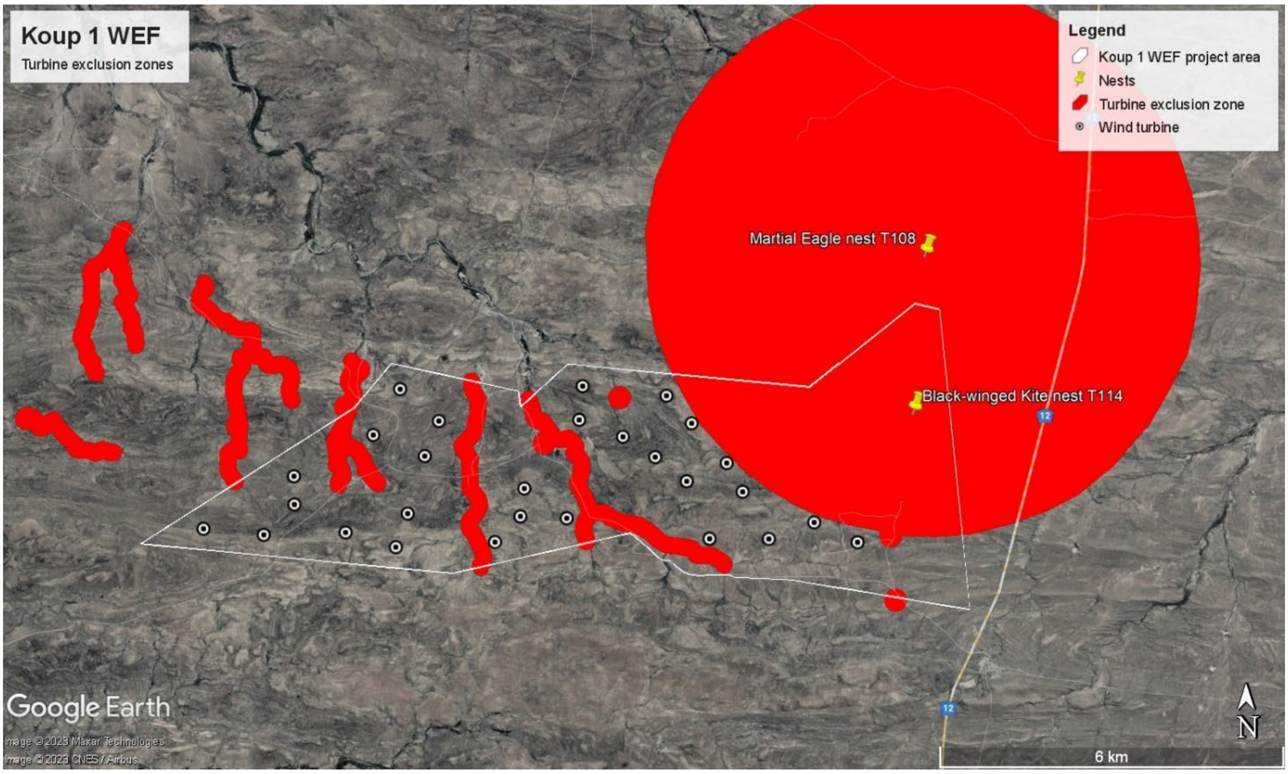
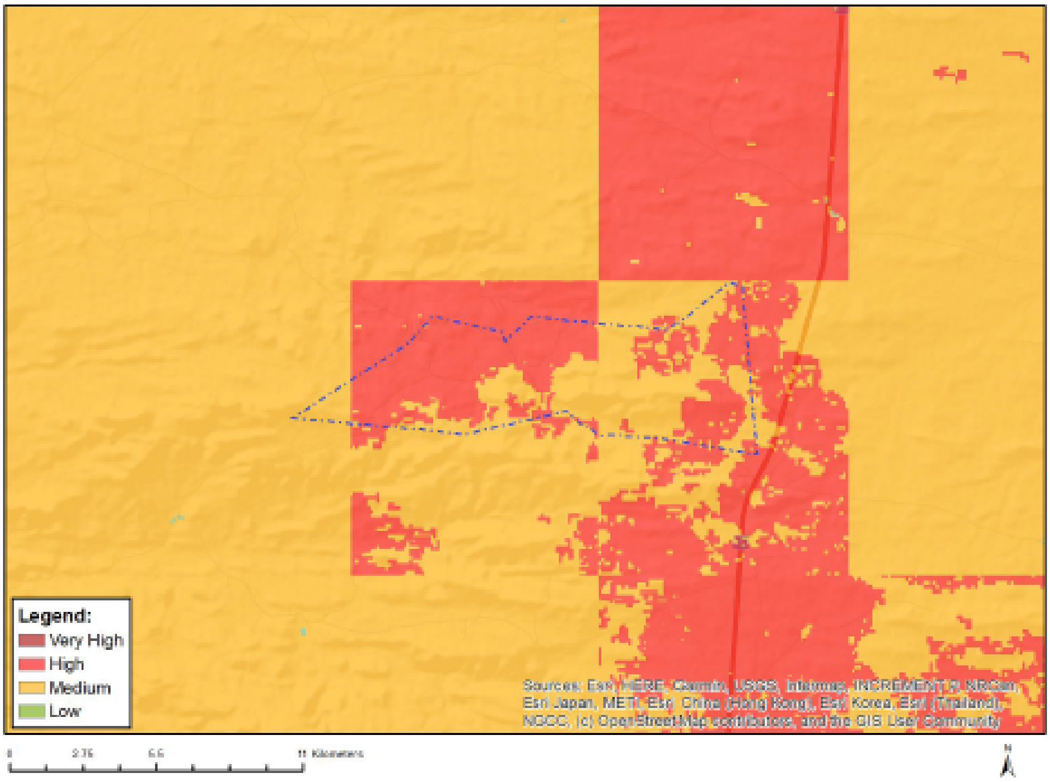


Figure 4: The 28 turbine layout with implemented buffer zones around surface water and SCC nests.

APPENDIX 1: DFFE SCREENING REPORT

MAP OF RELATIVE ANIMAL SPECIES THEME SENSITIVITY



Where only a sensitive plant unique number or sensitive animal unique number is provided in the screening report and an assessment is required, the environmental assessment practitioner (EAP) or specialist is required to email SANBI at eiadatarequests@sanbi.org.za listing all sensitive species with their unique identifiers for which information is required. The name has been withheld as the species may be prone to illegal harvesting and must be protected. SANBI will release the actual species name after the details of the EAP or specialist have been documented.

Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

Sensitivity	Feature(s)
High	Aves-Neotis ludwigii
High	Aves-Polemaetus bellicosus
Medium	Aves-Neotis ludwigii
Medium	Aves-Afrotis afra
Medium	Aves-Aquila verreauxii
Medium	Reptilia-Chersobius boulengeri

Figure 1: The results of the screening tool for the Koup 1 WEF. The high sensitivity is linked to the potential occurrence of Ludwig's Bustard *Neotis ludwigii* (Regional status: Endangered) and Martial Eagle *Polemaetus bellicosus* (Regional status: Endangered). The medium sensitivity is linked to Ludwig's Bustard, Southern Black Korhaan Afrotis afra (Regional status: Vulnerable) and Verreaux's Eagle *Aquila verreauxii* (Regional status : Vulnerable).

APPENDIX 2: BIRD HABITAT

Figure 1: Nama Karoo

Figure 2: Borehole with water trough

Figure 3: Drainage line with *Vachellia* woodland

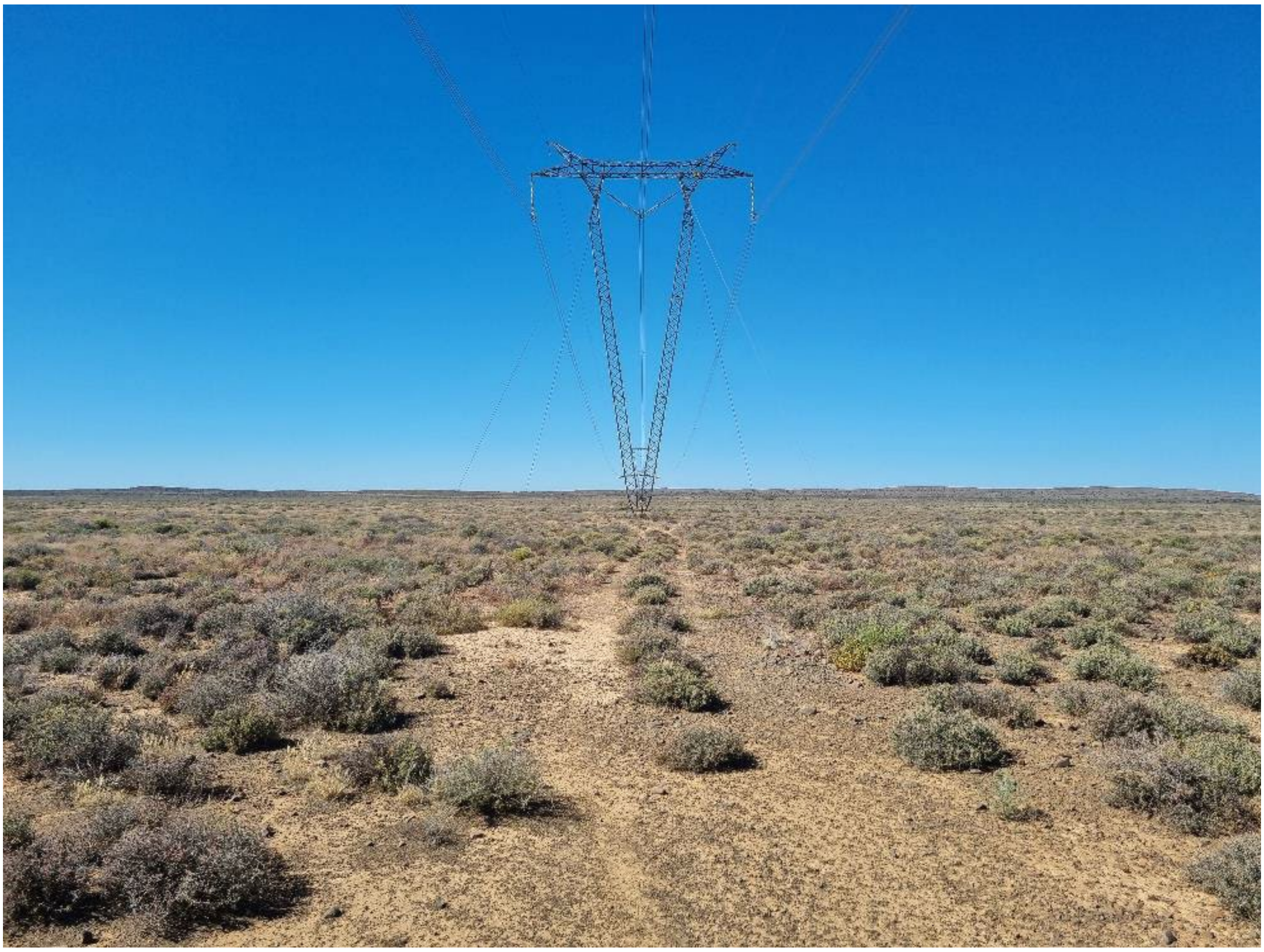


Figure 4: The Droërivier-Proteus 400kV HV line

APPENDIX 3: SPECIES LIST PRE-CONSTRUCTION MONITORING AT THE KOUP 1 AND 2 WEFS 2019 – 2020

Priority Species		**Transects turbine**	**Transects control**	**Focal point**	**VP**	**VP control**	**Incidental**
Karoo Korhaan	*Eupodotis vigorsii*	*	*		*	*	*
Ludwig's Bustard	*Neotis ludwigii*						*
Martial Eagle	*Polemaetus bellicosus*						*
Pale Chanting Goshawk	*Melierax canorus*	*	*		*	*	*
4		2	2		2	2	4

Non-Priority Species		**Transects turbine**	**Transects control**	**Focal point**
Acacia Pied Barbet	*Tricholaema leucomelas*	*	*	
African Red-eyed Bulbul	*Pycnonotus nigricans*	*	*	
African Spoonbill	*Platalea alba*			*
Barn Swallow	*Hirundo rustica*	*		
Bar-throated Apalis	*Apalis thoracica*	*		
Black-eared Sparrow-lark	*Eremopterix australis*		*	
Black-headed Canary	*Serinus alario*		*	
Black-headed Heron	*Ardea melanocephala*		*	
Blacksmith Lapwing	*Vanellus armatus*			*
Black-winged Stilt	*Himantopus himantopus*			*
Bokmakierie	*Telophorus zeylonus*	*	*	
Cape Bunting	*Emberiza capensis*	*	*	
Cape Crow	*Corvus capensis*	*	*	
Cape Penduline Tit	*Anthoscopus minutus*		*	
cape Robin-chat	*Cossypha caffra*	*		
Cape Shoveler	*Spatula smithii*			*
Cape Sparrow	*Passer melanurus*	*	*	
Cape Teal	*Anas capensis*			*
Cape Turtle Dove	*Streptopelia capicola*	*	*	
Cape wagtail	*Motacilla capensis*		*	
Cape White-eye	*Zosterops virens*	*		
Cardinal Woodpecker	*Dendropicos fuscescens*	*		
Chat Flycatcher	*Melaenornis infuscatus*	*	*	
Chestnut-vented Tit-Babbler	*Sylvia subcoerulea*	*	*	
Dusky Sunbird	*Cinnyris fuscus*	*	*	
Egyptian Goose	*Alopochen aegyptiaca*	*		*
Fairy Flycatcher	*Stenostira scita*	*	*	
Familiar Chat	*Oenanthe familiaris*	*	*	
Fiscal Flycatcher	*Melaenornis silens*	*	*	

Non-Priority Species		Transects turbine	Transects control	Focal point
Greater Striped Swallow	*Cecropis cucullata*	*		
Grey-backed Cisticola	*Cisticola subruficapilla*	*	*	
Grey-backed Sparrow-Lark	*Eremopterix verticalis*	*	*	
Hadeda Ibis	*Bostrychia hagedash*		*	
House Sparrow	*Passer domesticus*		*	
Karoo Chat	*Emarginata schlegelii*	*	*	
Karoo Eremomela	*Eremomela gregalis*	*	*	
Karoo Long-billed Lark	*Certhilauda subcoronata*	*	*	
Karoo Prinia	*Prinia maculosa*	*	*	
Karoo Scrub Robin	*Cercotrichas coryphoeus*	*	*	
Karoo Thrush	*Turdus smithi*	*		
Kittlitz's Plover	*Charadrius pecuarius*			*
Large-Billed Lark	*Galerida magnirostris*	*	*	
Lark-like Bunting	*Emberiza impetuani*	*	*	
Laughing Dove	*Spilopelia senegalensis*	*	*	
Layard's Tit-babbler	*Sylvia layardi*	*	*	
Little Grebe	*Tachybaptus ruficollis*			*
Little Swift	*Apus affinis*	*		
Long-billed Crombec	*Sylvietta rufescens*	*	*	
Long-billed Pipit	*Anthus similis*	*		
Malachite Sunbird	*Nectarinia famosa*		*	
Mountain Wheatear	*Myrmecocichla monticola*	*	*	
Namaqua Dove	*Oena capensis*		*	
Namaqua Sandgrouse	*Pterocles namaqua*		*	
Pale-winged Starling	*Onychognathus nabouroup*		*	
Pied Avocet	*Recurvirostra avosetta*			*
Pied Crow	*Corvus albus*	*	*	
Pied Starling	*Lamprotornis bicolor*		*	
Pririt batis	*Batis pririt*	*	*	
Red-billed Teal	*Anas erythrorhyncha*			*
Red-capped Lark	*Calandrella cinerea*		*	
Red-faced Mousebird	*Urocolius indicus*	*	*	
Rock Kestrel	*Falco rupicolus*	*		
Rock Martin	*Ptyonoprogne fuligula*	*		
Rufous-eared Warbler	*Malcorus pectoralis*	*	*	
South African Shelduck	*Tadorna cana*			*
Southern Double-collared Sunbird	*Cinnyris chalybeus*		*	
Southern Fiscal	*Lanius collaris*	*	*	
Southern Grey-headed Sparrow	*Passer diffusus*	*		
Southern masked Weaver	*Ploceus velatus*	*	*	
Speckled Pigeon	*Columba guinea*	*	*	

Non-Priority Species		Transects turbine	Transects control	Focal point
Spike-heeled Lark	*Chersomanes albofasciata*	*	*	
White-backed Mousebird	*Colius colius*	*		
White-necked Raven	*Corvus albicollis*	*		
White-rumped Swift	*Apus caffer*	*		
White-throated Canary	*Crithagra albogularis*	*	*	
Yellow Canary	*Crithagra flaviventris*	*	*	
Yellow-bellied Eremomela	*Eremomela icteropygialis*	*	*	
79		54	52	12
		56	**54**	12

APPENDIX 4: Expertise of Specialist

Curriculum vitae: Chris van Rooyen

Profession/Specialisation	:	Avifaunal Specialist
Highest Qualification	:	BA LLB
Nationality	:	South African
Years of experience	:	26 years

Key Experience

Chris van Rooyen has twenty-two years' experience in the assessment of avifaunal interactions with industrial infrastructure. He was employed by the Endangered Wildlife Trust as head of the Eskom-EWT Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has consulted in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. He also has extensive project management experience and he has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author and/or co-author of 17 conference papers, co-author of two book chapters, several research reports and the current best practice guidelines for avifaunal monitoring at wind farm sites. He has completed around 130 power line assessments; and has to date been employed as specialist avifaunal consultant on more than 50 renewable energy generation projects. He has also conducted numerous risk assessments on existing power lines infrastructure. He also works outside the electricity industry and he has done a wide range of bird impact assessment studies associated with various residential and industrial developments. He serves on the Birds and Wind Energy Specialist Group which was formed in 2011 to serve as a liaison body between the ornithological community and the wind industry.

Key Project Experience

Bird Impact Assessment Studies and avifaunal monitoring for wind-powered generation facilities:

1. Eskom Klipheuwel Experimental Wind Power Facility, Western Cape
2. Mainstream Wind Facility Jeffreys Bay, Eastern Cape (EIA and monitoring)
3. Biotherm, Swellendam, (Excelsior), Western Cape (EIA and monitoring)
4. Biotherm, Napier, (Matjieskloof), Western Cape (pre-feasibility)
5. Windcurrent SA, Jeffreys Bay, Eastern Cape (2 sites) (EIA and monitoring)
6. Caledon Wind, Caledon, Western Cape (EIA)
7. Innowind (4 sites), Western Cape (EIA)
8. Renewable Energy Systems (RES) Oyster Bay, Eastern Cape (EIA and monitoring)
9. Oelsner Group (Kerriefontein), Western Cape (EIA)
10. Oelsner Group (Langefontein), Western Cape (EIA)
11. InCa Energy, Vredendal Wind Energy Facility Western Cape (EIA)
12. Mainstream Loeriesfontein Wind Energy Facility (EIA and monitoring)
13. Mainstream Noupoort Wind Energy Facility (EIA and monitoring)
14. Biotherm Port Nolloth Wind Energy Facility (Monitoring)
15. Biotherm Laingsburg Wind Energy Facility (EIA and monitoring)
16. Langhoogte Wind Energy Facility (EIA)
17. Vleesbaai Wind Energy Facility (EIA and monitoring)
18. St. Helena Bay Wind Energy Facility (EIA and monitoring)
19. Electrawind, St Helena Bay Wind Energy Facility (EIA and monitoring)
20. Electrawind, Vredendal Wind Energy Facility (EIA)
21. SAGIT, Langhoogte and Wolseley Wind Energy facilities
22. Renosterberg Wind Energy Project – 12-month preconstruction avifaunal monitoring project
23. De Aar – North (Mulilo) Wind Energy Project – 12-month preconstruction avifaunal monitoring project
24. De Aar – South (Mulilo) Wind Energy Project – 12-month bird monitoring
25. Namies – Aggenys Wind Energy Project – 12-month bird monitoring
26. Pofadder - Wind Energy Project – 12-month bird monitoring
27. Dwarsrug Loeriesfontein - Wind Energy Project – 12-month bird monitoring
28. Waaihoek – Utrecht Wind Energy Project – 12-month bird monitoring
29. Amathole – Butterworth Utrecht Wind Energy Project – 12-month bird monitoring & EIA specialist
30. PhezukomEmaya and San Kraal Wind Energy Projects 12-month bird monitoring & EIA specialist study (Innowind)
31. Beaufort West Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
32. Leeuwdraai Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
33. Sutherland Wind Energy Facility 12-month bird monitoring (Mainstream)
34. Maralla Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
35. Esizayo Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
36. Humansdorp Wind Energy Facility 12-month bird monitoring & EIA specialist study (Cennergi)
37. Aletta Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
38. Eureka Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
39. Makambako Wind Energy Faclity (Tanzania) 12-month bird monitoring & EIA specialist study (Windlab)
40. R355 Wind Energy Facility 12-month bird monitoring (Mainstream)
41. Groenekloof Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
42. Tsitsikamma Wind Energy Facility 24-months post-construction monitoring (Cennergi)
43. Noupoort Wind Energy Facility 24-months post-construction monitoring (Mainstream)
44. Kokerboom Wind Energy Facility 12-month bird monitoring & EIA specialist study (Business Venture Investments)
45. Kuruman Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
46. Dassieklip Wind Energy Facility 3 years post-construction monitoring (Biotherm)
47. Loeriesfontein 2 Wind Energy Facility 2 years post-construction monitoring (Mainstream)
48. Khobab Wind Energy Facility 2 years post-construction monitoring (Mainstream)
49. Excelsior Wind Energy Facility 18 months construction phase monitoring (Biotherm)
50. Boesmansberg Wind Energy Facility 12-months pre-construction bird monitoring (juwi)
51. Mañhica Wind Energy Facility, Mozambique, 12-months pre-construction monitoring (Windlab)
52. Kwagga Wind Energy Facility, Beaufort West, 12-months pre-construction monitoring (ABO)

53. Pienaarspoort Wind Energy Facility, Touws River, Western Cape, 12-months pre-construction monitoring (ABO).

Bird Impact Assessment Studies for Solar Energy Plants:

1. Concentrated Solar Power Plant, Upington, Northern Cape.
2. Globeleq De Aar and Droogfontein Solar PV Pre- and Post-construction avifaunal monitoring
3. JUWI Kronos PV project, Copperton, Northern Cape
4. Sand Draai CSP project, Groblershoop, Northern Cape
5. Biotherm Helena PV Project, Copperton, Northern Cape
6. Biotherm Letsiao CSP Project, Aggeneys, Northern Cape
7. Biotherm Enamandla PV Project, Aggeneys, Northern Cape
8. Biotherm Sendawo PV Project, Vryburg, North-West
9. Biotherm Tlisitseng PV Project, Lichtenburg, North-West
10. JUWI Hotazel Solar Park Project, Hotazel, Northern Cape
11. Veld Solar One Project, Aggeneys, Northern Cape
12. Brypaal Solar Power Project, Kakamas, Northern Cape
13. ABO Vryburg 1,2,3 Solar PV Project, Vryburg, North-West
14. NamPower CSP Facility near Arandis, Namibia
15. Dayson Klip PV Facility near Upington, Northern Cape
16. Geelkop PV Facility near Upington, Northern Cape

Bird Impact Assessment Studies for the following overhead line projects:

1. Chobe 33kV Distribution line
2. Athene - Umfolozi 400kV
3. Beta-Delphi 400kV
4. Cape Strengthening Scheme 765kV
5. Flurian-Louis-Trichardt 132kV
6. Ghanzi 132kV (Botswana)
7. Ikaros 400kV
8. Matimba-Witkop 400kV
9. Naboomspruit 132kV
10. Tabor-Flurian 132kV
11. Windhoek - Walvisbaai 220 kV (Namibia)
12. Witkop-Overyssel 132kV
13. Breyten 88kV
14. Adis-Phoebus 400kV
15. Dhuva-Janus 400kV
16. Perseus-Mercury 400kV
17. Gravelotte 132kV
18. Ikaros 400 kV
19. Khanye 132kV (Botswana)
20. Moropule – Thamaga 220 kV (Botswana)
21. Parys 132kV
22. Simplon –Everest 132kV
23. Tutuka-Alpha 400kV
24. Simplon-Der Brochen 132kV
25. Big Tree 132kV
26. Mercury-Ferrum-Garona 400kV
27. Zeus-Perseus 765kV
28. Matimba B Integration Project
29. Caprivi 350kV DC (Namibia)
30. Gerus-Mururani Gate 350kV DC (Namibia)
31. Mmamabula 220kV (Botswana)
32. Steenberg-Der Brochen 132kV
33. Venetia-Paradise T 132kV
34. Burgersfort 132kV
35. Majuba-Umfolozi 765kV
36. Delta 765kV Substation
37. Braamhoek 22kV
38. Steelpoort Merensky 400kV
39. Mmamabula Delta 400kV
40. Delta Epsilon 765kV
41. Gerus-Zambezi 350kV DC Interconnector: Review of proposed avian mitigation measures for the Okavango and Kwando River crossings
42. Giyani 22kV Distribution line
43. Liqhobong-Kao 132/11kV distribution power line, Lesotho
44. 132kV Leslie – Wildebeest distribution line
45. A proposed new 50 kV Spoornet feeder line between Sishen and Saldanha
46. Cairns 132kv substation extension and associated power lines
47. Pimlico 132kv substation extension and associated power lines
48. Gyani 22kV
49. Matafin 132kV
50. Nkomazi_Fig Tree 132kV
51. Pebble Rock 132kV
52. Reddersburg 132kV
53. Thaba Combine 132kV
54. Nkomati 132kV
55. Louis Trichardt – Musina 132kV
56. Endicot 44kV

57. Apollo Lepini 400kV
58. Tarlton-Spring Farms 132kV
59. Kuschke 132kV substation
60. Bendstore 66kV Substation and associated lines
61. Kuiseb 400kV (Namibia)
62. Gyani-Malamulele 132kV
63. Watershed 132kV
64. Bakone 132kV substation
65. Eerstegoud 132kV LILO lines
66. Kumba Iron Ore: SWEP - Relocation of Infrastructure
67. Kudu Gas Power Station: Associated power lines
68. Steenberg Booysendal 132kV
69. Toulon Pumps 33kV
70. Thabatshipi 132kV
71. Witkop-Silica 132kV
72. Bakubung 132kV
73. Nelsriver 132kV
74. Rethabiseng 132kV
75. Tilburg 132kV
76. GaKgapane 66kV
77. Knobel Gilead 132kV
78. Bochum Knobel 132kV
79. Madibeng 132kV
80. Witbank Railway Line and associated infrastructure
81. Spencer NDP phase 2 (5 lines)
82. Akanani 132kV
83. Hermes-Dominion Reefs 132kV
84. Cape Pensinsula Strengthening Project 400kV
85. Magalakwena 132kV
86. Benficosa 132kV
87. Dithabaneng 132kV
88. Taunus Diepkloof 132kV
89. Taunus Doornkop 132kV
90. Tweedracht 132kV
91. Jane Furse 132kV
92. Majeje Sub 132kV
93. Tabor Louis Trichardt 132kV
94. Riversong 88kV
95. Mamatsekele 132kV
96. Kabokweni 132kV
97. MDPP 400kV Botswana
98. Marble Hall NDP 132kV
99. Bokmakiere 132kV Substation and LILO lines
100. Styldrift 132kV
101. Taunus – Diepkloof 132kV
102. Bighorn NDP 132kV
103. Waterkloof 88kV
104. Camden – Theta 765kV
105. Dhuva – Minerva 400kV Diversion
106. Lesedi –Grootpan 132kV
107. Waterberg NDP
108. Bulgerivier – Dorset 132kV
109. Bulgerivier – Toulon 132kV
110. Nokeng-Fluorspar 132kV
111. Mantsole 132kV
112. Tshilamba 132kV
113. Thabamoopo - Tshebela – Nhlovuko 132kV
114. Arthurseat 132kV
115. Borutho 132kV MTS
116. Volspruit - Potgietersrus 132kV
117. Neotel Optic Fibre Cable Installation Project: Western Cape
117. Matla-Glockner 400kV
118. Delmas North 44kV
119. Houwhoek 11kV Refurbishment
120. Clau-Clau 132kV
121. Ngwedi-Silwerkrans 134kV
122. Nieuwehoop 400kV walk-through
123. Booysendal 132kV Switching Station
124. Tarlton 132kV
125. Medupi - Witkop 400kV walk-through
126. Germiston Industries Substation
127. Sekgame 132kV
128. Botswana – South Africa 400kV Transfrontier Interconnector
129. Syferkuil – Rampheri 132kV
130. Queens Substation and associated 132kV powerlines
131. Oranjemond 400kV Transmission line
132. Aries – Helios – Juno walk-down
133. Kuruman Phase 1 and 2 Wind Energy facilities 132kV Grid connection
134. Transnet

Bird Impact Assessment Studies for the following residential and industrial developments:

1. Lizard Point Golf Estate
2. Lever Creek Estates
3. Leloko Lifestyle Estates
4. Vaaloewers Residential Development
5. Clearwater Estates Grass Owl Impact Study
6. Sommerset Ext. Grass Owl Study
7. Proposed Three Diamonds Trading Mining Project (Portion 9 and 15 of the Farm Blesbokfontein)
8. N17 Section: Springs To Leandra –“Borrow Pit 12 And Access Road On (Section 9, 6 And 28 Of The Farm Winterhoek 314 Ir)
9. South African Police Services Gauteng Radio Communication System: Portion 136 Of The Farm 528 Jq, Lindley.
10. Report for the proposed upgrade and extension of the Zeekoegat Wastewater Treatment Works, Gauteng.
11. Bird Impact Assessment for Portion 265 (a portion of Portion 163) of the farm Rietfontein 189-JR, Gauteng.
12. Bird Impact Assessment Study for Portions 54 and 55 of the Farm Zwartkop 525 JQ, Gauteng.
13. Bird Impact Assessment Study Portions 8 and 36 of the Farm Nooitgedacht 534 JQ, Gauteng.
14. Shumba’s Rest Bird Impact Assessment Study
15. Randfontein Golf Estate Bird Impact Assessment Study
16. Zilkaatsnek Wildlife Estate
17. Regenstein Communications Tower (Namibia)
18. Avifaunal Input into Richards Bay Comparative Risk Assessment Study
19. Maquasa West Open Cast Coal Mine
20. Glen Erasmia Residential Development, Kempton Park, Gauteng
21. Bird Impact Assessment Study, Weltevreden Mine, Mpumalanga
22. Bird Impact Assessment Study, Olifantsvlei Cemetery, Johannesburg
23. Camden Ash Disposal Facility, Mpumalanga
24. Lindley Estate, Lanseria, Gauteng
25. Proposed open cast iron ore mine on the farm Lylyveld 545, Northern Cape
26. Avifaunal monitoring for the Sishen Mine in the Northern Cape as part of the EMPr requirements
27. Steelpoort CNC Bird Impact Assessment Study

Professional affiliations

I work under the supervision of and in association with Albert Froneman (MSc Conservation Biology) (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003.

Chris van Rooyen
22 May 2023

Expertise of Specialist

Curriculum vitae: Albert Froneman (Pr.Sci.Nat Registration no: 400177/09)

Profession/Specialisation : Avifaunal Specialist
Highest Qualification : MSc (Conservation Biology)
Nationality : South African
Years of experience : 24 years

Key Qualifications

Albert Froneman **(**Pr.Sci.Nat) has more than 24 years' experience in the management of avifaunal interactions with industrial infrastructure. He holds a M.Sc. degree in Conservation Biology from the University of Cape Town. He managed the Airports Company South Africa (ACSA) – Endangered Wildlife Trust Strategic Partnership from 1999 to 2008 which has been internationally recognized for its achievements in addressing airport wildlife hazards in an environmentally sensitive manner at ACSA's airports across South Africa. Albert is recognized worldwide as an expert in the field of bird hazard management on airports and has worked in South Africa, Swaziland, Botswana, Namibia, Kenya, Israel, and the USA. He has served as the vice chairman of the International Bird Strike Committee and has presented various papers at international conferences and workshops. At present he is consulting to ACSA with wildlife hazard management on all their airports. He also an accomplished specialist ornithological consultant outside the aviation industry and has completed a wide range of bird impact assessment studies. He has co-authored many avifaunal specialist studies and pre-construction monitoring reports for proposed renewable energy developments across South Africa. He also has vast experience in using Geographic Information Systems to analyse and interpret avifaunal data spatially and derive meaningful conclusions. Since 2009 Albert has been a registered Professional Natural Scientist (reg. nr 400177/09) with The South African Council for Natural Scientific Professions, specialising in Zoological Science.

Key Project Experience

Renewable Energy Facilities –avifaunal monitoring projects in association with Chris van Rooyen Consulting

1. Jeffrey's Bay Wind Farm – 12-months preconstruction avifaunal monitoring project
2. Oysterbay Wind Energy Project – 12-months preconstruction avifaunal monitoring project
3. Ubuntu Wind Energy Project near Jeffrey's Bay – 12-months preconstruction avifaunal monitoring project
4. Bana-ba-Pifu Wind Energy Project near Humansdorp – 12-months preconstruction avifaunal monitoring project
5. Excelsior Wind Energy Project near Caledon – 12-months preconstruction avifaunal monitoring project
6. Laingsburg Spitskopvlakte Wind Energy Project – 12-months preconstruction avifaunal monitoring project
7. Loeriesfontein Wind Energy Project Phase 1, 2 & 3 – 12-months preconstruction avifaunal monitoring project
8. Noupoort Wind Energy Project – 12-months preconstruction avifaunal monitoring project
9. Vleesbaai Wind Energy Project – 12-months preconstruction avifaunal monitoring project
10. Port Nolloth Wind Energy Project – 12-months preconstruction avifaunal monitoring project
11. Langhoogte Caledon Wind Energy Project – 12-months preconstruction avifaunal monitoring project
12. Lunsklip – Stilbaai Wind Energy Project – 12-months preconstruction avifaunal monitoring project
13. Indwe Wind Energy Project – 12-months preconstruction avifaunal monitoring project
14. Zeeland St Helena bay Wind Energy Project – 12-months preconstruction avifaunal monitoring project
15. Wolseley Wind Energy Project – 12-months preconstruction avifaunal monitoring project
16. Renosterberg Wind Energy Project – 12-months preconstruction avifaunal monitoring project
17. De Aar – North (Mulilo) Wind Energy Project – 12-months preconstruction avifaunal monitoring project (2014)
18. De Aar – South (Mulilo) Wind Energy Project – 12-months bird monitoring
19. Namies – Aggenys Wind Energy Project – 12-months bird monitoring
20. Pofadder - Wind Energy Project – 12-months bird monitoring
21. Dwarsrug Loeriesfontein - Wind Energy Project – 12-months bird monitoring
22. Waaihoek – Utrecht Wind Energy Project – 12-months bird monitoring
23. Amathole – Butterworth Utrecht Wind Energy Project – 12-months bird monitoring & EIA specialist study
24. De Aar and Droogfontein Solar PV Pre- and Post-construction avifaunal monitoring
25. Makambako Wind Energy Faclity (Tanzania) 12-month bird monitoring & EIA specialist study (Windlab)
26. R355 Wind Energy Facility 12-month bird monitoring (Mainstream)
27. Groenekloof Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
28. Tsitsikamma Wind Energy Facility 24-months post-construction monitoring (Cennergi)
29. Noupoort Wind Energy Facility 24-months post-construction monitoring (Mainstream)
30. Kokerboom Wind Energy Facility 12-month bird monitoring & EIA specialist study (Business Venture Investments)
31. Kuruman Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
32. Mañhica Wind Energy Facility 12-month bird monitoring & EIA specialist study (Windlab)
33. Kwagga Wind Energy Facility, Beaufort West, 12-months pre-construction monitoring (ABO)
34. Pienaarspoort Wind Energy Facility, Touws River, Western Cape, 12-months pre-construction monitoring (ABO).

Bird Impact Assessment studies and / or GIS analysis:

1. Aviation Bird Hazard Assessment Study for the proposed Madiba Bay Leisure Park adjacent to Port Elizabeth Airport.
2. Extension of Runway and Provision of Parallel Taxiway at Sir Seretse Khama Airport, Botswana Bird / Wildlife Hazard Management Specialist Study
3. Maun Airport Improvements Bird / Wildlife Hazard Management Specialist Study
4. Bird Impact Assesment Study - Bird Helicopter Interaction – The Bitou River, Western Cape Province South Africa
5. Proposed La Mercy Airport – Bird Aircraft interaction specialists study using bird detection radar to assess swallow flocking behaviour
6. KwaZulu Natal Power Line Vulture Mitigation Project – GIS analysis
7. Perseus-Zeus Powerline EIA – GIS Analysis
8. Southern Region Pro-active GIS Blue Crane Collision Project.
9. Specialist advisor ~ Implementation of a bird detection radar system and development of an airport wildlife hazard management and operational environmental management plan for the King Shaka International Airport
10. Matsapha International Airport – bird hazard assessment study with management recommendations
11. Evaluation of aviation bird strike risk at candidate solid waste disposal sites in the Ekurhuleni Metropolitan Municipality

12. Gateway Airport Authority Limited – Gateway International Airport, Polokwane: Bird hazard assessment; Compile a bird hazard management plan for the airport
13. Bird Specialist Study - Evaluation of aviation bird strike risk at the Mwakirunge Landfill site near Mombasa Kenya
14. Bird Impact Assessment Study - Proposed Weltevreden Open Cast Coal Mine Belfast, Mpumalanga
15. Avian biodiversity assessment for the Mafube Colliery Coal mine near Middelburg Mpumalanga
16. Avifaunal Specialist Study - SRVM Volspruit Mining project – Mokopane Limpopo Province
17. Avifaunal Impact Assessment Study (with specific reference to African Grass Owls and other Red List species) Stone Rivers Arch
18. Airport bird and wildlife hazard management plan and training to Swaziland Civil Aviation Authority (SWACAA) for Matsapha and Sikhupe International Airports
19. Avifaunal Impact Scoping & EIA Study - Renosterberg Wind Farm and Solar PV site
20. Bird Impact Assessment Study - Proposed 60 year Ash Disposal Facility near to the Kusile Power Station
21. Avifaunal pre-feasibility assessment for the proposed Montrose dam, Mpumalanga
22. Bird Impact Assessment Study – Proposed ESKOM Phantom Substation near Knysna, Western Cape
23. Habitat sensitivity map for Denham's Bustard, Blue Crane and White-bellied Korhaan in the Kouga Municipal area of the Eastern Cape Province
24. Swaziland Civil Aviation Authority – Sikhuphe International Airport – Bird hazard management assessment
25. Avifaunal monitoring – extension of Specialist Study - SRVM Volspruit Mining project – Mokopane Limpopo Province
26. Avifaunal Specialist Study – Rooikat Hydro Electric Dam – Hope Town, Northern Cape
27. The Stewards Pan Reclamation Project – Bird Impact Assessment study
28. Airports Company South Africa – Avifaunal Specialist Consultant – Airport Bird and Wildlife Hazard Mitigation

Geographic Information System analysis & maps

1. ESKOM Power line Makgalakwena EIA – GIS specialist & map production
2. ESKOM Power line Benficosa EIA – GIS specialist & map production
3. ESKOM Power line Riversong EIA – GIS specialist & map production
4. ESKOM Power line Waterberg NDP EIA – GIS specialist & map production
5. ESKOM Power line Bulge Toulon EIA – GIS specialist & map production
6. ESKOM Power line Bulge DORSET EIA – GIS specialist & map production
7. ESKOM Power lines Marblehall EIA – GIS specialist & map production
8. ESKOM Power line Grootpan Lesedi EIA – GIS specialist & map production
9. ESKOM Power line Tanga EIA – GIS specialist & map production
10. ESKOM Power line Bokmakierie EIA – GIS specialist & map production
11. ESKOM Power line Rietfontein EIA – GIS specialist & map production
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36. ESKOM Wisani bridge EIA – GIS specialist & map production
37. City of Tswane – New bulkfeeder pipeline projects x3 Map production
38. ESKOM Lebohang Substation and 132kV Distribution Power Line Project Amendment GIS specialist & map production
39. ESKOM Geluk Rural Powerline GIS & Mapping
40. Eskom Kimberley Strengthening Phase 4 Project GIS & Mapping
41. ESKOM Kwaggafontein - Amandla Amendment Project GIS & Mapping
42. ESKOM Lephalale CNC – GIS Specialist & Mapping
43. ESKOM Marken CNC – GIS Specialist & Mapping
44. ESKOM Lethabong substation and powerlines – GIS Specialist & Mapping
45. ESKOM Magopela- Pitsong 132kV line and new substation – GIS Specialist & Mapping

Professional affiliations

South African Council for Natural Scientific Professions (SACNASP) registered Professional Natural Scientist (reg. nr 400177/09) – specialist field: Zoological Science. Registered since 2009.

Signature of the Specialist

Albert Froneman
22 May 2023

APPENDIX 5: POST-CONSTRUCTION MANAGEMENT PLAN

1 INTRODUCTION

The avifaunal post-construction monitoring at the proposed WEF must be conducted in accordance with the latest version (2015) of the *Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa* (Jenkins *et al*. 2015)[2].

2 AIM OF POST-CONSTRUCTION MONITORING

The avifaunal post construction monitoring aims to assess the impact of the WEF by comparing pre- and post- construction monitoring data and to measure the extent of bird fatalities caused by the WEF. Post-construction monitoring is therefore necessary to:

- Confirm as far as possible what the actual impacts of the WEF are on avifauna; and
- Determine what mitigation is required if need be (adaptive management).

The proposed post-construction monitoring can be divided into three categories:

- Habitat classification
- Quantifying bird numbers and movements (replicating baseline pre-construction monitoring)
- Quantifying bird mortalities.

Post-construction monitoring will aim to answer the following questions:

- How has the habitat available to birds in and around the WEF changed?
- How has the number of birds and species composition changed?
- How have the movements of priority species changed?
- How has the WEF affected priority species' breeding success?
- How many birds collide with the turbines? And are there any patterns to this?
- What mitigation is necessary to reduce the impacts on avifauna?

3 TIMING

Post-construction monitoring should commence as soon as possible after the first turbines become operational to ensure that the immediate effects of the facility on resident and passing birds are recorded, before they have time to adjust or habituate to the development. However, it should be borne in mind that it is also important to obtain an understanding of the impacts of the facility as they would be over the lifespan of the facility. Over time the habitat within the WEF may change, birds may become habituated to, or learn to avoid the facility. It is therefore necessary to monitor over a longer period than just an initial one year.

4 DURATION

Monitoring should take place in Year 1 and 2 of the operational phase, and then repeated in Year 5 and every five years after that. After the first year of monitoring, the programme should be reviewed in order to incorporate significant findings that have emerged. This may entail the revision of the number of turbines to be searched, and the size of the search plots, depending on the outcome of the first year of monitoring. If significant impacts are observed, i.e. exceeding predetermined thresholds, and mitigation is required, the

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[2] Jenkins, A.R., Van Rooyen, C.S., Smallie, J.J., Anderson, M.D., & A.H. Smit. 2015. Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa. Produced by the Wildlife & Energy Programme of the Endangered Wildlife Trust & BirdLife South Africa.

matter should be taken up with the operator to discuss potential mitigation. In such instances the scope of monitoring could be reduced to focus only on the impacts of concern.

5 HABITAT CLASSIFICATION

Any observed changes in bird numbers and movements at a WEF may be linked to changes in the available habitat. The avian habitats available must be mapped at least once a year (at the same time every year), using the same methods which were used during pre-construction.

6 BIRD NUMBERS AND MOVEMENTS

In order to determine if there are any impacts relating to displacement and/or disturbance, all methods used to estimate bird numbers and movements during baseline monitoring must be applied as far as is practically possible in the same way to post-construction work in order to ensure maximum comparability of these two data sets. This includes sample counts of small terrestrial species, counts of large terrestrial species and raptors, focal site surveys and vantage point surveys according to the current best practice.

7 MORTALITIES

The mortality monitoring must have four components:

- Experimental assessment of search efficiency and scavenging rates of bird carcasses on the site at least twice a year.
- Weekly searches in the immediate vicinity of the wind farm turbines for collision casualties.
- Estimation of collision rates at the end of each year of post construction monitoring. Observed mortality rates need to be adjusted to account for searcher efficiency and scavenger removal. There have been many different formulas proposed to estimate mortality rates. The available methodologies must be investigated, and an appropriate method will be applied. The current method which is used widely is the GenEst method.
- Monthly inspections of the overhead powerlines to look for potential collision and electrocution mortalities.

8 SEARCHER EFFICIENCY AND SCAVENGER REMOVAL

The value of surveying the area for collision victims is only valid if some measure of the accuracy of the survey method is developed. The probability of a carcass being detected and the rate of removal/decay of the carcass must be accounted for when estimating collision rates and when designing the monitoring protocol. This must be done in the form of searcher and scavenger trails at least twice a year.

9 CARCASS SURVEYS

9.1 Aligning search protocols.

The search protocol must be agreed upon between the bat and bird specialists to constitute an acceptable compromise between the current best practice guidelines for bird and bat monitoring.

9.2 Methodology

- The search plots must be defined by the avifaunal specialist.
- A team of searchers and one supervisor must be trained to implement the carcass searches.
- Searches must begin as early in the mornings as possible to reduce carcass removal by scavengers.
- Carcass searchers must walk in straight line transects, 6 m apart, covering 3 m on each side.
- The searchers must have a vehicle available for transport per site.

- The supervisor must assist with the collation of the data and to provide the data to the avifaunal specialist in electronic format on a weekly basis.
- The avifaunal specialist must ensure that the supervisor is completely familiar with all the procedures concerning the management of the data.
- The following must be loaded on a cloud server on a weekly basis for the avifaunal specialist to access:
    - Carcass fatality data (hardcopy and scans as well as data entered into Excel spreadsheets);
    - Pictures of any carcasses, properly labelled
    - GPS tracks of the search plots walked; and
    - Spreadsheet indicating the turbines searched on a weekly basis.

When a carcass is found, it must be bagged, labelled, and kept refrigerated for species confirmation when the specialist visits the site.

10 DELIVERABLES

10.1 Annual report

A post-construction monitoring report must be completed by the avifaunal specialist at the end of each year of operational monitoring. As a minimum, the report must attempt to answer the following questions:

- How has the habitat available to birds in and around the WEF changed?
- How has the number birds and species composition changed?
- How have the movements of priority species changed?
- How has the WEF affected priority species' breeding success?
- What are the likely drivers of any changes observed?
- What is the significance of any impacts observed?
- What mitigation measures are required to reduce the impacts?

10.2 Quarterly reports

Concise quarterly reports must be provided by the avifaunal specialist with basic statistics and any issues that need to be addressed.

Genesis Enertrag Koup 1 (Pty) Ltd

COMPARATIVE ENVIRONMENTAL NOISE IMPACT ASSESSMENT

of the proposed

Koup 1 Wind Energy Facility and associated Infrastructure south of Beaufort-west, Western Cape Province

Study done for:

ARCUS

Prepared by:

EARES
Enviro Acoustic Research

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EXECUTIVE SUMMARY

INTRODUCTION

Enviro-Acoustic Research cc was commissioned by the ARCUS Consulting South Africa SA (Pty) Ltd ("ARCUS") to reassess the potential noise impact from the construction and operation of the proposed Koup 1 Wind Energy Facility ("WEF") and associated infrastructure on the surrounding area.

The developer is proposing a number of changes to the WEF and it was requested to review the potential change in the noise impact and whether it would result in a change in the findings and recommendations of the previous ENIA. Potential changes would include:

- A change in the Wind Turbine Generator ("WTG") layout; and
- A change in the potential WTG.

This is a comprehensive, stand-alone report which describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the WF may have on the surrounding environment, highlighting the methods used, potential issues identified, findings and recommendations.

PROJECT DESCRIPTION

The authorized Koup 1 WEF is located approximately 55 km south of Beaufort West in the Western Cape Province.

The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line. The project propose a Battery Energy Storage System ("BESS"), located next to the onsite substation. The WEF will include the following infrastructure:

- Up to twenty-eight (28) WTG, each with a hub height of up to 200m, a rotor diameter of up to approximately 200m with a maximum generating capacity of 10MW;
- Permanent compacted hardstand areas / platforms (also known as crane pads) per turbine during construction and for on-going maintenance purposes;
- Electrical transformers (690V/33kV) adjacent to each wind turbine (typical footprint of up to approximately 2m x 2m) to step up the voltage to 11-33kV;
- Associated infrastructure of approximately 25ha which includes:
    - One (1) Independent Power Producer on-site substation including associated equipment and infrastructure.

- A Battery Energy Storage System ("BESS"), to be located next to the onsite substation. The storage capacity and type of technology would be determined at a later stage during the development phase, but most likely comprise an array of containers, outdoor cabinets and/or storage tanks.
- One (1) construction laydown / staging area.
- Operation and Maintenance ("O&M") buildings, including offices, a guard house, operational control centre, O&M area / warehouse / workshop and ablution facilities (to be located on the site identified for the substation).
- The wind turbines will be connected to the proposed substation via medium voltage (11-33kV) underground cabling and overhead power lines.
- Internal roads to access the wind turbines. Existing site roads will be used wherever possible, although new site roads will be constructed where necessary.

DESCRIPTION OF THE SURROUNDING LAND USE

Land use is mostly agricultural activities (game and sheep farming) and wilderness areas (including eco-tourism). 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.

DESCRIPTION OF THE CLOSEST POTENTIAL NOISE SENSITIVE RECEPTORS

Residential areas and potential noise-sensitive developments/receptors/communities ("NSR") were identified using aerial images as well as a physical site visit, with a number of locations identified that is used on a temporary or permanent basis for residential purposes.

BASELINE SOUND LEVELS

Ambient sound levels (residual noise levels) were measured at six locations over 35 hours from the afternoon of the 10th until the morning of the 12 June 2021 in the vicinity of the project focus area. The data indicate an area where ambient sound levels were low (typical of winter periods), though it should be noted that the period coincided with very low wind speeds.

Based on the sound measurements:

- More than 1,000 10-minute measurements were collected during the day, with the highest fast-weighted sound level (during the various 10-minute measurements) measured being 55.4 dBA, with the lowest sound level being 16.6 dBA;

- More than 650 10-minute measurements were collected during the night-time period, with the highest fast-weighted sound level (during the numerous 10-minute measurements) measured being 65.7 dBA, with the lowest sound level being 22.6 dBA;
- The average of the 10-minute sound levels at the seven measurement locations were 29.8 dBA for the daytime period and 23.3 dBA for the night-time period (fast-weighted sound levels).

ACCEPTABLE NOISE LIMITS

Based on the developmental character and ambient sound level measurements:

- The daytime rating level (zone sound level) would be typical of a rural noise district (45 dBA), setting a maximum noise limit of 52 dBA during the day; and
- The night-time rating level (zone sound limit) is typical of a rural noise district (35 dBA), setting a recommended noise limit of 42 dBA at night (for the construction phase).

Because the National and provincial Noise Control Regulations (NCR) and SANS 10103 does not cater for instances when background noise levels change due to the impact of external forces (such as noises induced by higher wind speeds), this assessment used international guidelines and local regulations to recommend more appropriate noise limits for this project.

This is important, as the wind turbines will only operate during periods of higher wind speeds, a period that may coincide with higher ambient sound levels. This assessment therefore recommends a night-time noise limit of 42 dBA (periods with low or no winds – with this limit relevant for the construction phase) and an upper limit of 45 dBA (periods that wind turbines may operate – the operational phase).

FINDINGS

This review assessment considers the potential noise impact on the surrounding environment due to the construction, operational and future decommissioning activities associated with the Project. It makes use of conceptual scenarios to develop noise propagation models to estimate potential noise levels. Considering the ambient sound levels measured onsite, the proposed noise limits as well as the calculated noise levels, it was determined that the significance of the potential noise impacts would be:

- of a **medium significance** for the construction of access roads (or upgrading of existing roads). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment.

Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;

- of a **medium significance** relating to noises from construction traffic. This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the assembly of the WTG and other infrastructure). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a potential **medium significance** for the night-time construction activities (the potential pouring of concrete, erection of WTG). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for daytime operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level; and
- of a **high significance** for night-time operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available and included in this assessment that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level.

There is a slight potential for a cumulative noise impact to occur during the operational phase. NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs and there is a slight cumulative impact at these NSR. Total cumulative noise levels are higher than 45 dBA at these NSR, but this noise impact mainly relates to noises from operating WTG of the Koup 1 WEF (potential noise levels due to the WTG of the Koup 2 WEF will be less than 40 dBA). Due to the **high significance** of the noise impact for the operational phase, the significance will remain high for the cumulative scenario.

MANAGEMENT & MITIGATION OF NOISE IMPACT

The significance of the noise impact will be of a **medium** significance for both day- and night-time activities and additional mitigation measures are required or recommended.

Night-time activities especially may generate noises at sufficient level to be annoying to some NSR and the following measures could reduce annoyance with construction activities. Potential measures could include:

- The applicant can relocate the access road further than 100m from structures used for residential purposes during the construction period;
- Applicant to minimize simultaneous construction activities when working within 2,000m from NSR (such as limiting construction activities at one WTG location);
- Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life;
- The Applicant to minimize night-time activities when working within 2,000m from any structure used for residential purposes where possible. Work should only take place at one WTG location to minimize potential night-time cumulative noises (when working at night within 2,000m from NSR used for residential purposes);
- The applicant must notify the NSR when night-time activities will be taking place within 2,000m from the NSR (including construction traffic passing NSR); and
- The applicant must plan the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period (even though it is expected that it is highly unlikely that this may take place at night).

The significance of the noise impact during the operation phase could be **medium** for daytime activities, but of a **high** significance for night -time operations. Operating WTG however will be clearly audible at closest NSR, especially at night. Potential measures could include:

- The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA re 1 pw) – the scenario illustrated in **Figure 9-5**; **<u>or</u>**
- The applicant can relocate one or NSR located within the 45dBA noise rating level contours;
- The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR[1].

- For the currently layout, noise levels less than 45dBA would be possible when relocating:
    - WTG 1 and 14 further than 2,500m from NSR01; **and**
    - WTG 17, 18 and 28 further than 2,500m from NSR02; **and**

- The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.

RECOMMENDATIONS

Active noise monitoring is recommended because the projected noise levels are more than 38.7 dBA (the level defined by the WHO where noise levels from WTG may become annoying) for the layout and WTG as assessed in this report. Noise levels is projected to be higher than 45 dBA at NSR for a WTG with an SPL of 107.5 dBA (re 1 pW).

From an acoustic perspective the WTG layout is considered acceptable should the applicant select to use a WTG with a SPL less than 107.5 dBA (re 1 pW). Should the applicant select to use a WTG with an SPL exceeding 107.5 dBA (re 1 pW), additional mitigation measures must be implemented to ensure that total noise levels are less than 45 dBA at verified NSR (locations where residential activities would be taking place during the operational phase), with the potential mitigation measures highlighted in this review assessment.

Subject to the condition that the applicant limit total noise levels to less than 45 dBA at the NSR, it is recommended that the Koup 1 WEF be authorized (from an acoustic perspective).

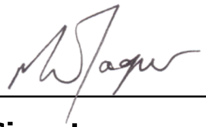
It is also highlighted that the applicant re-evaluates the noise impact:

1. should the layout be revised where:
    a. any WTG, located within 1,500 m from any NSR are moved closer;
    b. the number of WTG within 2,500 m from any NSR are increased; and
2. should the applicant make use of a wind turbine with a maximum SPL exceeding 112.2 dBA re 1 pW.

If the project is to be developed in the future, the final layout and sound power emission levels of the selected WTG **<u>must</u>** be re-accessed to ensure the noise levels are less than 45 dBA at verified NSR (if the applicant changed the layout or the WTG as assessed in this report).

- WTG 2 further than 2,500m from NSR04.

To ensure that noise does not become an issue for future residents, landowners or the local communities, it is recommended that the applicant get written agreement from current landowners/community leaders that no new residential dwellings will be developed within areas enveloped by the 42dBA noise level contour (of the Koup 1 WEF). Dwellings and structures located within the 45dBA noise rating level contour should not be used for permanent residential activities.



Signature
Morné de Jager
2023 – 06 – 26

Report should be sited as:

De Jager, M (2023). "*Comparative Environmental Noise Impact Assessment for the proposed Koup 1 Wind Energy Facility and associated Infrastructure south of Beaufort-west, Western Cape Province*", Enviro-Acoustic Research cc, Pretoria

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Date:

June 2023

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GLOSSARY OF ABBREVIATIONS

AESAG	Acciona Energy South Africa Global
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BA	Basic Assessment
BESS	Battery Energy Storage System
DEM	Digital Elevation Model
DFFE	Department of Forestry, Fisheries and the Environment
EAP	Environmental Assessment Practitioner
EARES	Enviro Acoustic Research cc
ECA	Environment Conservation Act
ECO	Environmental Control Officer
EGI	Electrical Grid Infrastructure
EHS	Environmental Health and Safety
EMPr	Environmental Management Programme
ENIA	Environmental Noise Impact Assessment

ENM	Environmental Noise Monitoring
ENPAT	Environmental Potential Atlas for South Africa
ETSU	Energy Technology Support Unit
EPs	Equator Principles
EPFIs	Equator Principles Financial Institutions
FEL	Front-end Loader
GN	Government Notice
GNR	Government Notice Regulation
HNI	House Not Inhabited
I&APs	Interested and Affected Parties
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Organization for Standardization
LAN	Local Authority Notice
METI	Ministry of Economy, Trade, and Industry
MTS	Main Transmission Substation
NA	No Access
NASA	National Aeronautical and Space Administration
NEMA	National Environmental Management Act
NCR	Noise Control Regulations
NSR	Noise-sensitive Receptor
PFA	Project Focus Area
PPP	Public Participation Process
SABS	South African Bureau of Standards
SANS	South African National Standards
SPL	Sound Power Emission Level (or Sound Power Level)
SR	Significance Rating
TLB	Tractor-Loader-Backhoe (also referred to as a backhoe)
UTM	Universal Transverse Mercator
WHO	World Health Organization
WEF	Wind Energy Facility
WF	Wind Farm
WIN	Wind Induced Noises
WTG	Wind Turbine Generator
WTN	Wind Turbine Noise

GLOSSARY OF UNITS

^oC	Degrees Celsius (measurement of temperature)
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)
pW	pico Watt (10^{-12}) (measurement of power – sound power in air)
μPa	Micro pascal (measurement of pressure – in air in this document)

1 CHECKLIST: GG43110 MINIMUM REQUIREMENTS

The National Web based Environmental Screening Tool[2] was used to screen the proposed site for the noise environmental sensitivity as per the requirements of GNR320 (20 March 2020), considering the site location illustrated in **Figure 2-1**.

The site report generated by the Screening Tool highlighted that a Noise Impact Assessment must be completed and appended to the Environmental Authorization (EA) documentation.

The screening report was developed for *Utilities Infrastructure => Electricity => Generation => Renewable => Wind* category, with the noise sensitive areas illustrated on **Figure 2-3**. The areas defined to have a potential "**very high**" sensitivity to noise were downloaded as a layer from the online screening tool.

In terms of GNR320 (20 March 2020), a Noise Study must contain, as a minimum, the following information:

Clause	Requirement	Comment / Reference
2.3.1	Current ambient sound levels recorded at relevant locations over a minimum of two nights and that provide a representative measurement of the ambient noise climate, with each sample being a minimum of ten minutes and taken at two different times of the night on each night, in order to record typical ambient sound levels at these different times of night	Sections 4.1 and 4.3
2.3.2	Records of the approximate wind speed at the time of the measurement	Section 4.3, Figure 4-33
2.3.3	Mapped distance of the receiver from the proposed development that is the noise source	Section 2.4.6 and 9
2.3.4	Discussion on temporal aspects of baseline ambient conditions	Section 4.1
2.4.1	Characterization and determination of noise emissions from the noise source, where characterization could include types of noise, frequency, content, vibration and temporal aspects	Table 5-2, Table 5-3 and Table 5-1
2.4.2	Projected total noise levels and changes in noise levels as a result of the construction, commissioning and operation of the proposed	Section 9

[2] https://screening.environment.gov.za/screeningtool/#/pages/welcome

	development for the nearest receptors using industry accepted models and forecasts	
2.5.1	Contact details of the environmental assessment practitioner or noise specialist, their relevant qualifications and expertise in preparing the statement, and a curriculum vitae	Appendix A
2.5.2	a signed statement of independence by the environmental assessment practitioner or noise specialist.	Appendix C
2.5.3	The duration and date of the site inspection and the relevance of the season and weather condition to the outcome of the assessment	See section 4
2.5.4	A description of the methodology used to undertake the on-site assessment, inclusive of the equipment and models used, as relevant, together with the results of the noise assessment	See section 4.1
2.5.5	a map showing the proposed development footprint (including supporting infrastructure) overlaid on the noise sensitivity map generated by the screening tool	See Figure 2-1
2.5.6	confirmation that all reasonable measures have been taken through micro- siting to minimize disturbance to receptors	Site development limited to wind resource
2.5.7	a substantiated statement from the specialist on the acceptability, or not, of the proposed development and a recommendation on the approval, or not, of the proposed development	See section 13
2.5.8	any conditions to which this statement is subjected	See section 8.6
2.5.9	the assessment must identify alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered	Site development limited to the location of the wind resource
2.5.10	A motivation must be provided if there were development footprints identified as per paragraph 2.5.9 above that were identified as having a "low" noise sensitivity and that were not considered appropriate	Site development limited to the location of the wind resource
2.5.11	where required, proposed impact management outcomes, mitigation measures for noise emissions during the construction and commissioning phases that may be of relative short duration, or any monitoring requirements for inclusion in the Environmental Management Programme (EMPr), and	See section 11
2.5.12	a description of the assumptions made and any uncertainties or gaps in knowledge or data as well as a statement of the timing and intensity of site inspection observations	See section 8

2 INTRODUCTION

2.1 INTRODUCTION AND PURPOSE

Enviro-Acoustic Research cc was commissioned by the ARCUS Consulting South Africa SA (Pty) Ltd ("ARCUS") to reassess the potential noise impact from the construction and operation of the proposed Koup 1 Wind Energy Facility ("WEF") and associated infrastructure on the surrounding area.

The developer is proposing a number of changes to the WEF and it was requested to review the potential change in the noise impact and whether it would result in a change in the findings and recommendations of the previous ENIA. Potential changes would include:

- A change in the Wind Turbine Generator ("WTG") layout; and
- A change in the potential WTG.

This is a comprehensive, stand-alone report which describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the WF may have on the surrounding environment, highlighting the methods used, potential issues identified, findings and recommendations.

This study considered local regulations and both local and international guidelines, using the terms of reference ("ToR") as proposed by SANS 10328:2008 for a comprehensive Environmental Noise Impact Assessment ("ENIA") and as proposed by the requirements specified in the Assessment Protocol for Noise that were published on 20 March 2020, in Government Gazette 43110, GN 320. The study also considers the noise limits as proposed by the International Finance Corporation ("IFC") which is based on studies completed by the World Health Organization ("WHO").

2.2 BRIEF PROJECT DESCRIPTION

The authorized Koup 1 WEF is located approximately 55 km south of Beaufort West in the Western Cape Province. The regional location of the project focus area ("PFA") is presented in **Figure 2-1**.

The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line. The project propose a Battery Energy Storage System ("BESS"), located next to the onsite substation. The WEF will include the following infrastructure:

- Up to twenty-eight (28) WTG, each with a hub height of up to 200m, a rotor diameter of up to approximately 200m with a maximum generating capacity of 10MW;
- Permanent compacted hardstand areas / platforms (also known as crane pads) per turbine during construction and for on-going maintenance purposes;
- Electrical transformers (690V/33kV) adjacent to each wind turbine (typical footprint of up to approximately 2m x 2m) to step up the voltage to 11-33kV;
- Associated infrastructure of approximately 25ha which includes:
    - One (1) Independent Power Producer on-site substation including associated equipment and infrastructure.
    - A Battery Energy Storage System ("BESS"), to be located next to the onsite substation. The storage capacity and type of technology would be determined at a later stage during the development phase, but most likely comprise an array of containers, outdoor cabinets and/or storage tanks.
    - One (1) construction laydown / staging area.
    - Operation and Maintenance ("O&M") buildings, including offices, a guard house, operational control centre, O&M area / warehouse / workshop and ablution facilities (to be located on the site identified for the substation).
    - The wind turbines will be connected to the proposed substation via medium voltage (11-33kV) underground cabling and overhead power lines.
    - Internal roads to access the wind turbines. Existing site roads will be used wherever possible, although new site roads will be constructed where necessary.

2.3 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 applicant has been evaluating several turbine models, however the selection will only be finalized at a later stage once a most optimal wind turbine is identified (factors such as meteorological data, price and financing options, guarantees and maintenance costs, etc. must be considered).

The applicant indicated that they are considering a number of different wind turbines, however, due to various reasons, a developer does not want to reveal the actual WTG that they may consider, whether for commercial/economic reasons, possible Non-Disclosure Agreements etc. As the noise propagation modelling requires the details of a wind turbine, the applicant requested that the assessment considers a potential worst-case scenario, using a WTG with a maximum sound power emission level ("SPL") of 112.2 dBA (re 1 pW), as well as the SPL of a quieter WTG with an SPL of 107.1 dBA (re 1 pW).

It is important to note that the exact details of the actual WTG are irrelevant to noise analysis, as the major factors that determine the noise levels are:

- The layout of the WEF (which would include the number of WTG as well as the distance from various receptors); and
- The sound power emission levels ("SPL") of the WTG (or noise source) selected/that the developer is considering.

Minor factors in the noise levels are:

- The spectral characteristics of the WTG;
- Temperature and Humidity;
- Noise abatement technologies implemented by the manufacturer;
- Topography and wind shear effects;
- The hub height of the WTG nacelle (the declared SPL level already include this factor, modelling using different hub height than the level specified by the manufacturer does have a slight influence on the calculated noise levels at a receptor location);
- Ground surface characteristics.

Factors that do influence SPL are:

- The rotor diameter of the WTG (the declared SPL level already include this factor);
- The manufacture of the WTG, the model name or number (the declared SPL level already include this factor).

The sound power emission levels are provided by the manufacturer either as the apparent SPL, maximum warranted SPL, a calculated SPL (for new WTG where the noise levels were not previously measured) or measured sound power levels as reported in terms of IEC 61400-11 or IEC 61400-14. It is unique for each make and model and the sound power levels already include the effect of the hub height, rotor diameter and abatement technologies.

There are smaller WTG with higher SPL, with larger WTG with a lower SPL. Therefore, the generating capacity, hub height or rotor diameter of the potential WTG should not be used to assume the noise levels.

Therefore, due to these factors, the total generating capacity of the WEF project may be less or more, when considering the individual generating capacity of the WTG (used for this noise specialist study) as well as the number of WTG in the layout. This however will not influence the findings of this noise specialist study.

2.4 STUDY AREA

The proposed Koup 1 WEF and associated infrastructure will be located within the Beaufort West Local Municipality, in the Central Karoo District Municipality, Western Cape Province. A project focus area ("PFA") was defined up to 2,000m from the WTG of the WEF, with the PFA further described in terms of environmental components that may contribute to or change the sound character in the area.

2.4.1 Topography

The Environmental Potential Atlas of South Africa (van Riet, 1998) [**141**] describes the topography as mainly *"extremely irregular plains"* within the PFA. The proposed WTG will be situated at approximately 950 – 1,050 meters above sea level ("mamsl"). There are little natural features that could act as noise barriers considering practical distances at which sound from a WTG may propagate.

2.4.2 Surrounding Land Use

Land use is mostly agricultural activities (game and sheep farming) and wilderness areas (including eco-tourism). 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.

2.4.3 Transportation Networks

The N12 pass the proposed WEF on the east (see **Figure 2-2**), though traffic on this road is low and will not influence ambient sound levels within the PFA. There are a number of small access roads leading from the N12, mainly to serve the farmers in the area. Traffic volumes on the small access roads are low and will be of no acoustical significance.

2.4.4 Other industries and mines

Based on a desktop assessment as well as information gained during the site visits, there are no industries and mines located within the PFA that would impact on the ambient sound levels in the area.

2.4.5 Ground conditions and vegetation

The area falls within the Nama Karoo biome (van Riet, 1998) [**141**] with most of the area well vegetated.

Taking into consideration available information it is the opinion of the author that the ground conditions (when considering acoustic propagation on a ground surface) can be classified as medium. 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. For modelling purposes, a ground surface factor of:

- 50% medium-hard ground (ground surface slightly acoustically absorbent) for modelling purposes for the construction phase.
- 75% hard ground (which implies that it is not very acoustically absorbent) used for the operational phase for modelling purposes (as recommended by the Institute of Acoustics ("IOA"), 2013) [**65**] for wind projects.

2.4.6 Potential Noise-sensitive Receptors

Potential noise-sensitive developments, receptors and communities ("NSR") were identified using tools such as Google Earth® up to a distance of 2,000m (recommendation SANS 10328:2008) from WTG locations. The statuses of these structures (see also **Figure 2-2**) were verified during the site visit in June 2021, with a list of the closest NSR presented in **Appendix F, Table 1**.

Also indicated on **Figure 2-2** are generalized 500, 1 000 and 2 000 m buffer zones. Generally, noises from wind turbines:

- could be significant within 500 m, with receptors[3] staying within 500 m from operational WTG subject to noises at a potentially sufficient level to be considered disturbing;
- are normally limited to a distance of approximately 1,000m from operational wind turbines (subject to WTG layout, as the WTG cumulatively contribute to noise levels with 2,000m from WTG). Night-time ambient sound levels could be elevated and the potential noise impact measurable; and
- likely to be audible up to a distance of 2,000m at night. Noises from the WTG are of a low concern at distances greater than 2,000m, although the sound of the WTGs may be audible at greater distances during certain metrological phenomena (sound levels are generally very low at distances greater than 2,000m).

[3] Depending on the layout as well as the specific sound power emission levels of the selected wind turbine.

2.5 ENVIRONMENTAL SENSITIVITY – NOISE THEME

The project site was assessed in terms of the Noise Sensitivity Theme using the online Environmental Screening Tool[4].

Potential noise-sensitive areas with a "very high" sensitivity were obtained from the online screening tool using the *Utilities Infrastructure => Electricity => Generation => Renewable => Wind* category, with the potential noise-sensitive areas illustrated on **Figure 2-3**. The screening report generated for the category *Utilities Infrastructure => Electricity => Generation => Renewable => Wind* does stipulate:

- that a Noise Specialist Study should be appended to the EIA, and
- that the GNR320 Assessment Protocol be followed when doing the noise impact assessment.

2.6 COMMENTS RECEIVED DURING THE EIA

The author is not aware of any comments raised by the authorities or interested and affected parties at the date this report was compiled.

2.7 TERMS OF REFERENCE

This assessment considers the requirements of GNR320 of 2020 (see **sub-section 2.7.1**) as well as SANS 10328:2008 (see **sub-section 2.7.2**).

2.7.1 Requirements as per Government Gazette 43110 of March 2020

The Department of Forestry, Fisheries and Environment ("DFFE") also promulgated Regulation 320, dated 20 March 2020 as published in Government Gazette No. 43110. The Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation would be applicable to this project.

This regulation defines the requirements for undertaking a site sensitivity verification, specialist assessment and the minimum report content requirements for environmental impact where a specialist assessment is required but no protocol has been prescribed. It requires that the current land use be considered using the national web based environmental

[4] https://screening.environment.gov.za/screeningtool/#/pages/welcome

screening tool to confirm the site sensitivity available at: https://screening.environment.gov.za.

If an applicant intending to undertake an activity identified in the scope of this protocol for which a specialist assessment has been identified on the screening tool on a site identified as being of:

- "very high" sensitivity for noise, must submit a Noise Specialist Assessment; or
- "low" sensitivity for noise, must submit a Noise Compliance Statement.

On a site where the information gathered from the site sensitivity verification differs from the designation of "very high" sensitivity on the screening tool and it is found to be of a "low" sensitivity, a Noise Compliance Statement must be submitted.

On a site where the information gathered from the initial site sensitivity verification differs from the designation of "low" sensitivity on the screening tool and it is found to be of a "very high" sensitivity, a Noise Specialist Assessment must be submitted.

If any part of the proposed development footprint falls within an area of "very high" sensitivity, the assessment and reporting requirements prescribed for the "very high" sensitivity apply to the entire footprint excluding linear activities for which noise impacts are associated with construction activities only and the noise levels return to the current levels after the completion of construction activities, in which case a compliance statement applies. In the context of this protocol, development footprint means the area on which the proposed development will take place and includes any area that will be disturbed.

The minimum requirements for a Noise Specialist Study (i.t.o. GNR 320 of 2020) are also covered in **Section 1** in the form of a checklist.

This assessment will be comprehensive and a Noise Specialist Assessment will be submitted because there may be a number of potential noise-sensitive receptors living within 2 000 m from the proposed Project.

2.7.2 Requirements as per South African National Standards ("SANS")

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

In addition, SANS 10328:2008 (Edition 3) [**116**] 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 EIA purposes. These minimum requirements are:

a) the purpose of the investigation (see **section 2.1**);
b) a brief description of the planned development or the changes that are being considered (see **section 2.2**);
c) a brief description of the existing environment including, where relevant, the topography, surface conditions and meteorological conditions during measurements (see **section 2.4 and 4**);
d) the identified noise sources together with their respective sound pressure levels or sound power levels (or both) and, where applicable, the operating cycles, the nature of sound emission, the spectral composition and the directional characteristics (see **sections 5** and **7**);
e) the identified noise sources that were not taken into account and the reasons as to why they were not investigated (see **sections 5, 7 and 8**);
f) the identified noise-sensitive developments and the noise impact on them (see **section 2.4.6, 9 and 10**);
g) where applicable, any assumptions, made with regard to any calculations or determination of source and propagation characteristics (see **section 8**);
h) an explanation, either by a brief description or by reference, of all measuring and calculation procedures that were followed, as well as any possible adjustments to existing measuring methods that had to be made, together with the results of calculations (see **section 7 and 8**);
i) an explanation, either by description or by reference, of all measuring or calculation methods (or both) that were used to determine existing and predicted rating levels, as well as other relevant information, including a statement of how the data were obtained and applied to determine the rating level for the area in question (see **section 4, 7 and 9**);
j) the location of measuring or calculating points in a sketch or on a map (see **Figure 9-4**);
k) quantification of the noise impact with, where relevant, reference to the literature consulted and the assumptions made (see **section 9**);
l) alternatives that were considered and the results of those that were investigated (see **section 10.4**);
m) a list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation (see **section 2.6**);

n) 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 (see **section 2.6**);
o) conclusions that were reached (see **section 13**);
p) proposed recommendations (see **section 13**);
q) 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 (see **section 11 and 13**); and
r) any follow-up investigation which should be conducted at completion of the project as well as at regular intervals after the commissioning of the project so as to ensure that the recommendations of this report will be maintained in the future (see **section 13**).

Figure 2-1: Regional Location of the proposed Koup 1 WEF

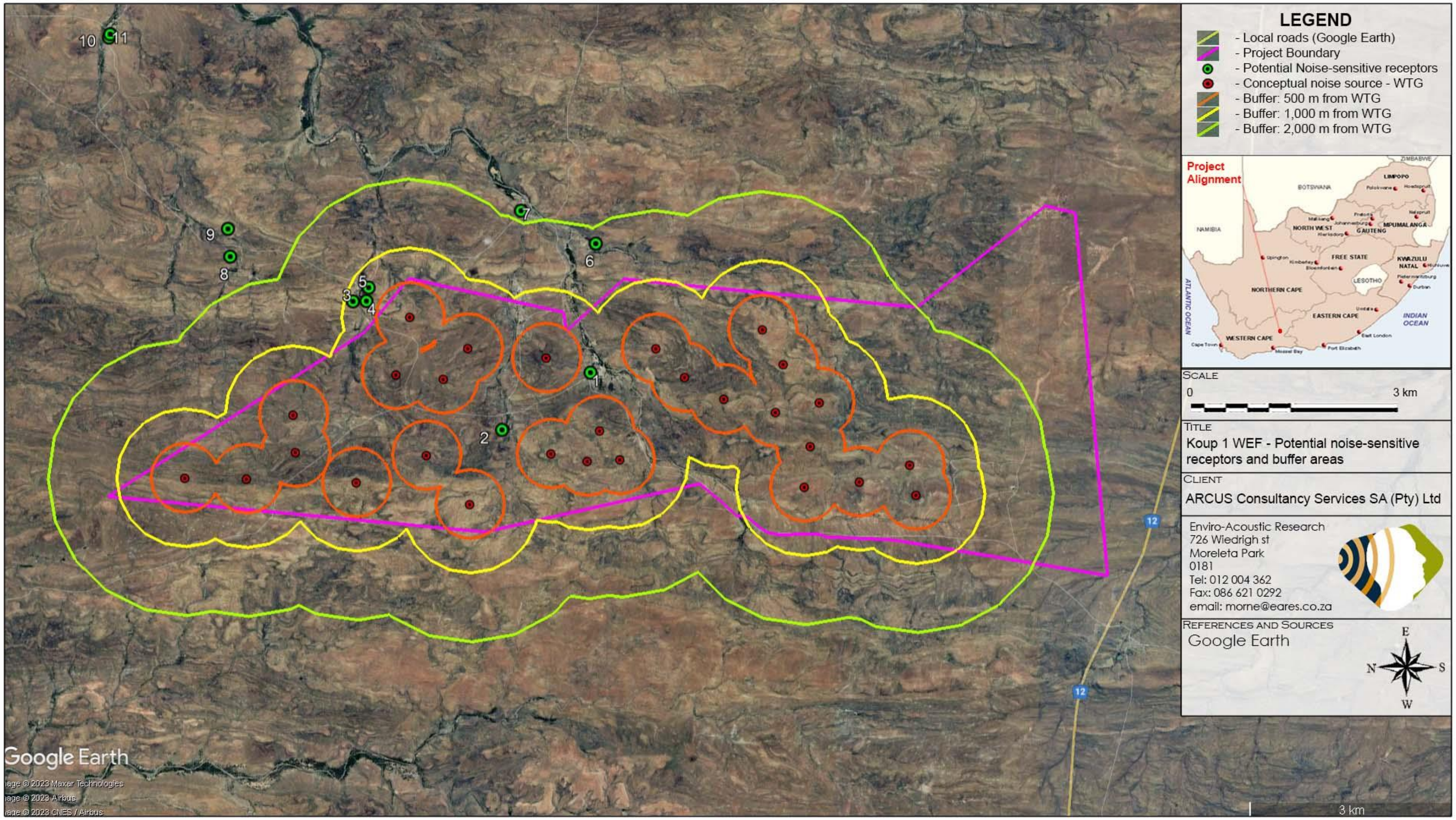

Figure 2-2: Study area and potential noise-sensitive receptors within the PFA of the Koup 1 WEF

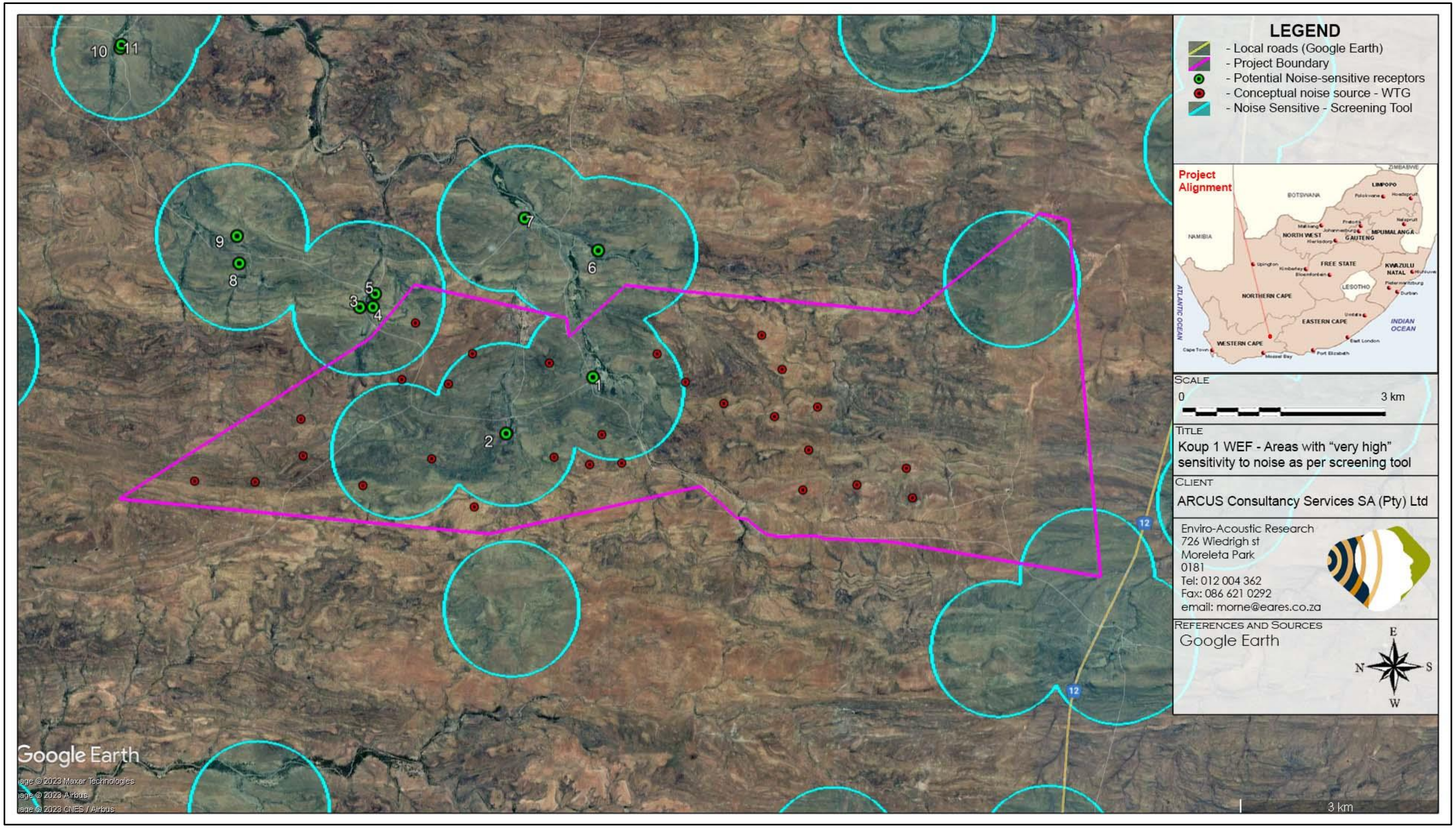

Figure 2-3: Study area and potential noise-sensitive areas identified by the online screening tool

3 LEGAL CONTEXT, POLICIES AND GUIDELINES

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

The environmental rights contained in section 24 of the Constitution provide that everyone is entitled to an environment that is not harmful to his or her well-being. In the context of noise, this requires a determination of what level of noise is harmful to well-being. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic, which has led to the development of noise standards (see **Section 3.4**).

"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.

3.2 THE ENVIRONMENT CONSERVATION ACT (ACT 73 OF 1989)

The Environment Conservation Act ("ECA") allows the Minister of Environment, Forestry and Fisheries to make regulations regarding noise, among other concerns. See also **section 3.2.1**.

3.2.1 National Noise Control Regulations (GN R154 of 1992)

The Noise Control Regulations ("NCR") were promulgated in terms of section 25 of the ECA. The NCRs were revised under Government Notice Number R. 55 of 14 January 1994 to make it obligatory for all authorities to apply the regulations.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996 legislative responsibility for administering the noise control regulations was devolved to provincial and local authorities. Provincial noise control regulations exist in the Free State, Gauteng and Western Cape provinces.

3.2.2 Western Cape Provincial Noise Control Regulations (PN 200 of 2013)

The control of noise in the Western Cape is legislated in the form of the Noise Control Regulations in terms of Section 25 of the Environment Conservation Act No. 73 of 1989, applicable to the Province of the Western Cape as Provincial Notice 200 of 20 June 2013.

The regulations define:

- "**ambient noise**" means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes".

- "**disturbing noise**" means a noise, excluding the unamplified human voice, which—
- *(a)* exceeds the rating level by 7 dBA;
- *(b)* exceeds the residual noise level where the residual noise level is higher than the rating level;
- *(c)* exceeds the residual noise level by 3 dBA where the residual noise level is lower than the rating level; or
- *(d)* in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103;

- **''noise sensitive activity''** means any activity that could be negatively impacted by noise, including residential, healthcare, educational or religious activities;

- **''low-frequency noise''** means sound which contains sound energy at frequencies predominantly below 100 Hz;

- **''rating level''** means the applicable outdoor equivalent continuous rating level indicated in Table 2 of SANS 10103;

- **''residual noise''** means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise. In this report the term ambient sound level (instead of Residual Noise) will be used, as defined in the National Noise Control Regulations;

- **"sound level''** means the equivalent continuous rating level as defined in SANS 10103, taking into account impulse, tone and night-time corrections;

- These Regulations prohibits anyone from causing a disturbing noise (Clause 2) and uses the $L_{Aeq,impulse}$ descriptor to define ambient sound and noise levels.

Also, in terms of regulation 4:

(1) The local authority, or any other authority responsible for considering an application for a building plan approval, business license approval, planning approval or environmental authorisation, may instruct the applicant to conduct and submit, as part of the application—

(a) a noise impact assessment in accordance with SANS 10328 to establish whether the noise impact rating of the proposed land use or activity exceeds the appropriate rating level for a particular district as indicated in SANS 10103; or

(b) where the noise level measurements cannot be determined, an assessment, to the satisfaction of the local authority, of the noise level of the proposed land use or activity.

(2) *(a)* A person may not construct, erect, upgrade, change the use of or expand any building that will house a noise-sensitive activity in a predominantly commercial or industrial area, unless he or she insulates the building sufficiently against external noise so that the sound levels inside the building will not exceed the appropriate maximum rating levels for indoor ambient noise specified in SANS 10103.

(b) The owner of a building referred to in paragraph *(a)* must inform prospective tenants or buyers in writing of the extent to which the insulation measures contemplated in that paragraph will mitigate noise impact during the normal use of the building.

(c) Paragraph *(a)* does not apply when the use of the building is not changed.

(3) Where the results of an assessment undertaken in terms of sub regulation (1) indicate that the applicable noise rating levels referred to in that sub regulation will likely be exceeded, or will not be exceeded but will likely exceed the existing residual noise levels by 5 dBA or more—

(a) the applicant must provide a noise management plan, clearly specifying appropriate mitigation measures to the satisfaction of the local authority, before the application is decided; and

(b) implementation of those mitigation measures may be imposed as a condition of approval of the application.

(4) Where an applicant has not implemented the noise management plan as contemplated in sub regulation (3), the local authority may instruct the applicant in writing to—

(a) cease any activity that does not comply with that plan; or

(b) reduce the noise levels to an acceptable level to the satisfaction of the local authority.

3.3 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 any facility to prevent noise pollution occurring. NEMA sets out measures, which may be regarded as reasonable. They include the following 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 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 the pollution or degradation
5. to eliminate any source of the pollution or degradation
6. to remedy the effects of the pollution or degradation

In addition, a number of regulations have been promulgated as Regulation 982 of December 2014 (Government Notice 38282) in terms of this Act. It defines minimum information requirements for specialist reports, with Government Gazette ("GG") 43110 (20 March 2020) updating the minimum requirements for reporting, with this protocol referred as GNR320 of 2020.

GNR320 prescribe general requirements for undertaking site sensitivity verification and for protocols for the assessment and minimum report content requirements of environmental impacts for environmental themes for activities requiring environmental authorisation. These protocols were promulgated in terms of sections 24(5)(a), (h) and 44 of the NEMA.

When the requirements of a protocol apply, the requirements of Appendix 6 of the Environmental Impact Assessment Regulations, as amended, (EIA Regulations), promulgated under sections 24(5) and 44 of the NEMA are replaced by these requirements.

3.4 NOISE STANDARDS

There are a few South African scientific standards ("SABS") relevant to noise from developments, industry and roads. They are:

- SANS 10103:2008. 'The measurement and rating of environmental noise with respect to annoyance and to speech communication' [**113**].
- SANS 10210:2004. 'Calculating and predicting road traffic noise' [**115**].
- SANS 10328:2008. 'Methods for environmental noise impact assessments' [**116**].
- SANS 10357:2004. 'The calculation of sound propagation by the Concave method' [**117**].

- SANS 10181:2003. 'The Measurement of Noise Emitted by Road Vehicles when Stationary' [**114**].

The relevant standards use the equivalent continuous rating level (calculated from the sound pressure levels over the reference time, see **Appendix A**) 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. With regards to SANS 10103:2008, the recommendations are likely to inform decisions by authorities, but non-compliance with the standard will not necessarily render an activity unlawful *per se.*

3.5 INTERNATIONAL GUIDELINES

While a number of international guidelines and standards exists, those selected below are used by numerous countries for environmental noise management.

3.5.1 Guidelines for Community Noise (WHO, 1999) [146]

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 [**146**]. It is based on the document entitled "Community Noise" that was prepared for the WHO and published in 1995 by the Stockholm University and Karolinska Institute.

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

- Interference with communication, noise-induced hearing impairment, sleep disturbance effects, cardiovascular and psychophysiological effects, mental health effects, effects on performance, annoyance responses and effects on social behavior.

It further discusses how noise can affect (and propose guideline noise levels) specific environments such as residential dwellings, schools, preschools, hospitals, ceremonies, festivals and entertainment events, sounds through headphones, impulsive sounds from toys, fireworks and firearms, and parklands and conservation areas.

To protect the majority of people from being affected by noise during the daytime, it proposes that sound levels at outdoor living areas should not exceed 55 dB L_{Aeq} for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the day, the outdoor sound pressure level should not exceed 50 dB L_{Aeq}. At night, equivalent sound levels at the outside façades of the living spaces should not exceed 45 dBA and 60 dBA L_{Amax} so that people may sleep with bedroom windows open. It is critical to note that this guideline requires the sound level measuring instrument to be set on the "fast" detection setting.

3.5.2 Night Noise Guidelines for Europe (WHO, 2009) [147]

Refining previous Community Noise Guidelines issued in 1999, and incorporating more recent research, the WHO has released a comprehensive report on the health effects of night time noise, along with new (non-mandatory) guidelines for use in Europe (WHO, 2009) [**147**]. Rather than a maximum of 30 dB inside at night (which equals 45-50 dB max outside), the WHO now recommends a maximum year-round outside night-time noise average of 40 db to avoid sleep disturbance and its related health effects. The report notes that only below 30 dB (outside annual average) are "*no significant biological effects observed*," and that between 30 and 40 dB, several effects are observed, with the chronically ill and children being more susceptible; however, "*even in the worst cases the effects seem modest*." Elsewhere, the report states more definitively, "*There is no sufficient evidence that the biological effects observed at the level below 40 dB (night, outside) are harmful to health*." At levels over 40 dB "*Adverse health effects are observed*" and "*many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected*."

The 184-page report offers a comprehensive overview of research into the various effects of noise on sleep quality and health (including the health effects of non-waking sleep arousal), and is recommended reading for anyone working with noise issues. The use of an outdoor noise standard is in part designed to acknowledge that people do prefer to leave windows open when sleeping, though the year-long average may be difficult to obtain (it would require longer-term sound monitoring than is usually budgeted for by either industry or neighbourhood groups).

While recommending the use of the average level, the report notes that some instantaneous effects occur in relation to specific maximum noise levels, but that the health effects of these "cannot be easily established."

3.5.3 The Assessment and Rating of Noise from Wind Farms (Energy Technology Support Unit, 1997)

This report describes the findings of a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry (ETSU, 1997) [**42**]. It was developed as an Energy Technology Support Unit[5] ("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 are more appropriate;
2. $L_{A90,10mins}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels;
3. The effects of other wind turbines in a given area[6] should be added to the effect of any proposed Wind Farm ("WF"), to calculate the cumulative effect;
4. Noise from a WF should be restricted to no more than 5 dBA above the current ambient noise level at a Noise Sensitive Receptor(s) ("NSR"). Ambient noise levels are 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 35 dBA to 40 dBA (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 NSR has financial investments in the WF; and
6. A penalty system should be implemented for wind turbine/s that operates with a tonal characteristic.

While this guideline may be 25 years old, planning policy in England, Scotland, Wales and Northern Ireland still refer to the ETSU-R97 for guidance on the assessment of wind turbine noise (Cooper, 2020) [**22**], (EPA, 2011) [**41**], (IOA, 2013) [**65**], (The Scottish Government, 2011) [**131**], (UK Department for Communities and Local Government, 2013) [**134**]. In Australia and New Zealand, ETSU-R-97 has been adopted as the base assessment method of assessment (Cooper, 2020) [**22**], (EPA, 2009) [**40**]. The ETSU-R97 is referenced in

[5] 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.

[6] Though the area has not been defined, it is the opinion of the author that this would be withing the potential area of effect, defined as 2,000m in SANS 10328:2008. Considering that WTG from two adjacent WEFs may have a slight influence at 2,000m, this area typically would be a maximum of 4,000m from two or more WEFs

NARUC (2011) [**89**] as well as the recommended method in IFC (2015) [**64**]. Because of its international importance, the methodologies used in the ETSU R97 document will be considered in this report for implementation should projected noise levels (from the proposed WFs at NSR) exceed the zone sound levels as recommended by SANS 10103:2008.

3.5.4 Noise Guidelines for Wind Farms (MoE, 2008) [87]

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 ECA 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 3-1**[7]
- 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;
    - Prediction methods to be used (ISO 9613-2);
    - Cumulative impact assessment requirements;
    - It also defines specific model input parameters;
    - Methods on how the results must be presented; and
    - Assessment of Compliance (defining magnitude of noise levels).

Table 3-1: 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 a WF), this criterion will be considered during the determination of the significance of the noise impact.

[7]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

3.5.5 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 Equator Principles were developed by private sector banks and were launched in June 2003. Revision III of the EPs has been in place since June 2013. As of March 2021, 116 financial institutions in 37 countries have officially adopted the Equator Principles, covering the majority of international project finance debt in emerging and developed markets.

The participating banks chose to model the Equator Principles on the environmental standards of the World Bank (1999) and the social policies of the International Finance Corporation ("IFC"). As of beginning 2022:

- More than 90 banks and financial institutions have voluntarily adopted the Equator Principles, which are based on IFC's Performance Standards[8].
- 32 export credit agencies of the Organization of Economic Co-operation and Development countries benchmark private sector projects against IFC's Performance Standards.
- The Multilateral Investment Guarantee Agency applies IFC's Performance Standards in its operations.
- The World Bank applies IFC's Performance Standards (known as World Bank Performance Standards) to projects supported by International Bank for Reconstruction and Development ("IBRD") and the International Development Association ("IDA") that are owned, constructed and/or operated by the private sector.

3.5.6 IFC: General EHS Guidelines – Environmental Noise Management [63]

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

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8 https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/performance-standards

Document 1.7[9] of the IFC: General EHS Guidelines states that noise prevention and mitigation measures should be applied where predicted or measured noise impacts from project facilities/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 source. It goes as far as to proposed 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 minimize 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 3-2**) and highlights certain monitoring requirements pre- and post-development. It adds another criterion in that the existing background ambient noise level should not rise by more than 3 dBA. This criterion will effectively sterilize large areas of any development. Therefore, it is EARE's considered opinion that this criterion was introduced to address cases where the existing ambient noise level is already at, or in excess of the recommended limits.

9 https://www.ifc.org/wps/wcm/connect/4a4db1c5-ee97-43ba-99dd-8b120b22ea32/1-7%2BNoise.pdf?MOD=AJPERES&CVID=nPtgwZY

Table 3-2: 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 $L_{Aeq,1hr}$ noise descriptors to define noise levels. It does not determine the detection period, but refers to the IEC standards, which requires the fast detector setting on the Sound Level Meter during measurements in Europe.

3.5.7 European Parliament Directive 2000/14/EC [36]

Directive 2000/14/EC relating to the noise emission in the environment by equipment for use outdoors was adopted by the European Parliament and the Council and first published in May 2000 and applied from 3 January 2002. The directive placed sound power limits on equipment to be used outdoors in a suburban or urban setting. Failure to comply with these regulations may result in products being prohibited from being placed on the EU market. Equipment list is vast and includes machinery such as compaction machineries, dozers, dumpers, excavators, etc. Manufacturers as a result started to consider noise emission levels from their products to ensure that their equipment will continue to have a market in most countries.

3.5.8 Environmental, Health, and Safety Guidelines for Wind Energy [64]

The EHS Guidelines for wind energy include information relevant to environmental, health, and safety aspects of onshore and offshore wind energy facilities. It should be applied to wind energy facilities from the earliest feasibility assessments, as well as from the time of the environmental impact assessment, and continue to be applied throughout the construction and operational phases.

It provides a brief overview of construction and operational noises, potential operational mitigation measures and a number of principles on the assessment of noise impacts, including:

- Receptors should be chosen according to their environmental sensitivity (human, livestock, or wildlife);
- Preliminary modeling should be carried out to determine whether more detailed investigation is warranted. The preliminary modeling can be as simple as assuming hemispherical propagation (i.e., the radiation of sound, in all directions, from a source point). Preliminary modeling should focus on sensitive receptors within 2,000 meters (m) of any of the turbines in a wind energy facility;

- If the preliminary model suggests that turbine noise at all sensitive receptors is likely to be below an L_{A90} of 35 dBA at a wind speed of 10 meters/second (m/s) at 10 m height during day and night times, then this preliminary modeling is likely to be sufficient to assess noise impact; otherwise it is recommended that more detailed modeling be carried out, which may include background ambient noise measurements;
- All modeling should take account of the cumulative noise from all wind energy facilities in the vicinity having the potential to increase noise levels;
- If noise criteria based on ambient noise are to be used, it is necessary to measure the background noise in the absence of any wind turbines. This should be done at one or more noise-sensitive receptors. Often the critical receptors will be those closest to the wind energy facility, but if the nearest receptor is also close to other significant noise sources, an alternative receptor may need to be chosen; and
- The background noise should be measured over a series of 10-minute intervals, using appropriate wind screens. At least five of these 10-minute measurements should be taken for each integer wind speed from cut-in speed to 12 m/s.

3.5.9 Environmental Noise Guidelines for the European Region (2018) [148]

This document identifies levels at which noise has "adverse health effects" and recommends actions to reduce exposure. Compared to previous WHO guidelines on noise, this version contains five significant developments:

- Stronger evidence of the cardiovascular and metabolic effects of environmental noise;
- Inclusion of new noise sources, namely wind turbine noise and leisure noise, in addition to noise from transportation (aircraft, rail, and road traffic);
- Use of a standardized approach to assess the evidence;
- A systematic review of evidence, defining the relationship between noise exposure and risk of adverse health outcomes;
- Use of long-term average noise exposure indicators to better predict adverse health outcomes.

The WHO (2018) considers adverse health effects in **section 2.4.3.2** of the report, dividing these effects into the following health outcomes:

- Cardiovascular disease – Ischaemic heart disease and hypertension;
- Cognitive impairment – Reading and oral comprehension;
- Permanent hearing impairment; and
- Self-reported sleep disturbance and annoyance.

While the WHO (2018) highlights that there is insufficient evidence of adverse health effects at noise levels below 40 dBA L_{night}, adverse health effects were reported at levels starting from 40 dB L_{night}. At 40 dB, about 3–4% of the population still reported being highly sleep-disturbed due to noise, which was considered relevant to health. It recommends that the guideline level should minimise adverse health effects to less than:

- 3% of the population experiencing sleep disturbances; and
- 10% of the population being highly annoyed.

This report recommends, that, for average noise exposure, the WHO Guideline Development Group conditionally recommends reducing noise levels produced by wind turbines below 45 dB L_{den}[10], as wind turbine noise above this level is associated with adverse health effects.

3.5.10 Concluding remarks on the use of International Guidelines in this Assessment

As highlighted in **section 6.4**, South African guidelines (such as SANS 10103:2008) or regulations (such as GNR.154 of 1992 or PN.200 of 213), does not cater for instances when background noise levels change due to the impact of external forces (such as the influence of increased winds). As such this report considers both local legislation, regulations and guidelines as well as international guidelines. Of the more than 340,000 WTG operation in the rest of the world (more than 2,000 wind farms[11]), less than 500 WTG are currently operational in South Africa (less than 40 wind farms[12]). The rest of the world have had experience with the effects and impacts of wind farms since 1980, South Africa since 2002.

As such, almost all the scientific articles, papers, publications and presentations available are based on the research and experiences gained from these international wind farms. Therefore, discarding the knowledge and experiences gained by the rest of the world would be irresponsible and unwise. In summary:

- The WHO Guidelines for Community Noise recommends that night-time equivalent sound levels (at the outside façades of the living spaces) not exceed 45 dBA with L_{Amax} less than 60 dBA so that people may sleep with bedroom windows open **(Section 3.5.1)**;

[10] *Day–evening–night noise level is a European standard to express noise level over an entire day. It imposes a penalty on sound levels during evening and night and it is primarily used for noise assessments of airports, busy main roads, main railway lines and in cities over 100,000 residents. This equates to a night-time equivalent noise level of approximately 38.7 dBA.*

[11] *https://gwec.net/there-are-over-341000-wind-turbines-on-the-planet-heres-how-much-of-a-difference-theyre-actually-making/*

[12] *https://sawea.org.za/wind-map/wind-ipp-table/*

- The Night Noise Guidelines for Europe revised noise levels, recommending a maximum year-round outside night-time noise average of 40 dB to avoid sleep disturbance and its related health effects **(Section 3.5.2)**;
- The ETSU-R97 guideline recommends an upper noise limit of 45 dBA for project participants, and a noise limit of 40 dBA for external parties **(Section 3.5.3)**;
- The MoE guideline propose a changing noise limit at different wind speeds for wind farm developments, varying from 40 dBA (at a wind speed of 4 m/s) to a maximum of 51 dBA (at a wind speed of 10 m's or more) **(Section 3.5.4)**;
- The environmental standards of the World Bank have been integrated into the social policies of the IFC since April 2007, with the guidelines recommending a night-time noise limit of 45 dBA **(Section 3.5.6)**;
- The European Directives does not set noise limits, but it obligate equipment manufacturers to define and indicate the sound power emission levels of their equipment. When presented with a number of equipment options, applicants can use this data to select the quietest piece of equipment, in such to minimize noise levels **(Section 3.5.7)**;
- While the IFC EHS Guidelines for Wind Energy does not stipulate specific noise limits, it does recommend the measurement of ambient sound levels at different speeds (referring to the ETSU-R97 guidelines discussed in **Section 3.5.3** should noise criteria based on ambient sound levels be used **(Section 3.5.8)**; and
- The Environmental Noise Guidelines for the European Region report recommends that, for average noise exposure, noise levels produced by wind turbines should remain below 45 dBA L_{den} (an L_{Aeq} of ± 38.7 dBA at night) **(Section 3.5.9)**.

As WTGs only operate during a period with wind speeds are elevated, a period that generally coincide with increased noise levels (due to wind-induced noises – "WIN") this report recommends an upper noise limit of 45 dBA (focusing on the night-time period), at the same time considering the international recommended levels (as further motivated in **sections 6.4.1** and **6.4.3**) and summarized in **Table 6-2**.

4 CURRENT ENVIRONMENTAL SOUND CHARACTER

4.1 INFLUENCE OF SEASON 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) [**45**] 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.

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 higher wind speeds may have an insignificant 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 is more significant during the warmer spring and summer months as various species communicate in an effort to find mates. Faunal communication is normally less during the colder months, with ambient sound levels measured during the winter period frequently being very low.
- The occurrence of temperature inversions, see **Sub Section 4.1.1**, and
- Seasonal changes in weather patterns, mainly due to increased wind speeds (also see **Sub Section 4.1.2 4.1.1**below) and potential gustiness of the wind.

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 the sub-sections below.

Ambient sound levels are generally less during the colder months (due to less faunal communication) and higher during the warmer months.

4.1.1 Effect of Temperature inversions

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, but, during certain meteorological conditions, the normal vertical temperature gradient could be inverted so that the air is colder near the surface, with a warmer layer blanketing the lower layer. This is illustrated in **Figure 4-1** below.

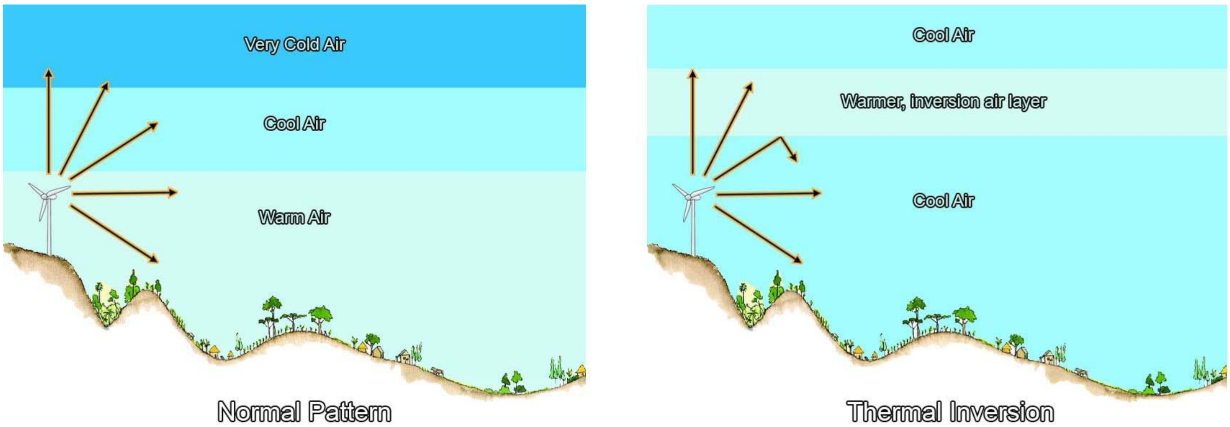

Figure 4-1: Influence of temperature inversions on the propagation of sound

When such an inversion layer is present, some of the sound waves will be refracted[13] by the temperature gradient, with the refracted sound waves returned to the ground. This effect has been noticed near airports and roads, where noises can be heard over greater distances at night than other times of day (Parnell, 2015, [**98**]; Saurenman, 2005, [**118**]), and reported by Van der Berg (2003) [**136**] for WEF noises.

Like wind gradients, temperature gradients can influence sound propagation over long distances, complicate sound level measurements as well as propagation modelling.

4.1.2 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

[13] Redirecting the wave propagation direction due to a change in the density of the air which influence the speed of sound.

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 conifers), 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).

4.1.3 Effect of Humidity and Temperature

Generally, sound propagate 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).

The effect of humidity on sound propagation is quite complex, but effectively relates to how increased humidity 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).

Together, the impact of temperature and humidity (together with air pressure - to a minor extent) are complex and highly dependent on the frequency composition of the noise. This is illustrated in **Figure 4-2**.

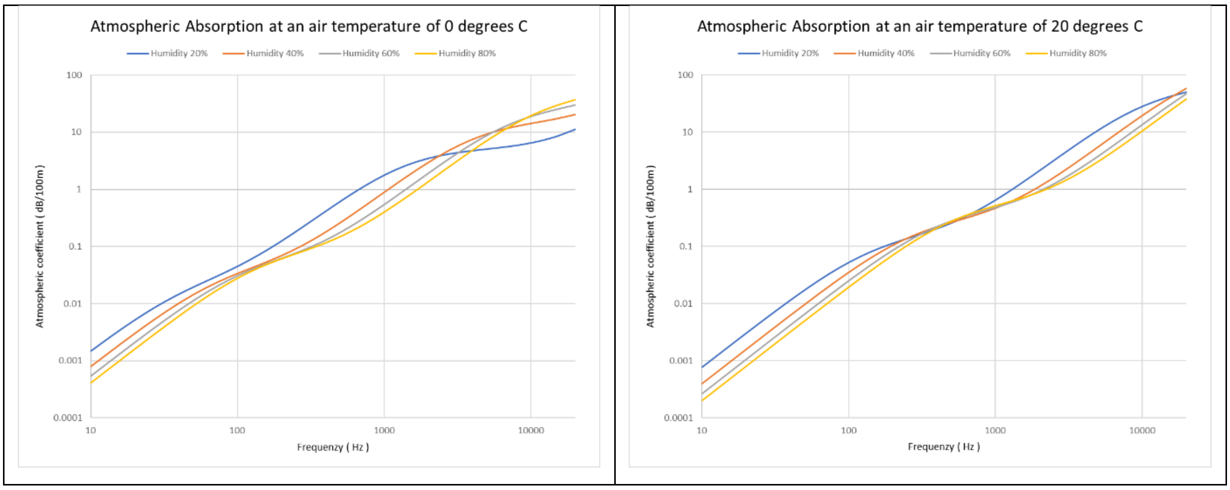

Figure 4-2: Effect of Temperature and Humidity on propagation of Sound

4.2 Temperature and Humidity Measurements

Temperature and humidity were measured during the site visit from 10 to 12 June 2021, with the average, maximum and minimum readings defined in **Table 4-1** with the various readings illustrated in **Figure 4-3**.

For the purpose of modelling, average humidity of 70% and temperatures of 10 °C at an air pressure of 950 kPA will be used (parameters ideal for the propagation of noise, the worst-case scenario).

Table 4-1: Temperature and Humidity measured onsite

	Humidity	Temperature
Day average	38.3	16.5
Night average	44.7	11.8
Day minimum	25.0	9.2
Day maximum	59.0	26.7
Night minimum	34.0	9.5
Night maximum	57.0	13.5

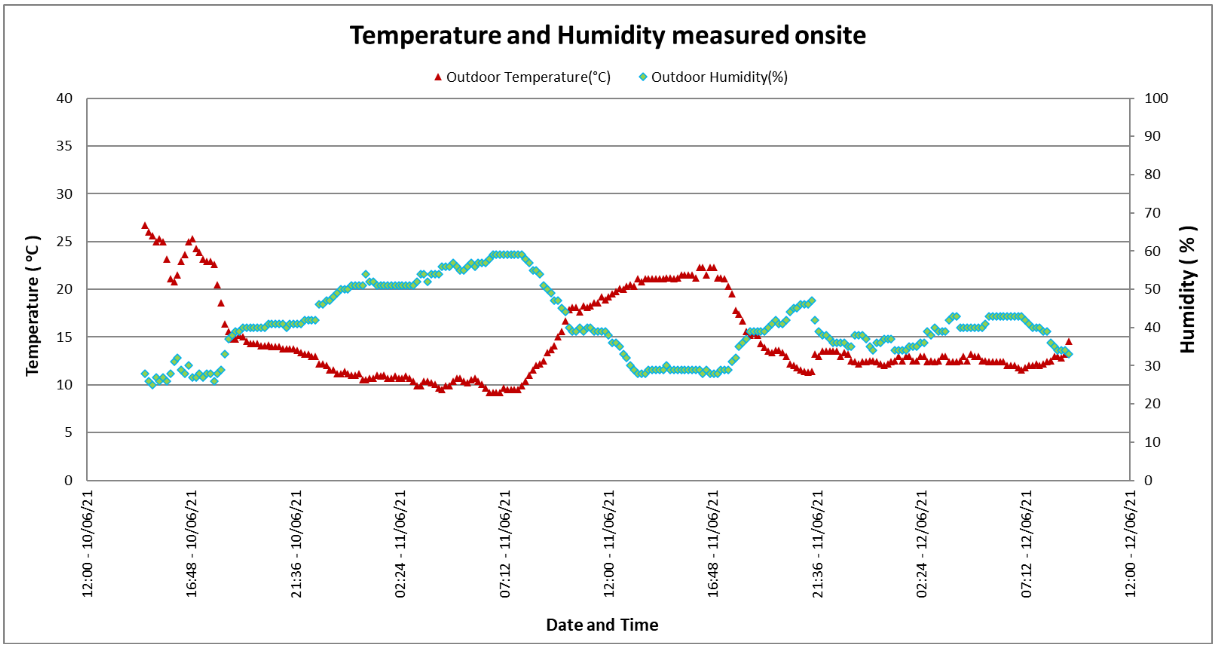

Figure 4-3: Temperature and Humidity readings measured onsite

4.3 Sound Measurements – Procedure and Data

Ambient sound levels (residual noise levels) were measured at six locations over 35 hours from the afternoon of the 10th until the morning of the 12 June 2021 in the vicinity of the project focus area. The data indicate an area where ambient sound levels were low (typical of winter periods), though it should be noted that the period coincided with very low wind speeds.

Ambient sound levels (residual noise levels) were measured in accordance with the South African National Standard ("SANS") 10103:2008 "***The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication***". Long-term measurements were done over a period of 2 nights as per the protocols defined in GG 43110.

The guidelines and protocol define the procedures, minimum equipment accuracy and time periods (in which measurements must be collected) such as:

- type of equipment (Class 1) to be used;
- minimum duration of measurement as well as time periods when measurements must take place;
- microphone positions and height above ground level;
- calibration procedures and instrument checks; and
- supplementary weather measurements and observations.

The sound levels were measured using class-1 Sound Level Meters ("SLMs") with the measurement localities presented in **Figure 4-4**. The SLMs would measure "average" sound levels over 10-minute periods, save the data and start with a new 10-minute measurement till the instrument was stopped. The SLMs were referenced at 1,000 Hz directly before and after the measurements were taken. In all cases drift was less than 1.0 dBA.

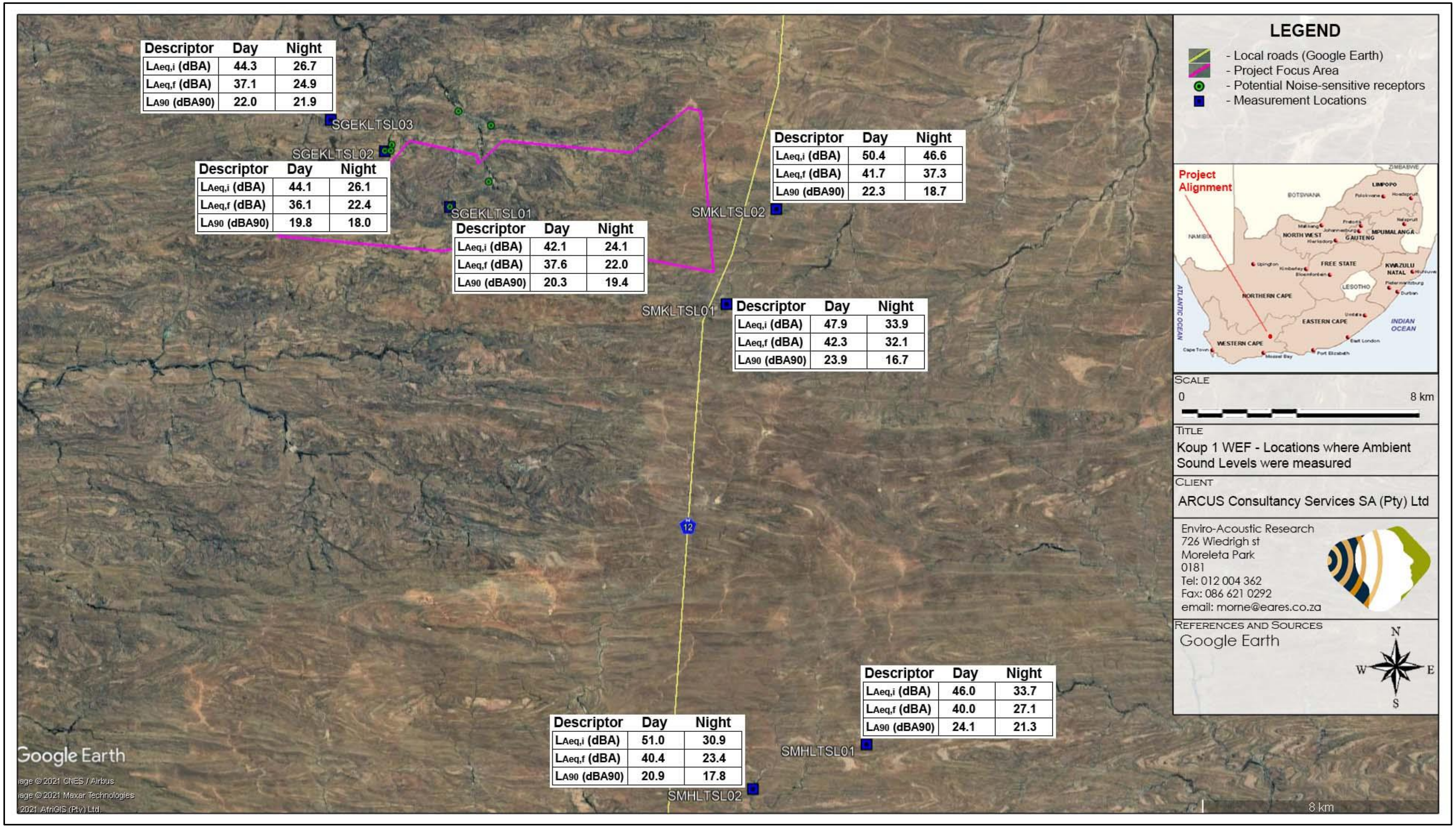

Figure 4-4: Localities where ambient sound levels were measured

4.3.1 Long-term Measurement Location SGEKLTSL01

The microphone was deployed in front of the residential dwelling, with some vegetation within 10 m of the microphone. This vegetation may increase Wind-induced Noises ("WIN") during periods of increased winds. The equipment defined in **Table 4-2** was used for gathering data with **Table 4-3** highlighting sounds heard during equipment deployment and collection. **Appendix E.1** presents photos of the measurement location.

Table 4-2: Equipment used to gather data at SGEKLTSL01

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34160	March 2021
Microphone	ACO 7052E & SV 12L	54645	March 2021
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-3: Noises/sounds heard during site visits at SGEKLTSL01

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • Barely Audible • Audible • Dominating	**During equipment deployment and collection of instrument**	
	Faunal and Natural	Bird calls dominant.
	Sounds associated with the household/ farm	-
	Industrial & transportation	-

Fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-5** and summarized in **Table 4-4** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-6**.

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.

The L_{A90} level is presented in this report to define the "background residual noise level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[14].

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-7** (night) and **Figure 4-8** (day).

Table 4-4: Sound levels considering various sound level descriptors at SGEKLTSL01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	30.4	26.1	20.3	-
Night arithmetic average	-	22.1	20.8	19.4	-
Day Equivalent Levels	-	42.1	37.6	-	-
Night Equivalent Levels	-	24.1	22.0	-	-
Day minimum	-	19.3	19.1	-	18.5
Day maximum	85.1	59.9	55.2	-	-
Night minimum	-	19.2	19.0	-	18.4
Night maximum	58.9	38.5	33.1	-	-
Day 1 equivalent	-	43.3	32.3	-	-
Night 1 Equivalent	-	24.0	22.8	-	-
Day 2 equivalent	-	36.1	29.3	-	-
Night 2 Equivalent	-	24.2	21.0	-	-
Day 3 equivalent	-	40.8	36.9	-	-

(14) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

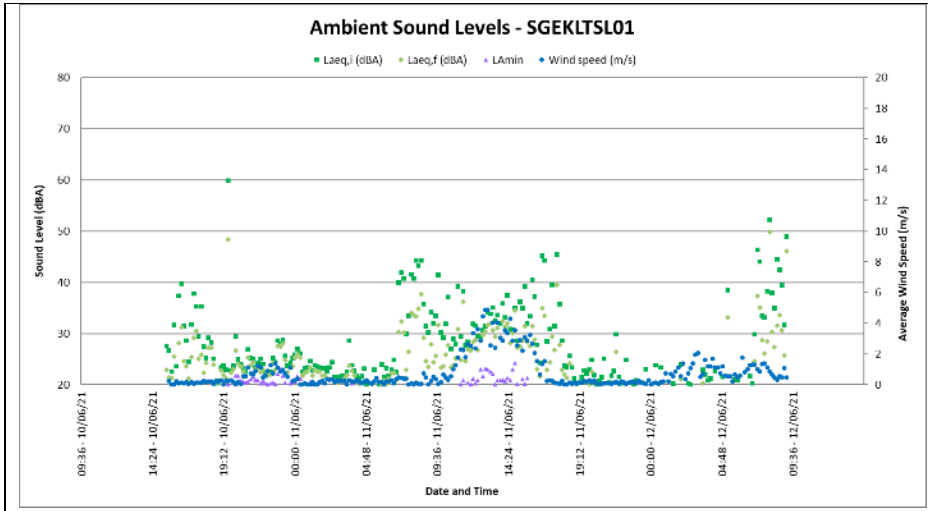

Figure 4-5: Ambient Sound Levels at SGEKLTSL01

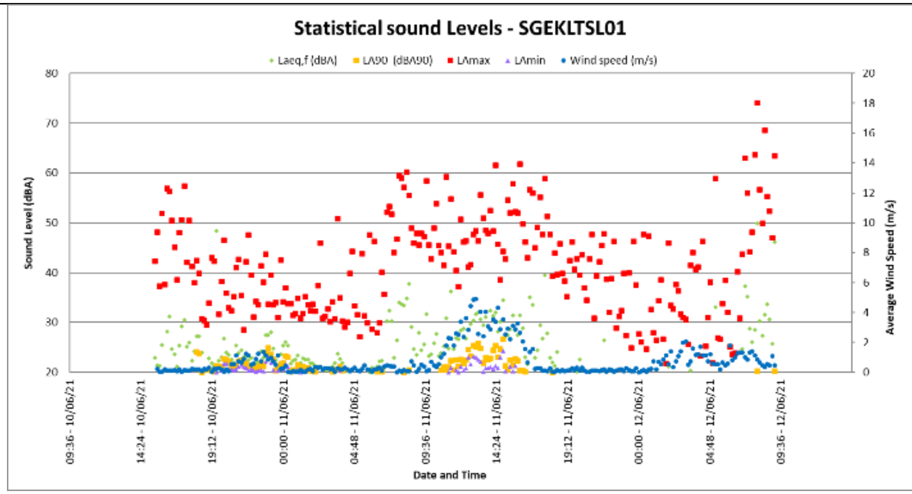

Figure 4-6: Maximum, minimum and Statistical sound levels at SGEKLTSL01

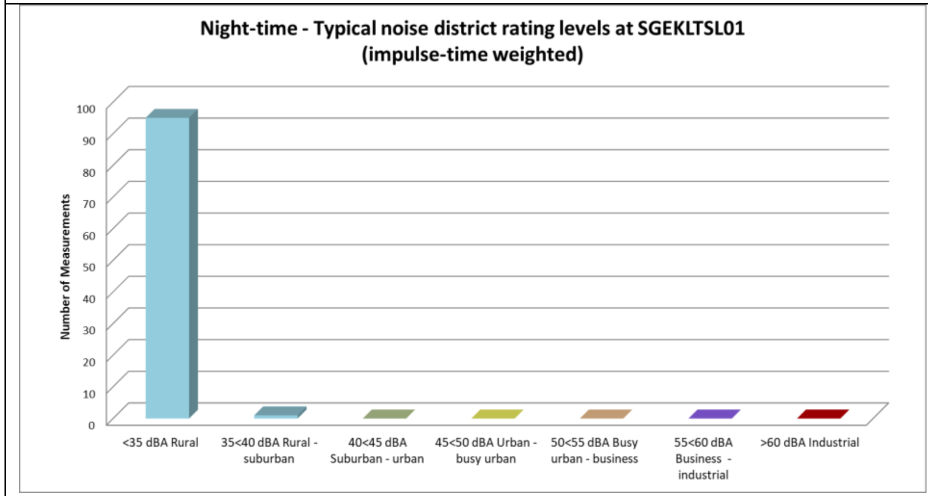

Figure 4-7: Classification of night-time measurements in typical noise districts at SGEKLTSL01

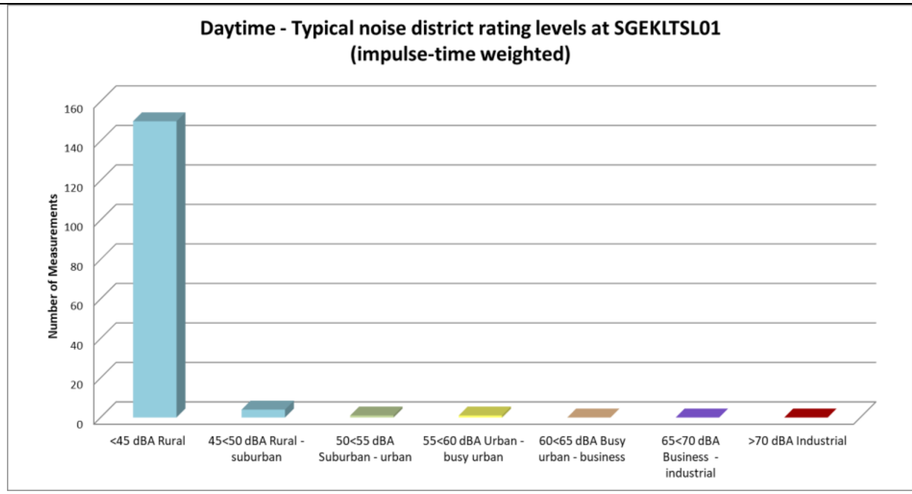

Figure 4-8: Classification of daytime measurements in typical noise districts at SGEKLTSL01

4.3.2 Long-Term Measurement Location - SGEKLTSL02

This measurement location was deployed close to a dwelling, reported to be renovated in the future for residential use. There were a significant number of large trees close to the microphone which may significantly influence WIN. The equipment defined in **Table 4-5** was used for gathering data with **Table 4-6** highlighting sounds heard during equipment deployment and collection. **Appendix E.2** presents photos of the measurement location.

Table 4-5: Equipment used to gather data at SGEKLTSL02

Equipment	Model	Serial no	Calibration Date
SLM	BSWA 308	589036	March 2020
Microphone and Pre-amplifier	MP231	570172	March 2020
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-6: Noises/sounds heard during site visits at SGEKLTSL02

<table>
<tr><th colspan="3">Noises/sounds heard during onsite investigations</th></tr>
<tr><td rowspan="4">Magnitude Scale Code:
• Barely Audible
• Audible
• Dominating</td><td colspan="2">During equipment deployment and collection of instrument</td></tr>
<tr><td>Faunal and Natural</td><td>Birds dominant.</td></tr>
<tr><td>Sounds associated with the household/ farm</td><td>Sheep audible.</td></tr>
<tr><td>Industrial & transportation</td><td>-</td></tr>
</table>

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-9** and summarized in **Table 4-7** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-10**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little

noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[15].

Table 4-7: Sound level descriptors as measured at SGEKLTSL02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	33.0	27.5	19.8	-
Night arithmetic average	-	21.8	19.5	18.0	-
Day Equivalent Levels	-	44.1	36.1	-	-
Night Equivalent Levels	-	26.1	22.4	-	-
Day minimum	-	18.5	17.4	-	16.7
Day maximum	72.1	54.4	55.2	-	-
Night minimum	-	18.1	17.1	-	16.6
Night maximum	61.7	41.6	37.3	-	-
Day 1 equivalent	-	38.8	29.3	-	-
Night 1 Equivalent	-	24.7	22.2	-	-
Day 2 equivalent	-	41.9	34.1	-	-
Night 2 Equivalent	-	27.1	22.5	-	-
Day 3 equivalent	-	40.0	31.7	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-11** (night) and **Figure 4-12** (day).

(15) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

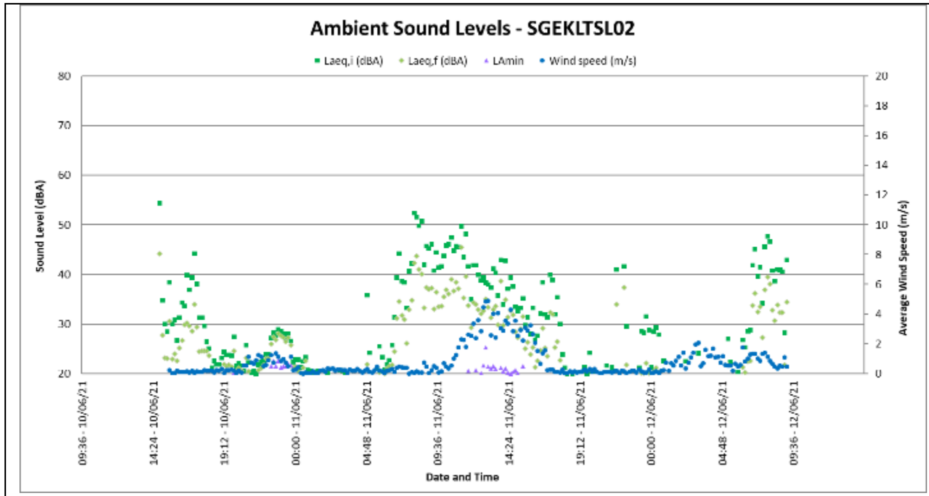

Figure 4-9: Ambient sound levels at SGEKLTSL02

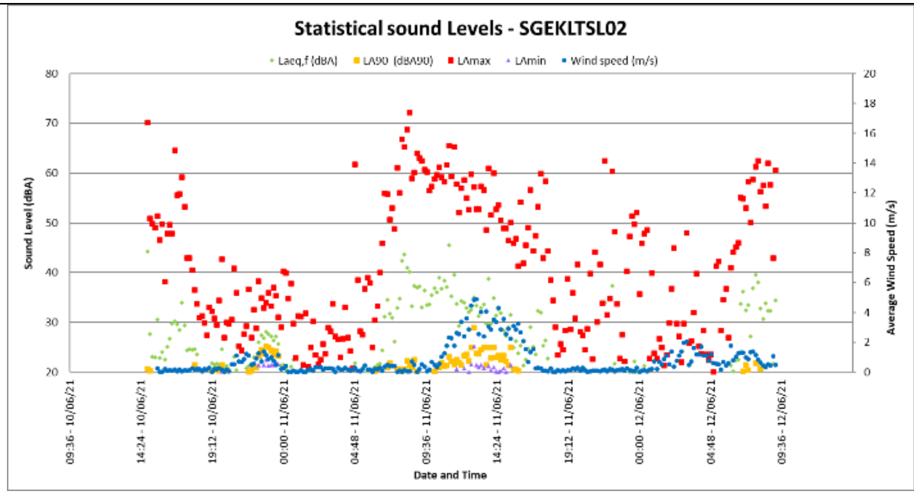

Figure 4-10: Maximum, minimum and statistical values at SGEKLTSL02

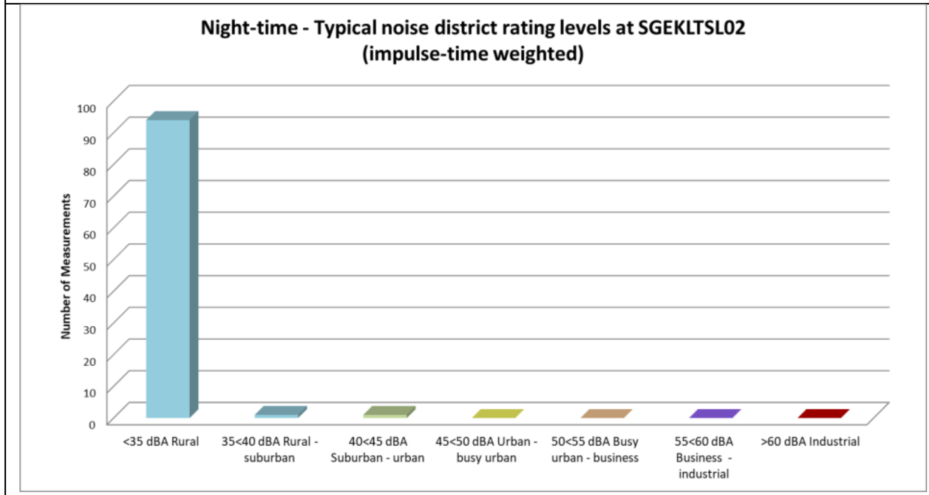

Figure 4-11: Classification of night-time measurements in typical noise districts at SGEKLTSL02

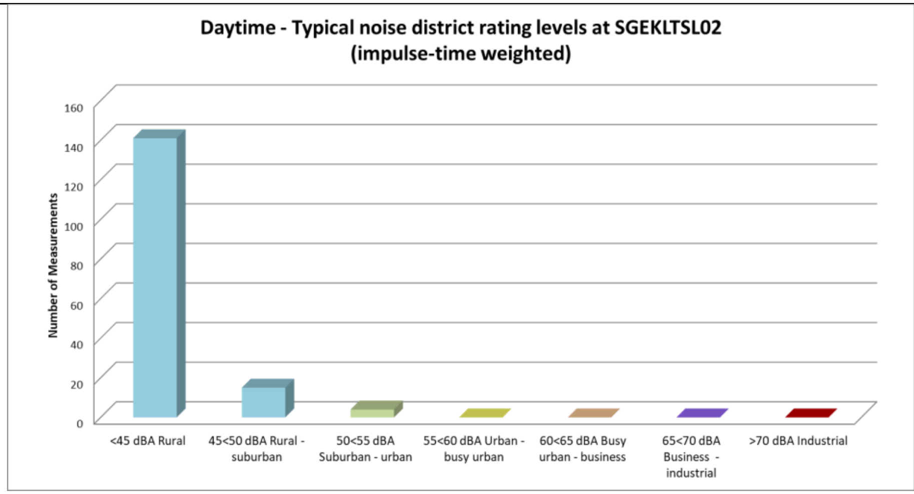

Figure 4-12: Classification of daytime measurements in typical noise districts at SGEKLTSL02

4.3.3 Long-term Measurement Location - SGEKLTSL03

The measurement location was located in an open area in front of the residential house, with some vegetation in the area. The owner confirmed that the house is mainly used over weekends. The equipment defined in **Table 4-8** was used for gathering data with **Table 4-9** highlighting sounds heard during equipment deployment and collection, with photos of this measurement location presented in **Appendix E.3**.

Table 4-8: Equipment used to gather data at SGEKLTSL03

Equipment	Model	Serial no	Calibration Date
SLM	SVAN 977	36176	January 2020
Microphone	ACO 7052E & SV 12L	49596	January 2020
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-9: Noises/sounds heard during site visits at SGEKLTSL03

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • Barely Audible • Audible • Dominating	**During equipment deployment and collection of instrument**	
	Faunal and Natural	Bird communication dominant.
	Sounds associated with the household/ farm	-
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-13** and summarized in **Table 4-10** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-14**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background residual noise level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little

noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[16].

Table 4-10: Sound levels considering various sound level descriptors at SGEKLTSL03

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	33.4	28.5	22.0	-
Night arithmetic average	-	25.2	23.5	21.9	-
Day Equivalent Levels	-	44.3	37.1	-	-
Night Equivalent Levels	-	26.7	24.9	-	-
Day minimum	-	22.6	21.3	-	20.4
Day maximum	76.8	53.2	55.2	-	-
Night minimum	-	21.4	21.0	-	20.3
Night maximum	52.4	35.3	33.4	-	-
Day 1 equivalent	-	37.1	28.9	-	-
Night 1 Equivalent	-	28.1	26.5	-	-
Day 2 equivalent	-	41.9	34.2	-	-
Night 2 Equivalent	-	24.6	22.4	-	-
Day 3 equivalent	-	40.5	34.0	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-15** (night) and **Figure 4-16** (day).

(16) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

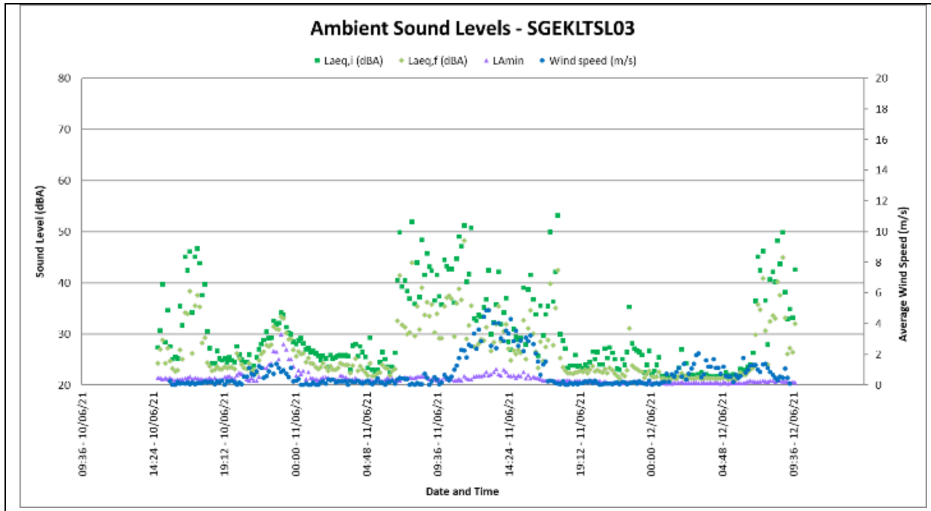

Figure 4-13: Ambient Sound Levels at SGEKLTSL03

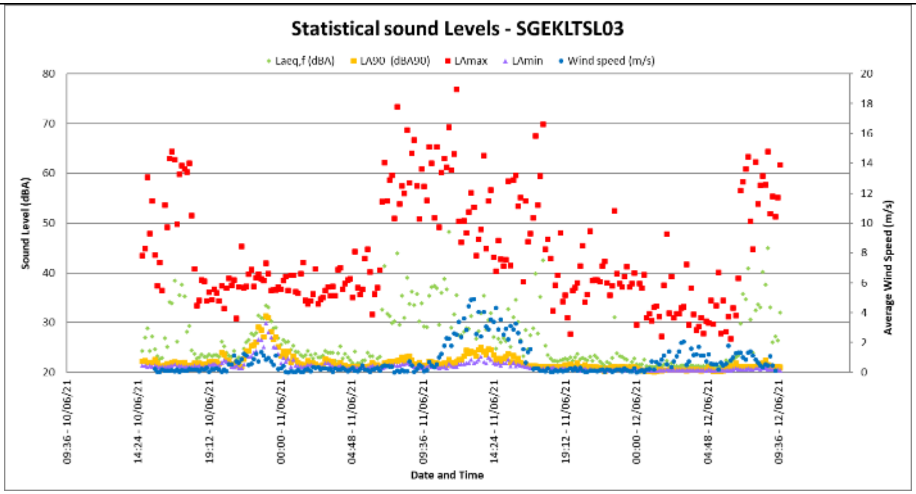

Figure 4-14: Maximum, minimum and Statistical sound levels at SGEKLTSL03

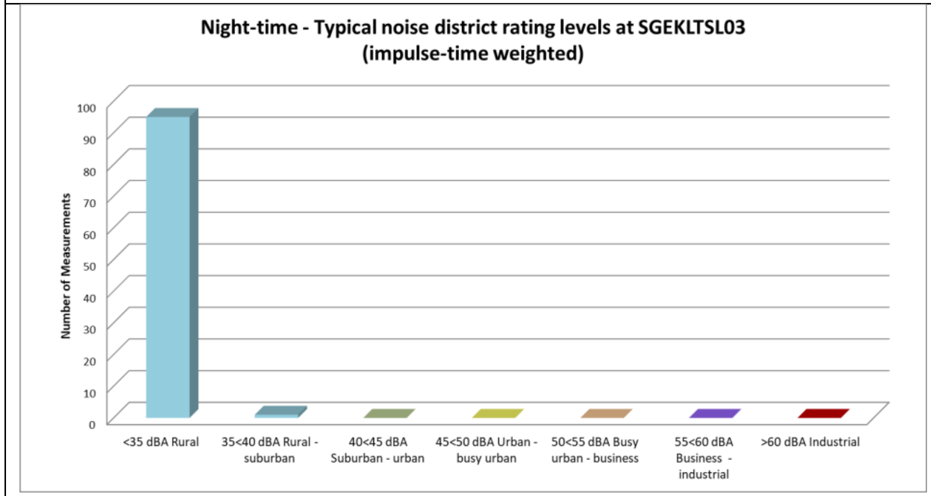

Figure 4-15: Classification of night-time measurements in typical noise districts at SGEKLTSL03

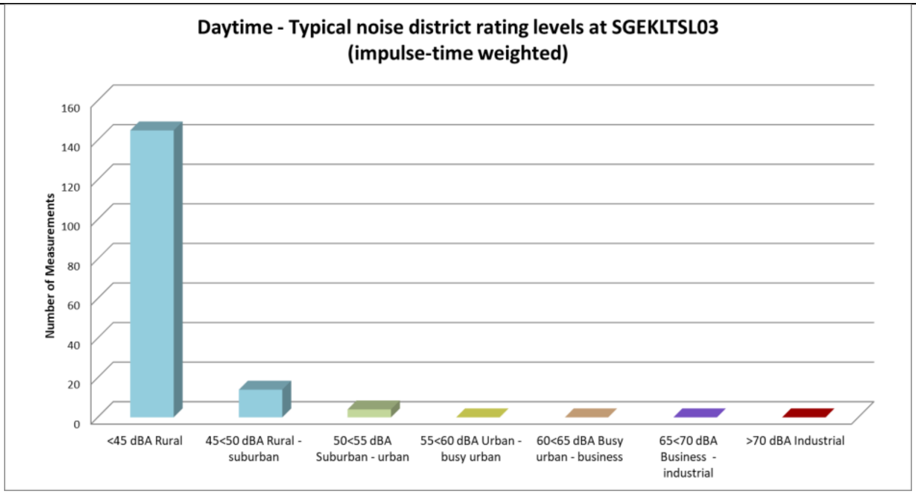

Figure 4-16: Classification of daytime measurements in typical noise districts at SGEKLTSL03

4.3.4 Long-term Measurement Location - SMKLTSL01

The instrument was deployed close to the residential dwelling of a farm worker. The ambient sound level measurements are representative of the area surrounding the small residence. The equipment defined in **Table 4-11** was used for gathering data with

Equipment	Model	Serial no	Calibration Date
SLM	NL-32	01182945	October 2020
Microphone	NH-21	28879	October 2020
Calibrator	Quest CA-22	J 2080094	June 2020

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

Table 4-12 highlighting sounds heard during equipment deployment and collection. **Appendix E.4** presents photos of the measurement location.

Table 4-11: Equipment used to gather data at SMKLTSL01

Equipment	Model	Serial no	Calibration Date
SLM	NL-32	01182945	October 2020
Microphone	NH-21	28879	October 2020
Calibrator	Quest CA-22	J 2080094	June 2020

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

Table 4-12: Noises/sounds heard during site visits at SMKLTSL01

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • **Barely Audible** • **Audible** • **Dominating**	**During equipment deployment and collection of instruments**	
	Faunal and Natural	Birds audible.
	Sounds associated with the household	Geese clearly audible and dominant at times. Voices of people at guest house just audible, with voices not influencing measurements.
	Industrial & transportation	Road traffic noises audible and dominant during passing. Road traffic noises did influence the measurements.

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-17** and summarized in **Table 4-13** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-18**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background residual noise level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[17].

Table 4-13: Sound levels considering various sound level descriptors at SMKLTSL01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	40.9	37.1	23.9	-
Night arithmetic average	-	28.8	27.0	16.7	-
Day Equivalent Levels	-	47.9	42.3	-	-
Night Equivalent Levels	-	33.9	32.1	-	-
Day minimum	-	21.0	20.0	-	14.4
Day maximum	66.5	55.4	55.2	-	-
Night minimum	-	14.9	14.7	-	14.0
Night maximum	58.6	41.3	39.3	-	-
Day 1 equivalent	-	36.0	31.9	-	-
Night 1 Equivalent	-	31.4	29.7	-	-
Day 2 equivalent	-	45.7	39.9	-	-
Night 2 Equivalent	-	35.5	33.6	-	-
Day 3 equivalent	-	43.9	38.6	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-19** (night) and **Figure 4-20** (day).

(17) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

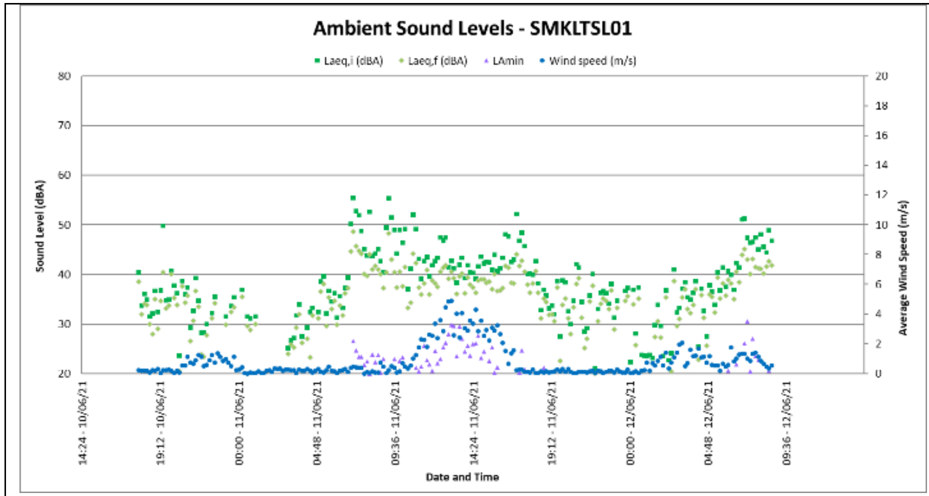

Figure 4-17: Ambient Sound Levels at SMKLTSL01

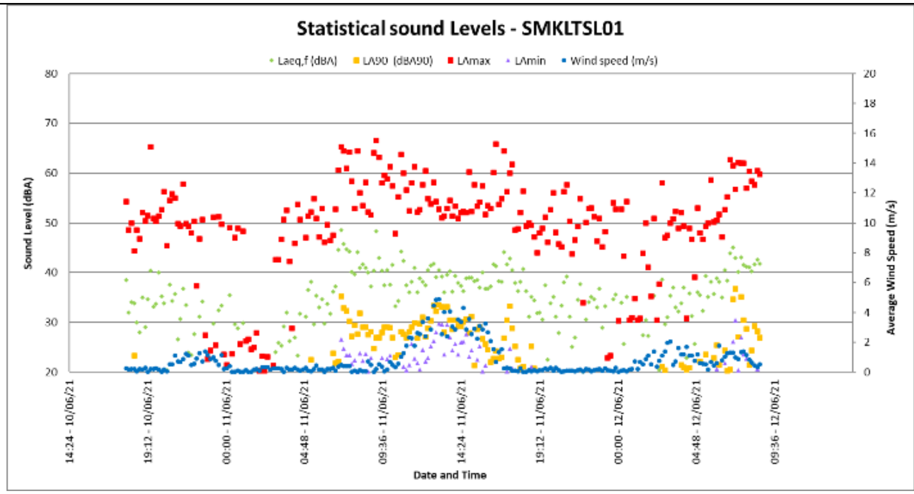

Figure 4-18: Maximum, minimum and Statistical sound levels at SMKLTSL01

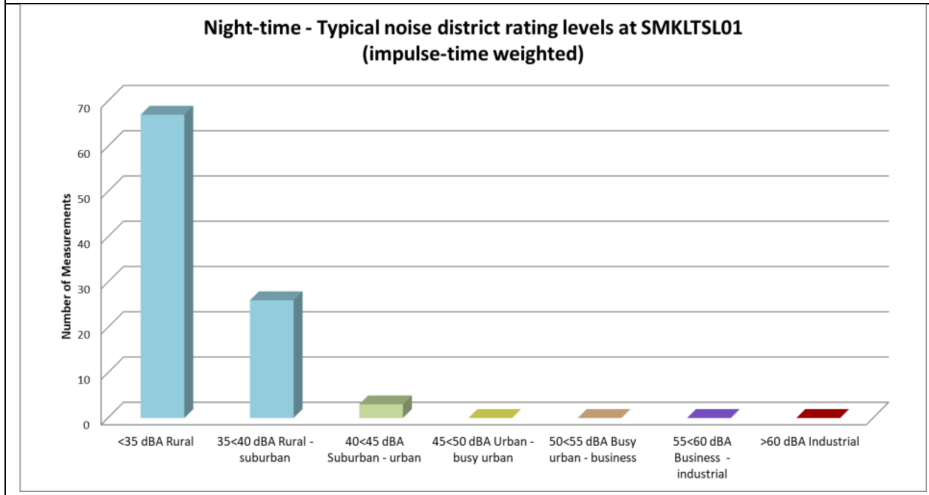

Figure 4-19: Classification of night-time measurements in typical noise districts at SMKLTSL01

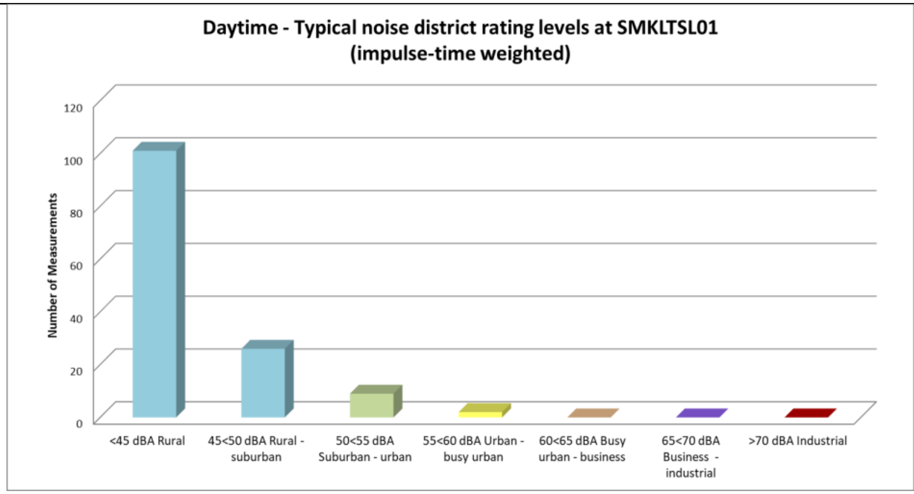

Figure 4-20: Classification of daytime measurements in typical noise districts at SMKLTSL01

4.3.5 Long-term Measurement Location - SMKLTSL02

The measurement location was deployed in an open area near the residence of a farm worker. There is very little vegetation near the microphone. The equipment defined in **Table 4-14** was used for gathering data with **Table 4-15** highlighting sounds heard during equipment deployment and collection, with photos of this measurement location presented in **Appendix E.5**.

Table 4-14: Equipment used to gather data at SMKLTSL02

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34849	October 2018
Microphone and Pre-amplifier	ACO 7052E & SV 12L	33077	October 2018
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-15: Noises/sounds heard during site visits at SMKLTSL02

<table>
<tr><th colspan="3">Noises/sounds heard during onsite investigations</th></tr>
<tr><td rowspan="4">Magnitude Scale Code:
• Barely Audible
• Audible
• Dominating</td><td colspan="2">During equipment deployment and collection of instruments</td></tr>
<tr><td>Faunal and Natural</td><td>Birds dominant noise.</td></tr>
<tr><td>Sounds associated with the household</td><td>Dog barking in area (audible to significant).</td></tr>
<tr><td>Industrial & transportation</td><td>Road noises audible during passing.</td></tr>
</table>

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-21** and summarized in **Table 4-16** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-22**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little

noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

Maximum noise level exceeded 65 dBA at least 1 time the second night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[18].

Table 4-16: Sound levels considering various sound level descriptors at SMKLTSL02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	37.2	33.8	22.3	-
Night arithmetic average	-	28.2	26.3	18.7	-
Day Equivalent Levels	-	50.5	41.7	-	-
Night Equivalent Levels	-	46.6	37.3	-	-
Day minimum	-	19.1	18.8	-	18.2
Day maximum	86.9	64.3	55.2	-	-
Night minimum	-	18.9	18.7	-	18.2
Night maximum	86.5	66.3	56.4	-	-
Day 1 equivalent	-	47.2	38.5	-	-
Night 1 Equivalent	-	30.0	28.2	-	-
Day 2 equivalent	-	49.7	40.6	-	-
Night 2 Equivalent	-	49.6	40.1	-	-
Day 3 equivalent	-	43.0	35.3	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-23** (night) and **Figure 4-24** (day).

(18) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

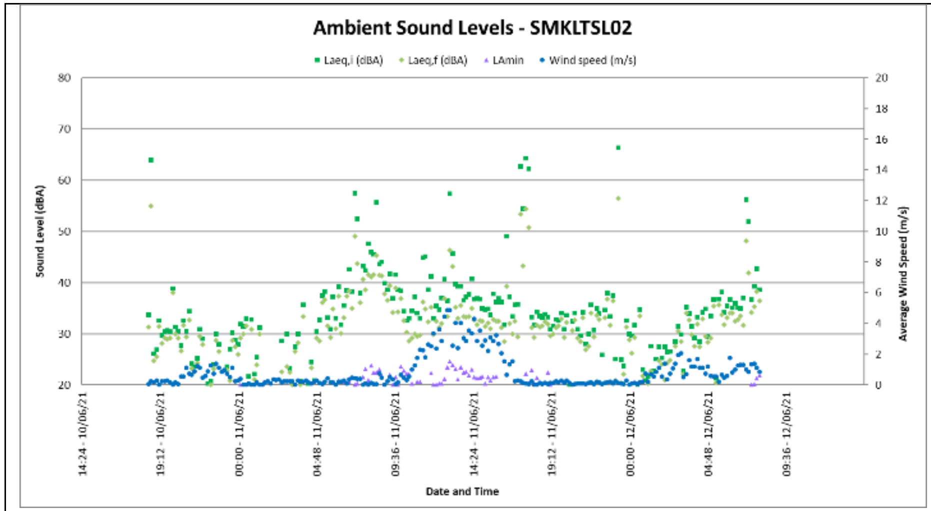

Figure 4-21: Ambient Sound Levels at SMKLTSL02

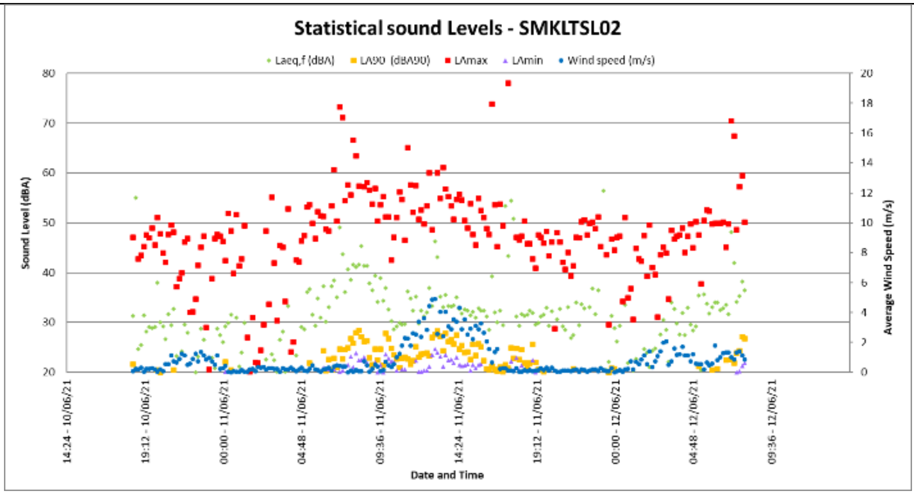

Figure 4-22: Maximum, minimum and Statistical sound levels at SMKLTSL02

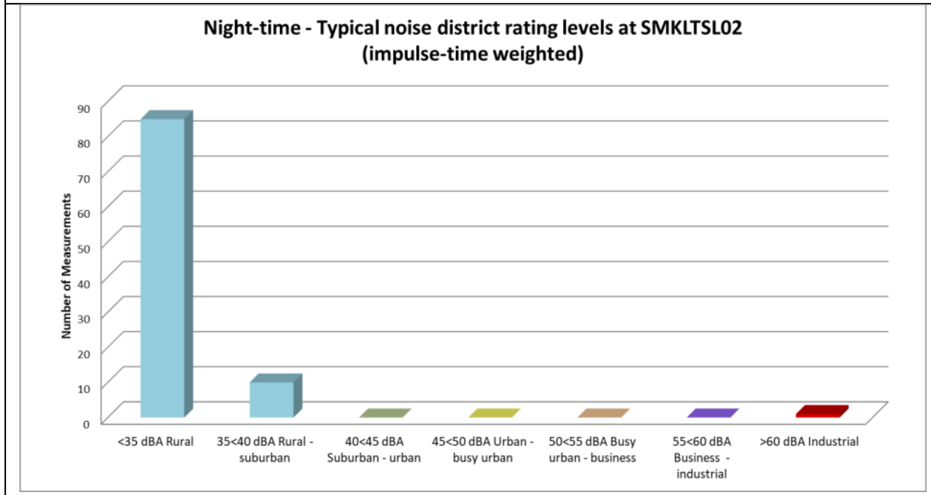

Figure 4-23: Classification of night-time measurements in typical noise districts at SMKLTSL02

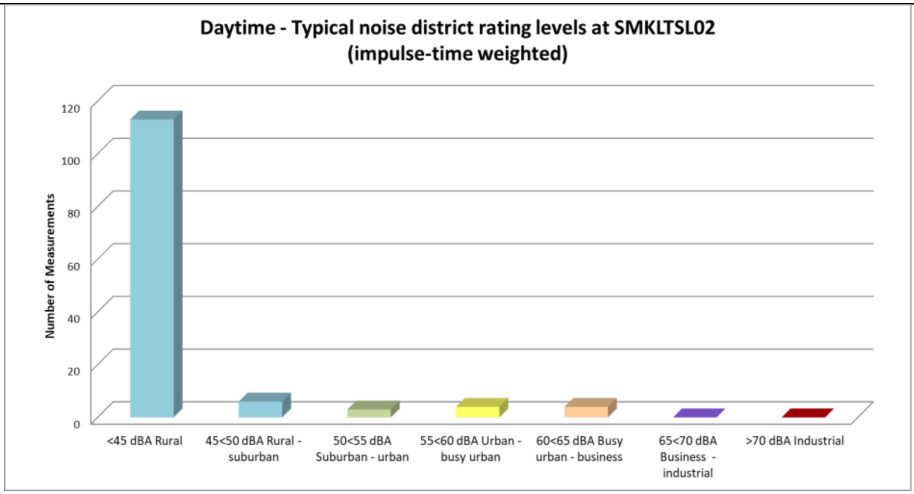

Figure 4-24: Classification of daytime measurements in typical noise districts at SMKLTSL02

4.3.6 Long-term Measurement Location - SMHLTSL01

The measurement location was located in front of the house, with significant vegetation close to the microphone. There were peacocks in the area, which would at times result in high noise levels. The equipment defined in **Table 4-17** was used for gathering data with **Table 4-18** highlighting sounds heard during equipment deployment and collection. **Appendix E.6** presents photos of the measurement location.

Table 4-17: Equipment used to gather data at SMHLTSL01

SLM	Svan 955	27637	October 2020
Microphone and Pre-amplifier	ACO 7052E & SV 12L	52437	October 2020
Calibrator	Quest CA-22	J 2080094	June 2020
SLM	Svan 955	27637	October 2020

Table 4-18: Noises/sounds heard during site visits at SMHLTSL01

<table>
<tr><th colspan="3">Noises/sounds heard during onsite investigations</th></tr>
<tr><td rowspan="4">Magnitude Scale Code:
• Barely Audible
• Audible
• Dominating</td><td colspan="2">During equipment deployment and collection of instruments</td></tr>
<tr><td>Faunal and Natural</td><td>Birds audible and dominant.</td></tr>
<tr><td>Sounds associated with the household</td><td>Dogs barking in area.</td></tr>
<tr><td>Industrial & transportation</td><td>-</td></tr>
</table>

Fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-25** and summarized in **Table 4-19** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-26**.

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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

Maximum noise level exceeded 65 dBA at least 1 time the first night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[19].

Table 4-19: Sound levels considering various sound level descriptors at SMHLTSL01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	34.4	29.1	24.1	-
Night arithmetic average	-	19.4	16.2	21.3	-
Day Equivalent Levels	-	46.0	40.0	-	-
Night Equivalent Levels	-	33.7	27.1	-	-
Day minimum	-	12.1	8.6	-	3.2
Day maximum	73.6	51.3	55.2	-	-
Night minimum	-	11.3	7.2	-	3.2
Night maximum	77.7	52.3	45.5	-	-
Day 1 equivalent	-	32.4	26.6	-	-
Night 1 Equivalent	-	36.5	29.5	-	-
Day 2 equivalent	-	42.4	37.6	-	-
Night 2 Equivalent	-	23.3	21.3	-	-
Day 3 equivalent	-	43.6	36.2	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-27** (night) and **Figure 4-28** (day).

(19) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

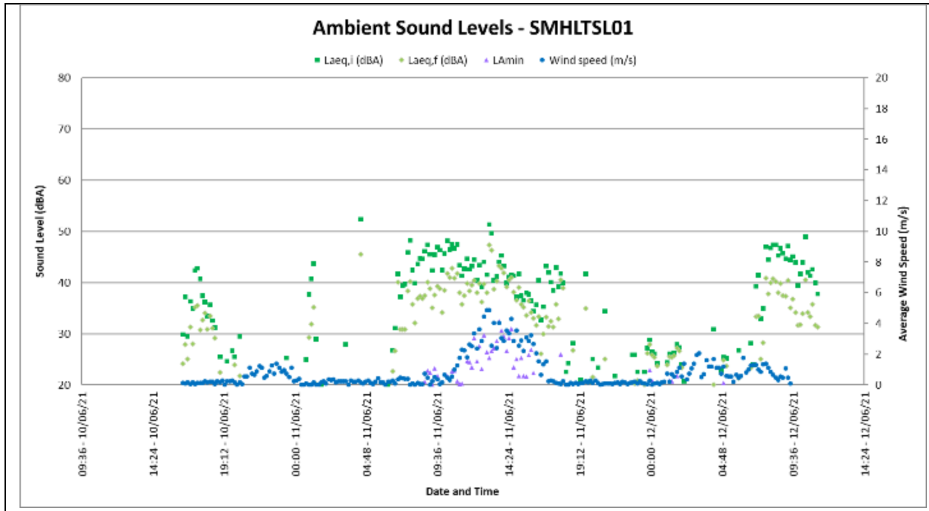

Figure 4-25: Ambient Sound Levels at SMHLTSL01

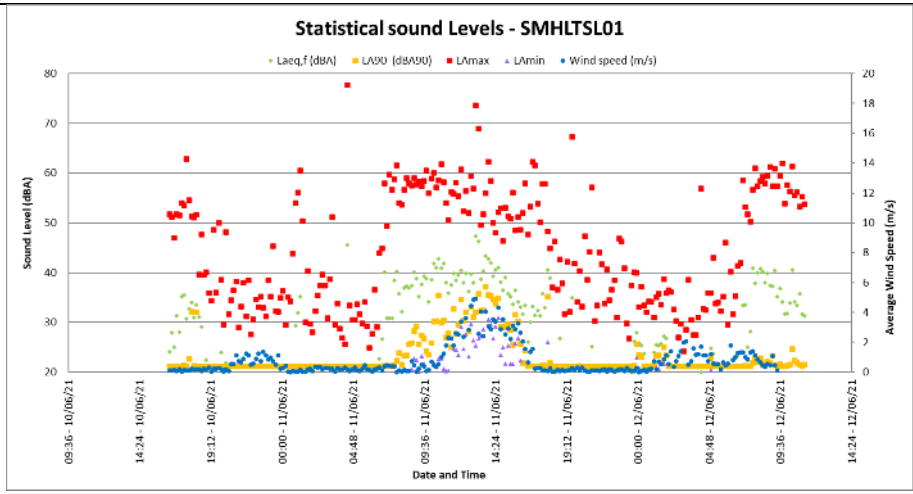

Figure 4-26: Maximum, minimum and Statistical sound levels at SMHLTSL01

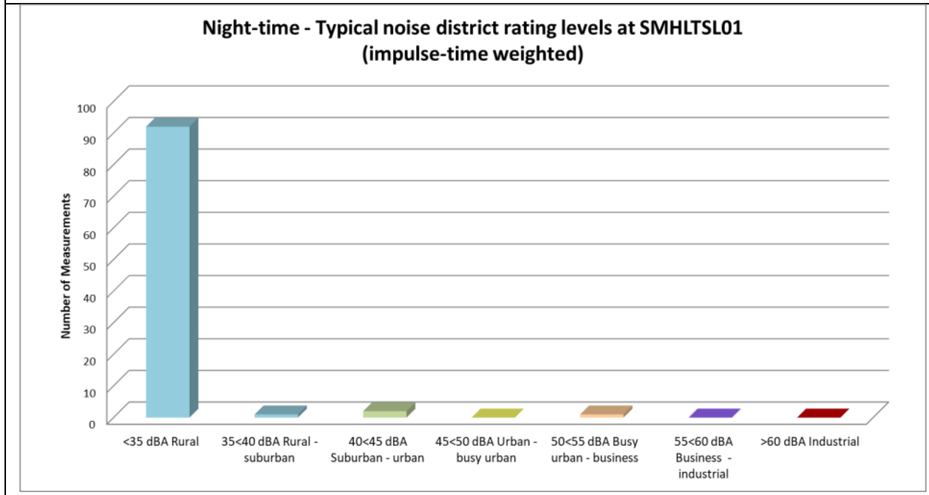

Figure 4-27: Classification of night-time measurements in typical noise districts at SMHLTSL01

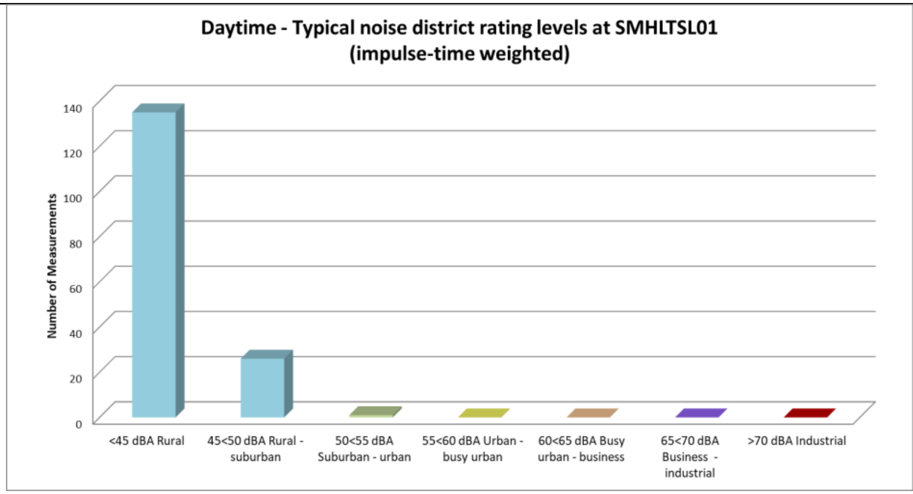

Figure 4-28: Classification of daytime measurements in typical noise districts at SMHLTSL01

4.3.7 Long-term Measurement Location - SMHLTSL02

The measurement location was located in an open area close to residential dwellings. There is significant vegetation in the areas. The equipment defined in **Table 4-20** was used for gathering data with **Table 4-21** highlighting sounds heard during equipment deployment and collection. **Appendix E.7** presents photos of the measurement location.

Table 4-20: Equipment used to gather data at SMHLTSL02

Equipment	Model	Serial no	Calibration
SLM	NA-28	00901489	April 2019
Microphone	NH-23	01533	April 2019
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-21: Noises/sounds heard during site visits at SMHLTSL02

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • **Barely Audible** • **Audible** • **Dominating**	**During equipment deployment and collection of instruments**	
	Faunal and Natural	Bird sound constant and the dominant noise source.
	Sounds associated with the household	Dogs chained to tree frequently barking.
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-29** and summarized in **Table 4-22** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-30**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

Maximum noise level exceeded 65 dBA at least 1 time the first night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[20].

Table 4-22: Sound levels considering various sound level descriptors at SMHLTSL02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	37.4	30.6	20.9	-
Night arithmetic average	-	20.9	19.8	17.8	-
Day Equivalent Levels	-	51.0	40.4	-	-
Night Equivalent Levels	-	30.9	23.4	-	-
Day minimum	-	14.6	16.6	-	15.3
Day maximum	84.0	66.6	55.4	-	-
Night minimum	-	14.4	16.6	-	15.3
Night maximum	65.3	47.2	38.1	-	-
Day 1 equivalent	-	36.0	27.3	-	-
Night 1 Equivalent	-	30.9	23.3	-	-
Day 2 equivalent	-	51.0	40.4	-	-
Night 2 Equivalent	-	20.5	18.4	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-31** (night) and **Figure 4-32** (day).

(20) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

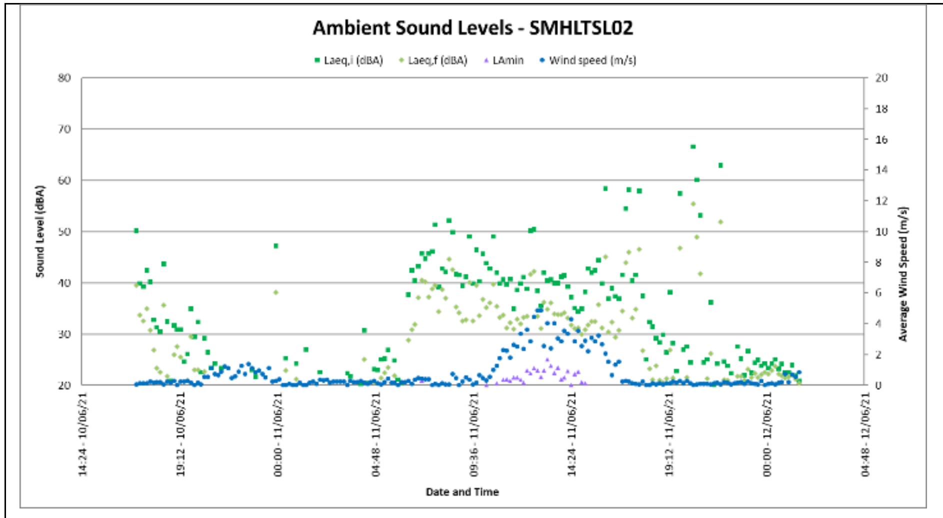

Figure 4-29: Ambient Sound Levels at SMHLTSL02

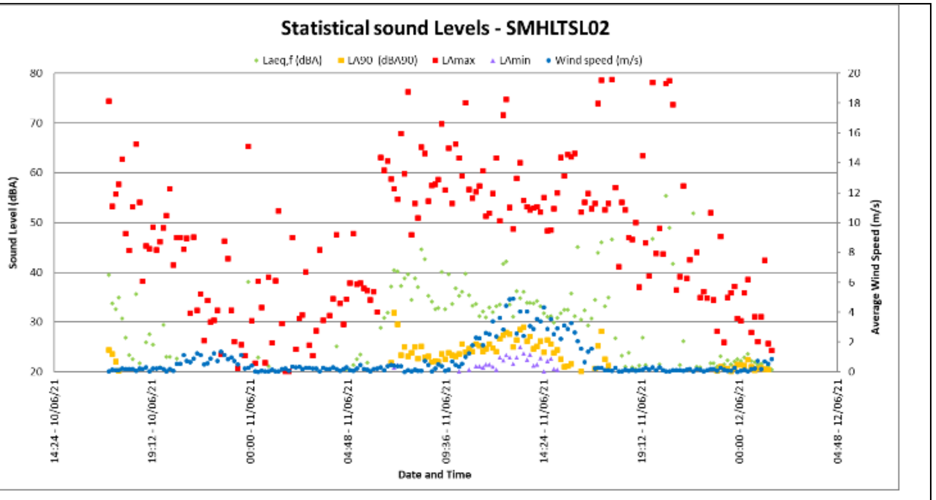

Figure 4-30: Maximum, minimum and Statistical sound levels at SMHLTSL02

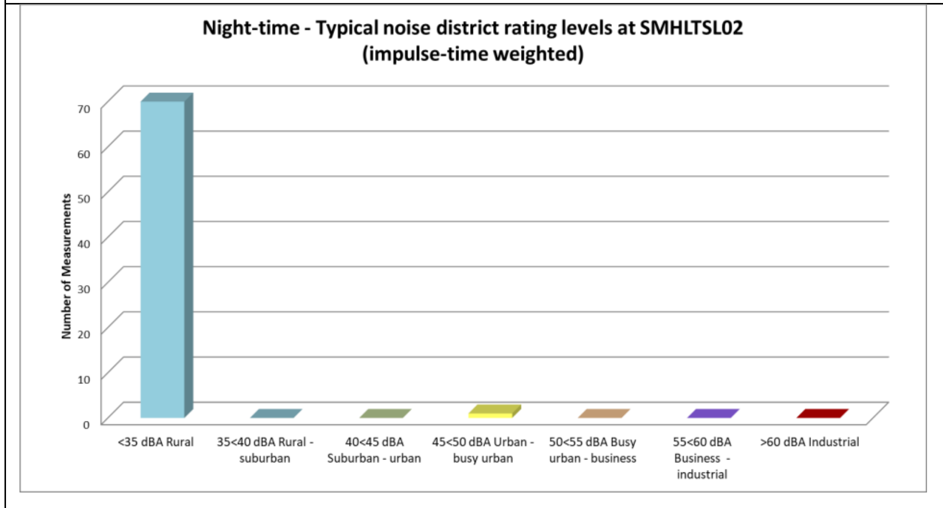

Figure 4-31: Classification of night-time measurements in typical noise districts at SMHLTSL02

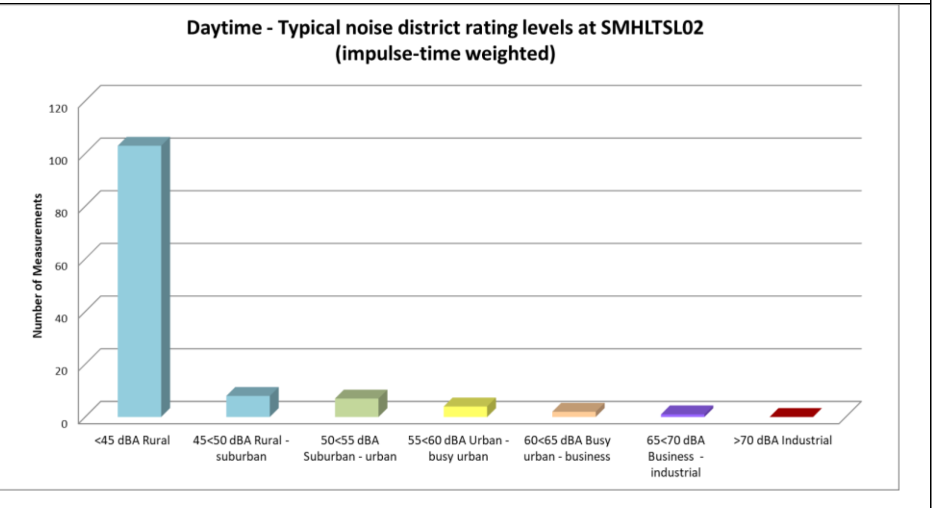

Figure 4-32: Classification of daytime measurements in typical noise districts at SMHLTSL02

4.4 AMBIENT SOUND LEVELS – FINDINGS AND SUMMARY

Based on the sound measurements:

- More than 1,000 10-minute measurements were collected during the day, with the highest fast-weighted sound level (during the various 10-minute measurements) measured being 55.4 dBA, with the lowest sound level being 16.6 dBA;
- More than 650 10-minute measurements were collected during the night-time period, with the highest fast-weighted sound level (during the numerous 10-minute measurements) measured being 65.7 dBA, with the lowest sound level being 22.6 dBA;
- The average of the 10-minute sound levels at the seven measurement locations were 29.8 dBA for the daytime period and 23.3 dBA for the night-time period (fast-weighted sound levels).

Considering the developmental character, the acceptable zone sound level (noise rating level) during low and no-wind conditions would be expected to be that of a rural noise district for both the daytime and night-time period:

- **45 dBA for the daytime period;** and,
- **35 dBA for the night-time period**.

To assess the noise impact occurring during the construction phase, this assessment will use the following noise limits:

- **52 dBA for the daytime period**; and,
- **42 dBA for the night-time period**.

Considering measurements collected over the past decade at numerous locations during different seasons, ambient sound levels will likely increase as wind speeds increase, as illustrated in **Figure 4-33**. The sound level data collected for this project is also illustrated on these figures. This figure also illustrates a trend of increased ambient sound levels as wind speed increase. The same trend will also be assumed for the project site as illustrated on **Figure 4-33**. This increasing ambient sound level, as wind speeds increase, will be considered for the operational phase (as the wind turbines will only operate during a period with increased wind speeds).

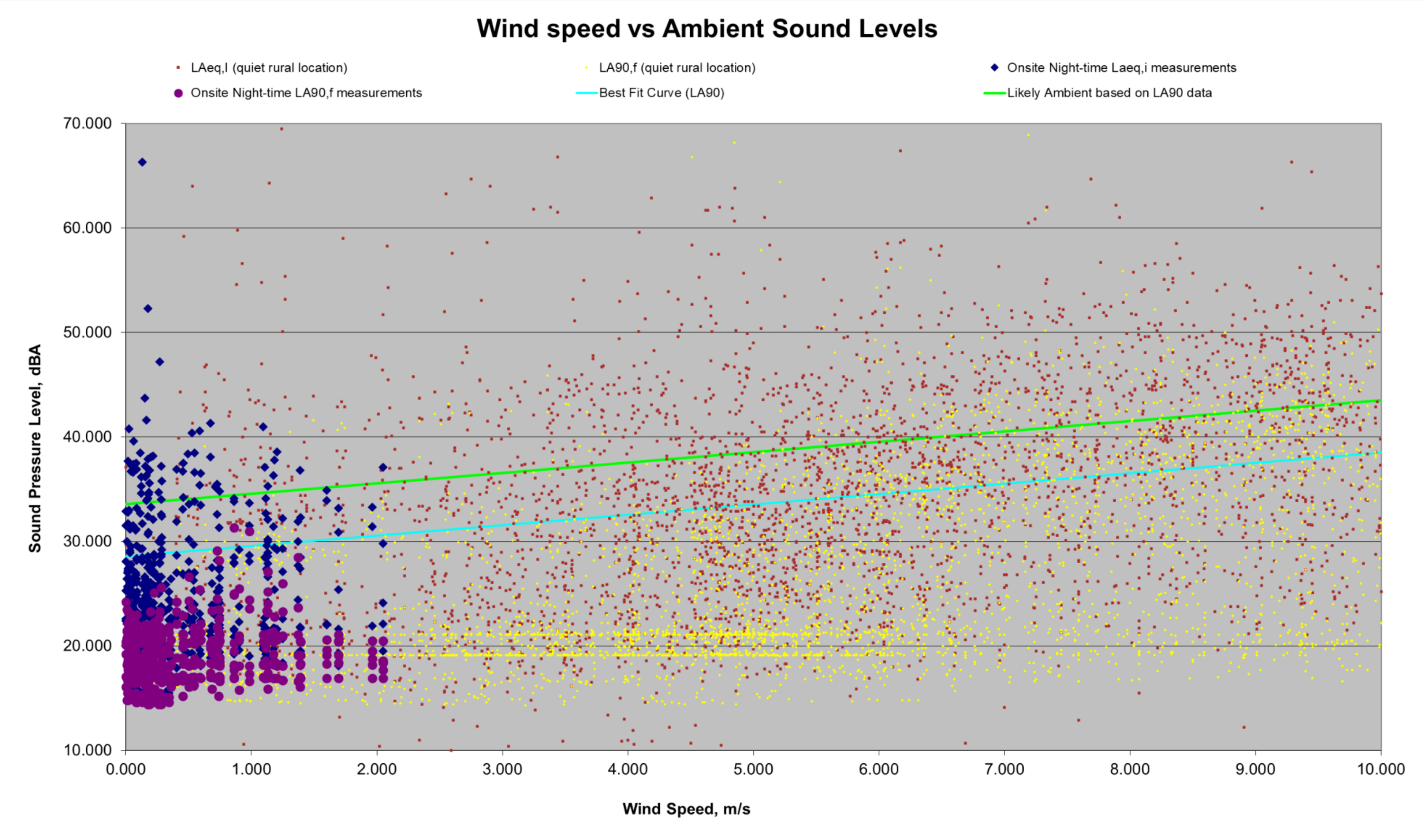

Figure 4-33: Night-time residual noise levels measured in vicinity of project

5 POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the proposed Koup 1 WEF 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.

5.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

5.1.1 Construction equipment

It is estimated that construction will take approximately 24 - 30 months subject to the final design of the WEF, 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 with WTG component 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.
- Transport of components & equipment to site – all components will be brought to site in sections by means of flatbed trucks. Additionally, components of various specialized 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 may require up to 100 concrete trucks, and is undertaken as a continuous pour);
- Establishment of laydown & 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 are removed; 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 5-2**.

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 5-3**.

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.

Noise from the contractor’s camp will be minimal and will not influence the ambient sound levels in the surrounding area. The noise levels and the octave sound power emission levels used for modelling for the construction phase are highlighted in **Table 5-1**.

Table 5-1: Equipment list and Sound power emission levels used for modelling

Equipment	Sound power level, dB re1 pW, in octave band, Hz							SPL
Centre frequency	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**(dBA)**
Construction and WTG equipment and activities								
Bulldozer CAT D5	107.4	105.9	104.8	104.5	104.4	97.5	90.2	107.4
Diesel Generator (Large - mobile)	107.2	104.0	102.4	102.7	100.2	99.5	97.4	106.1
Excavator and truck	111.0	112.2	109.3	106.4	105.4	101.6	98.4	112.0
General noise (Construction)	95.0	100.0	103.0	105.0	105.0	100.0	100.0	113.6
Goldwind GW155-4.5	109.8	108.9	109.5	107.4	101.0	92.3	77.4	107.5
Goldwind GW182-7.2 (maximum)	Octave SPL not available, use octave SPL of the GW155-4.5							112.6
Road Transport Reversing/Idling	108.2	104.6	101.2	99.7	105.4	100.7	98.7	108.2
Vestas V162-7.2MW	114.2	113.3	110.0	105.4	100.8	95.1	86.8	107.1
Area noise sources (using the octave sound power characteristics of General Noise)								
General noise (dBA/m^2 re 1 pW)	95.0	100.0	103.0	105.0	105.0	100.0	100.0	65.0

5.1.2 Material supply: Concrete batching plants

There exist mainly two 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 closer to the activities. This would most likely be a movable plant.

This noise study will consider the use of a concrete batching plant, though the infrastructure layout indicate that the batching plants are further than 1,000m from any NSR. Potential noise from this source will be minimal.

5.1.3 Blasting

Though unlikely, blasting may be required as part of the civil works to clear obstacles or to prepare foundations (of either the WEF, power pylons or other infrastructure).

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. The breaking of rocks and obstacles with explosives is also a specialized field, and when correct techniques are used, it causes less noise than using a rock-breaker.
- People are generally more concerned over ground vibration and air blast levels that might cause building damage than the impact of the noise from the blast.
- Blasts are an infrequent occurrence, with a loud but a relative instantaneous character. Potentially affected parties normally receive sufficient notice (siren), and the knowledge that the duration of the siren noise as well as the blast will be over relatively fast, resulting in a higher acceptance of the noise.

5.1.4 Construction Traffic

The last potential significant source of noise during the construction phase is additional traffic to and from the site, as well as traffic on 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). Traffic volumes were estimated using up to 10 trucks and cars each, travelling on a gravel road at 40 km/hr, as well as a surfaced road at 80 km/hr.

Table 5-2: Potential maximum noise levels generated by construction equipment

Equipment Description[21]	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 modeling 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
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
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
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
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
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
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

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

Table 5-3: 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	55.6	47.6	41.5	38.0	35.4	31.9	27.3	23.6	20.9	14.2
Bulldozer CAT D10	111.9	86.9	80.9	74.9	66.9	60.8	57.3	54.7	51.2	46.6	42.9	40.2	33.5
Cement truck (with cement)	111.7	86.7	80.7	74.7	66.7	60.6	57.1	54.5	51.0	46.4	42.7	40.0	33.3
Crane	107.5	82.5	76.5	70.5	62.5	56.4	52.9	50.3	46.8	42.2	38.5	35.8	29.1
Diesel Generator (Large - mobile)	106.1	81.1	75.1	69.1	61.1	55.0	51.5	48.9	45.4	40.8	37.1	34.4	27.7
Dumper/Haul truck - Terex 30 ton	112.2	87.2	81.2	75.2	67.2	61.1	57.6	55.0	51.5	46.9	43.2	40.5	33.8
Excavator - Hitachi EX1200	113.1	88.1	82.1	76.1	68.1	62.0	58.5	55.9	52.4	47.8	44.1	41.4	34.7
FEL (988) (FM)	115.6	90.6	84.6	78.6	70.6	64.5	61.0	58.4	54.9	50.3	46.6	43.9	37.2
General noise	108.8	83.8	77.8	71.8	63.8	57.7	54.2	51.6	48.1	43.5	39.8	37.1	30.4
Grader - Operational Hitachi	108.9	83.9	77.9	71.9	63.9	57.8	54.3	51.7	48.2	43.6	39.9	37.2	30.5
Road Truck average	109.6	84.6	78.6	72.6	64.6	58.5	55.0	52.4	48.9	44.3	40.6	37.9	31.2
Rock Breaker, CAT	120.7	95.7	89.7	83.7	75.7	69.6	66.1	63.5	60.0	55.4	51.7	49.0	42.3
Vibrating roller	106.3	81.3	75.3	69.3	61.3	55.2	51.7	49.1	45.6	41.0	37.3	34.6	27.9
Substation (one transformer)	85.2	60.2	54.2	48.2	40.2	34.1	30.6	28.0	24.5	19.9	16.2	13.5	6.8
Water Dozer, CAT	113.8	88.8	82.8	76.8	68.8	62.7	59.2	56.6	53.1	48.5	44.8	42.1	35.4
Wind Turbine: Acciona AW125/3000	108.5	83.5	77.5	71.5	63.5	57.4	53.9	51.3	47.8	43.2	39.5	36.8	30.1
Wind Turbine: Goldwind GW165 6.0	112.6	87.6	81.6	75.6	67.6	61.5	58.0	55.4	51.9	47.3	43.6	40.9	34.2
Wind Turbine: Goldwind GW182 7.2	112.2	87.2	81.2	75.2	67.2	61.1	57.6	55.0	51.5	46.9	43.2	40.5	33.8
Wind Turbine: Nordex N163 / 5.X	109.2	84.2	78.2	72.2	64.2	58.1	54.6	52.0	48.5	43.9	40.2	37.5	30.8
Wind Turbine: Vesta V66, ave	110.4	85.4	79.4	73.4	65.4	59.3	55.8	53.2	49.7	45.1	41.4	38.7	32.0
Wind Turbine: Vestas V162-7.2MW	107.1	82.1	76.1	70.1	62.1	56.0	52.5	49.9	46.4	41.8	38.1	35.4	28.7

5.2 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 Project. 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 noise sources of lower levels, such as the substations and traffic (maintenance).

The noise levels and the octave sound power emission levels of the selected WTG used for the operational noise model are highlighted in **Table 5-1**.

5.2.1 Wind Turbine Noise: Aerodynamic sources [7, 17, 29, 39, 108]

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

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

Therefore, as the wind speed increases, noises created by the wind turbine also increase. 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 5-1**.

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. As the noise propagation modelling requires the details of a wind turbine, the applicant requested that the assessment considers a potential worst-case scenario, using a WTG with a sound power emission level ("SPL") of 112.2 dBA (re 1 pW), using the SPL characteristics of the Goldwind GW182-7.2 WTG (Goldwind, 2023 **[52]**) for the worst-case scenario, as well as the SPL characteristics of the Vestas V162-7.2 WTG (Vestas, 2023 [**142**]).

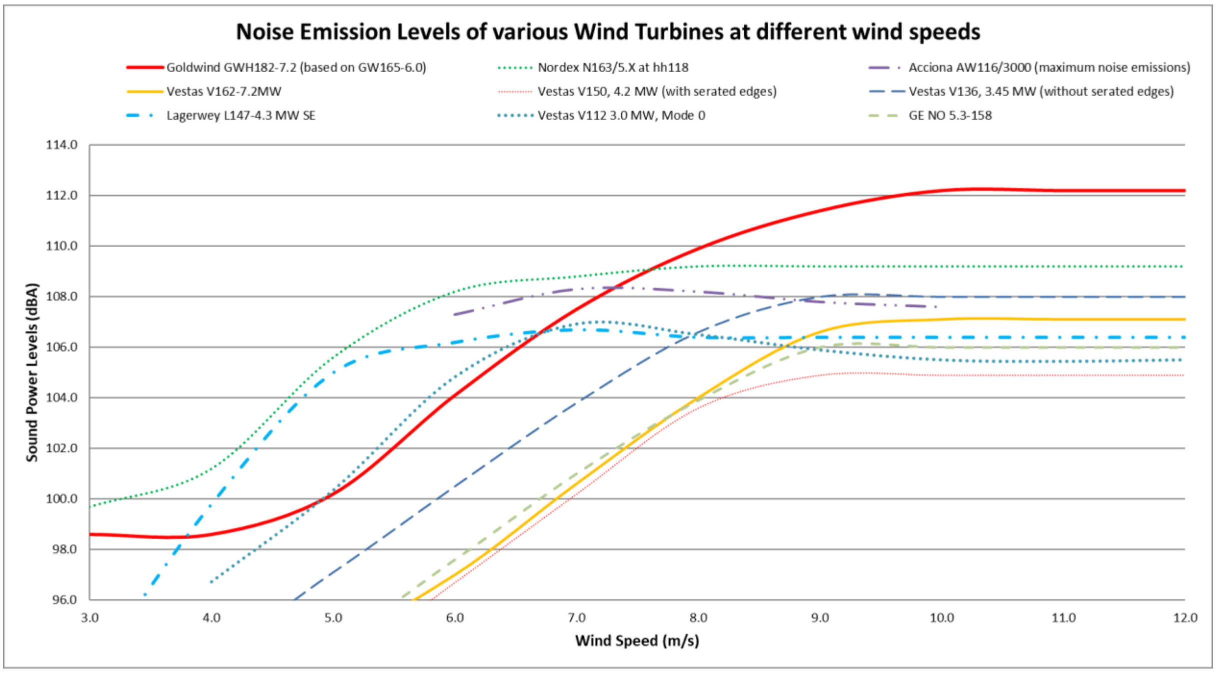

Figure 5-1: Noise Emissions Curve of a number of different wind turbines (figure for illustration purposes only)

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 emission levels for various wind turbines are presented on **Figure 5-2**.

5.2.1.1 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 from the different manufacturers); 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.

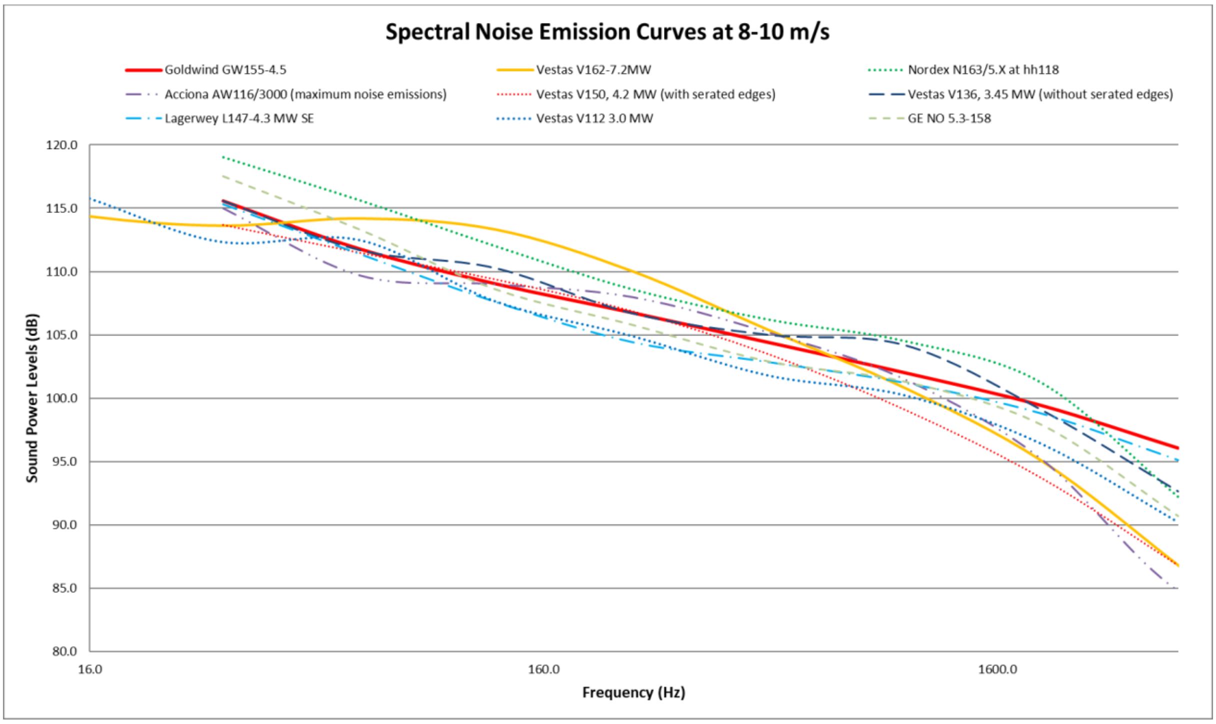

Figure 5-2: Octave sound power emissions of various wind turbines

5.2.2 Wind Turbine: Mechanical sources [42, 61, 108, 111]

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 minimize 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***.

5.2.3 Low Frequency Noise

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 (DELTA, 2008) [**32**], (HGC Engineering, 2006 [**60**], (O'Neal *et al*., 2011) [**95**], (Van den Berg, 2004) [**137**].

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 5-3**, 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 (Bolin *et al*, 2011) [**10**], (DELTA, 2008) [**32**], (Kamperman and James, 2008) [**72**].

Ambrose (2011) [**1**] and other authors have confirmed modulations consistent with the frequency that the blade pass the tower. 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 (BWEA, 2005) [**16**], (Cummings, 2012) [**28**], (HGC Engineering, 2006) [**60**].

The British Wind Energy Association (BWEA) [**16**] highlighted that these sounds are below the threshold of perception, 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 (DEFRA, 2003) [**30**], (Evans, Cooper and Lenchine, 2012) [**44**], (HGC Engineering, 2011) [**62**], (Oud, 2012) [**97**].

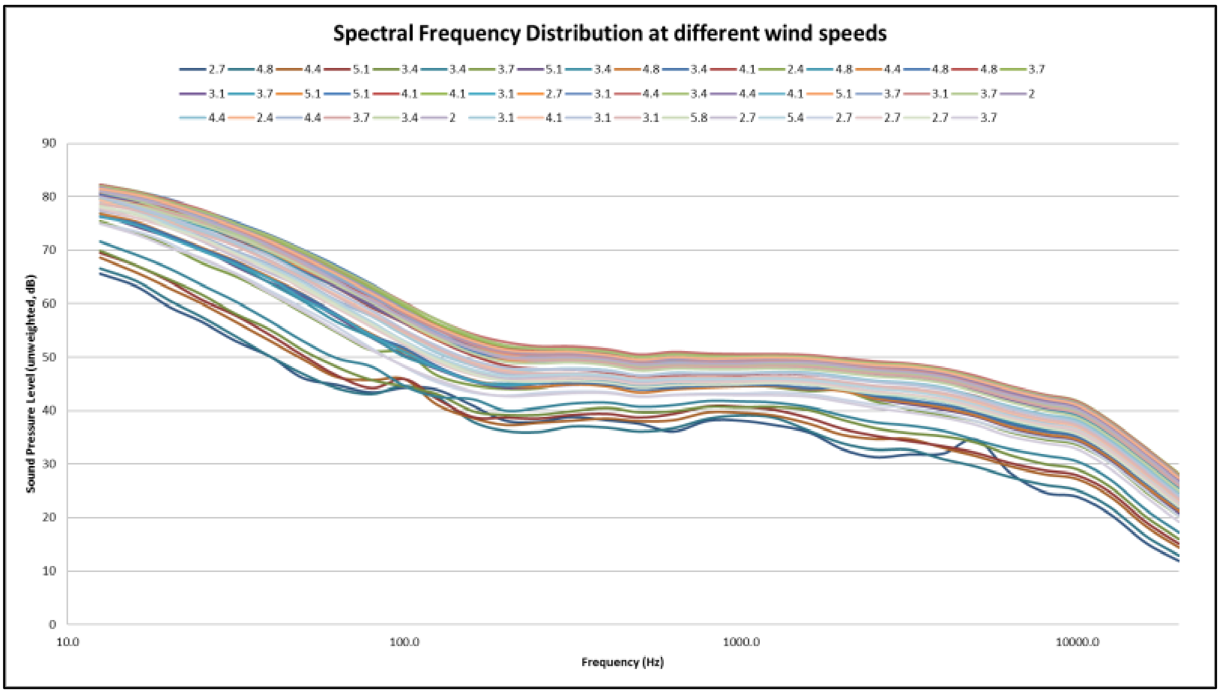

Figure 5-3: Third octave band sound power levels at various wind speeds at a location where wind induced noises dominate

In February 2013, the Environmental Protection Authority of South Australia published the results of a study into low-frequency noise near wind farms (Evans and Cooper, 2012) [**43**, **44**]. This study measured infrasound levels at urban locations, rural locations with wind turbines close by, and rural locations with no wind turbines in the vicinity. It found that infrasound levels near wind farms are comparable to levels away from wind farms in both urban and rural locations. Infrasound levels were also measured during organized shut-downs of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.

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.

5.2.4 Amplitude modulation

Wind Turbine Noise (WTN) includes a steady component (see also the preceding section **5.2.1** and **5.2.2**) as well as, in some circumstances, a periodically fluctuating or Amplitude Modulated (AM) component or character (RenewableUK, 2013) [**112**]. Although generally considered rare, it is a characteristic of WTN that increases the annoyance with a project above that of other long-term noise sources (Bowdler, 2008) [**12**], (Conrady et al., 2019) [**20**], (DEFRA, 2007) [**31**], (Noise-con, 2008) [**91**], (Smith *et al.*, 2012) [**126**].

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 rotational speed, sometimes referred to as a “swish” or “thump”.

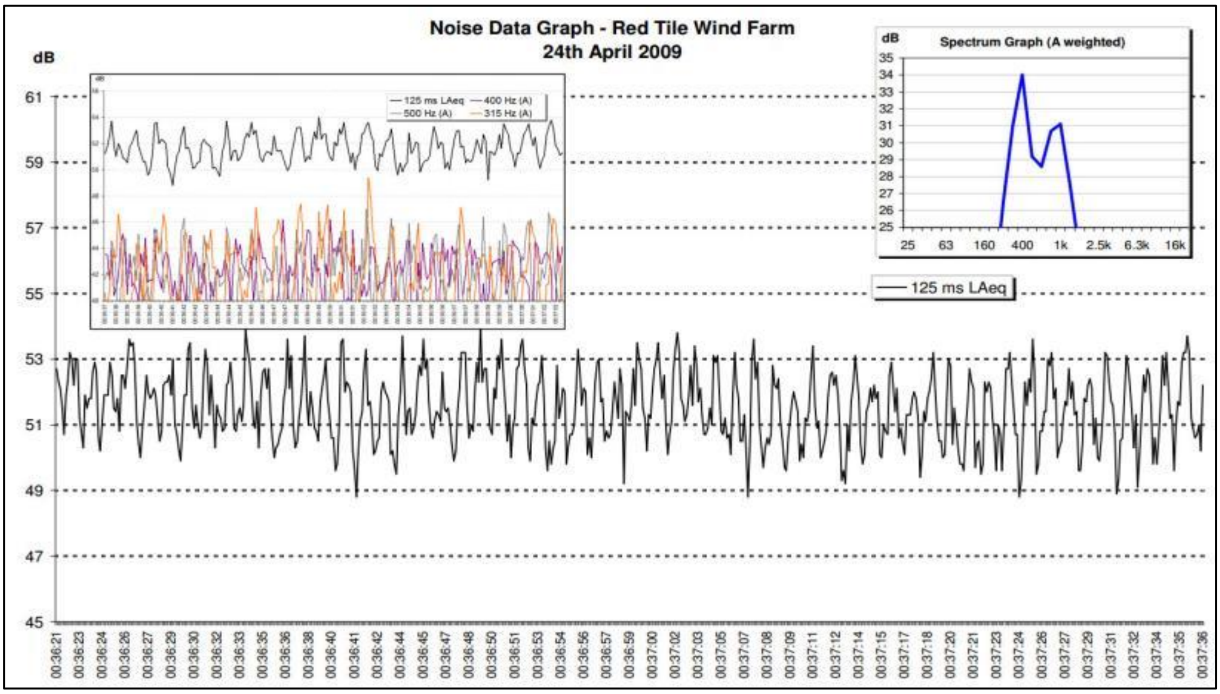

Figure 5-4: Example time-sound series graph illustrating AM as measured by Stigwood (2013) [127]

Pedersen (2003) [**103**] 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, with people able to distinguish between background ambient sounds and the sounds that the blades made. The noise produced by the blades lead to most complaints. Most of the annoyance was experienced between 16:00 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.

That AM can be a risk and significantly increase the annoyance with WEFs that cannot be disputed. It has been reported with a number of recent studies confirming this significant noise characteristic (Pedersen, Halmstad and Högskolan, 2003) [**103**]. However, even though there are thousands of wind turbine generators in the world, amplitude modulation is still one subject receiving the least complaints and due to these very few complaints, less research went into this subject. It is also a complex source of wind turbine noise, with studies highlighting that time of year, atmospheric conditions, wind direction and atmospheric conditions all play a role in the generation of AM (CanWEA, 2007) [**17**]**,** (Cummings , 2012) **[28**], (Cummings, 2009) **[29**], (RenewableUK, 2013) [**112**].

How people may respond to AM is also complex. WSP (2016) [**149**], in a study done for the Department of Energy and Climate Change summarized that:

- Within both laboratory and field test environments there is a strong association between increasing overall time-average levels of AM WTN-like sounds with increasing ratings of annoyance.
- Within a laboratory test environment:
    - subjects rated noticeable modulating WTN-like sounds as more annoying than similar noise without significant modulation;
    - the onset of fluctuation sensation for a modulating WTN-like sound appeared to be in the region of around 2 dB modulation depth;
    - increasing modulation depth above the onset of fluctuation sensation showed a broadly increasing trend in mean ratings of annoyance, but changes in mean annoyance rating tended to be relatively small and, in some cases, inconsistent;
    - equivalent annoyance ratings of AM and steady WTN-like sounds derived by level adjustment did not show a strong increasing trend with increasing depth of modulation; and
    - equivalent 'noisiness perception' of WTN-like AM sounds compared with a steady sound showed a gradually increasing trend with modulation depth.

WSP (2016) also concluded that the results from both the laboratory and field studies should be approached with caution, since they may not readily translate to how people respond to WTN exposure in their homes (WSP, 2016) [**149**].

This assessment notes the various findings from these studies, and recommend a more precautious approach, raising the probability of a noise impact occurring with one point for all night-time operational activities where (whichever is the lowest):

- the projected noise levels exceed the long-term fast-weighted ambient sound levels with more than 3 dB, or
- the projected noise levels exceed the typical rating levels for the area with more than 5 dBA.

5.2.5 Battery Energy Storage Systems

The developer proposes to include a BESS at their WEF to store energy for use at a later time or date using electro-chemical solutions. The typical components of a BESS are:

- The battery system which could consist of:
  - Multiple cells,
  - The battery management system; and,
  - The battery thermal management system.
- Components required for the reliable operation of the overall system, including:
  - Energy management system; and,
  - System thermal management.
- Power electronics that can be grouped into the conversion unit (such as an invertor), which manage the power flow between the grid and battery, including the required control and monitoring components, voltage sensing units and thermal management of power electronic components (fans or climate control system).

There could be numerous such BESS modules running in parallel to increase the total storage capacity of the system up to the desired or needed capacity. The typical components are illustrated in **Figure 5-5**.

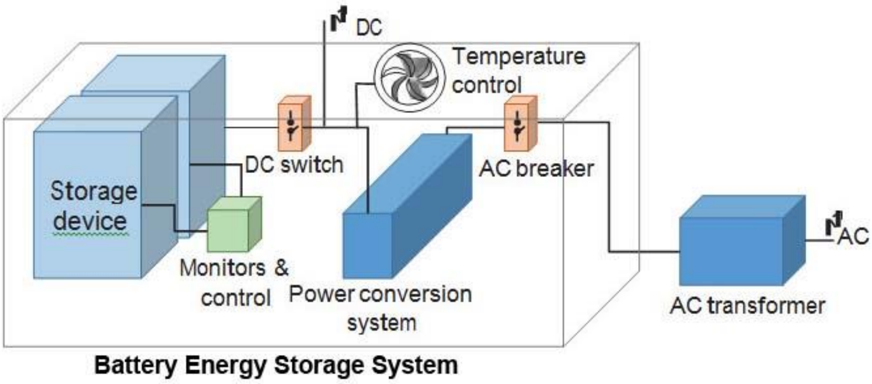

Figure 5-5: Conceptual BESS components[22]

While certain components may generate a slight hum under load, the dominant source of noise is from the fans or climate control system used to manage heat in the system and/or

[22] Source: http://www.amdcenergy.com/battery-energy-storage-system.html

to maintain the BESS within its optimal operating temperature range. These BESSs however generate low noise levels, with any potential noise impact generally limited to areas within 200m of the BESS. This is an insignificant noise level and the significance of this noise will be low.

5.2.6 Transformer noises (Substations)

Also known as magnetostriction[23], is when the sheet steel used in the core of the transformer tries to change shape when being magnetised. When the magnetism is taken away, the shape returns, only to try and deform in a different manner when the polarity is changed.

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

However, this is a relatively easy noise to mitigate with the use of acoustic shielding and/or placement of the transformer and will not be considered further in this ENIA study. Substations in addition generate low noise levels, with the hum from the transformers inaudible further than 200 m from the transformers.

5.2.7 Transmission Line Noise (Corona noise)

Corona noise[24] 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

[23] https://en.wikipedia.org/wiki/Magnetostriction
[24] https://en.wikipedia.org/wiki/Corona_discharge

'crackling' or 'buzzing', but ***fortunately it is generally only a feature that occurs 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 METHODS: NOISE IMPACT ASSESSMENT

6.1 NOISE IMPACT ON ANIMALS

A significant amount of research was undertaken during the 1960's and 70's on the effects of aircraft noise on animals (Autumn, 2007) [**2**], (Noise quest, 2010) [**92**]. While aircraft noise has a specific characteristic that might not be comparable with industrial noise, the findings should be relevant to most noise sources. A general animal behavioural reaction to aircraft noise is the startle response with the strength and length of the startle response to be dependent on the following:

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

Overall, the research suggests that species differ in their response to noise depending on the duration, magnitude, characteristic and source of the noise, as well as how accustomed the animals are to the noise (previous exposure).

Extraneous noises impact on animals as it can increase stress levels and even impact on their hearing. Masking sounds may affect their ability to react to threats, compete and seek mates and reproduce, hunt and forage, communicate and generally to survive.

Unfortunately, there are numerous other factors in the faunal environment 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.

The only animal species studied in detail are humans, and studies are still continuing in this regard. These studies also indicate that there is considerable variation between individuals, highlighting the loss of sensitivity to higher frequencies as humans age. Sensitivity also varies with frequency with humans. Considering the variation in the sensitivity to frequencies and between individuals, this is likely similar with all faunal species. Some of these studies are repeated on animals, with behavioural hearing tests being able to define the hearing threshold range for some animals as indicated on **Figure 6-1**.

Only a few faunal (animal) species have been studied in a bit more detail so far, with the potential noise impact on marine animals most likely the most researched subject, with a few studies that discuss behavioural changes in other faunal species due to increased noises. Few studies indicate definitive levels where noises start to impact on animals, with most based on laboratory level research (USEPA, 1971) [**135**] that subject animals to noise levels that are significantly higher than the noise levels these animals may experience in their environment (excluding the rare case where bats and avifauna fly extremely close to an anthropogenic noise, such as from a moving car or the blades of a wind turbine).

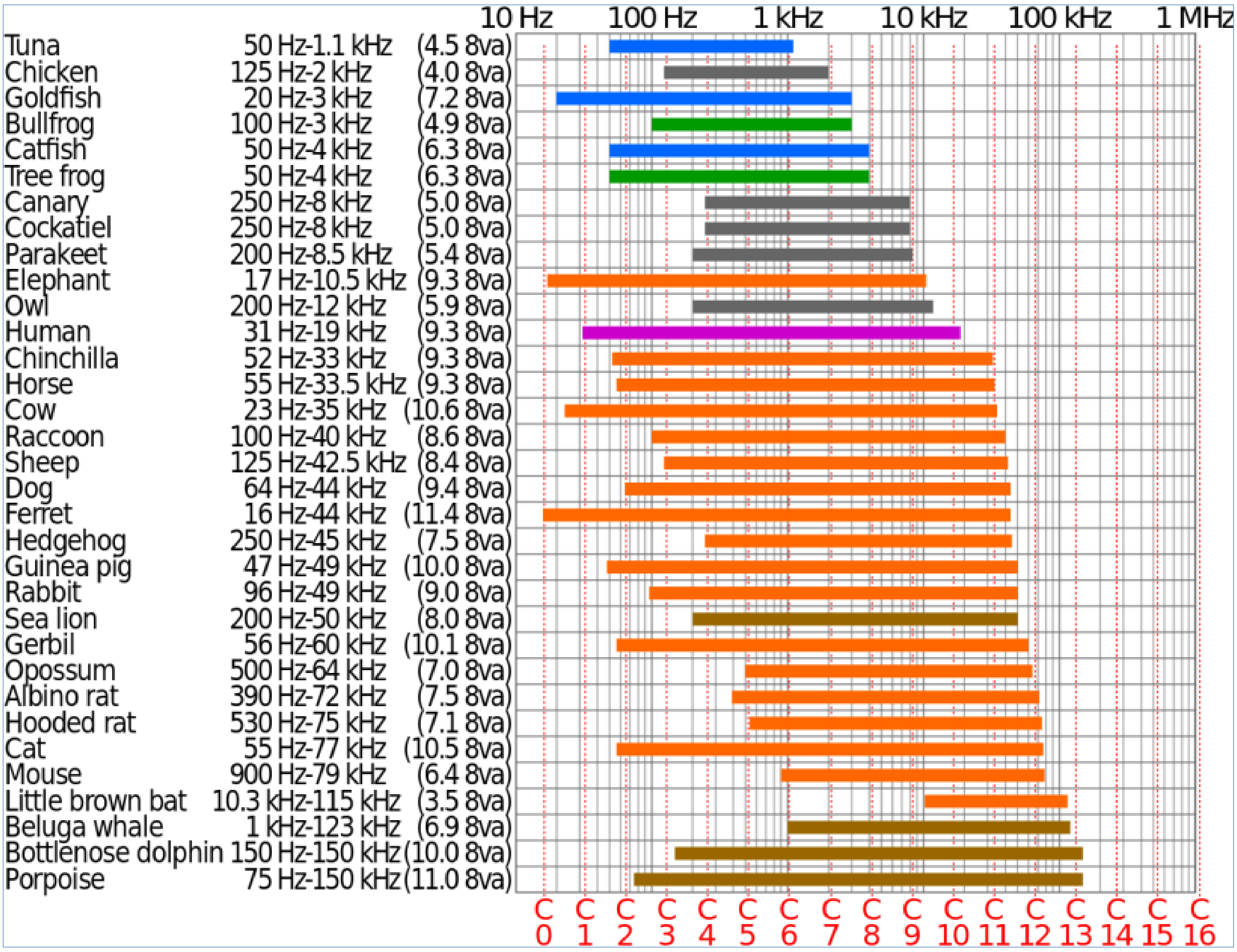

Figure 6-1: Logarithmic Chart of the Hearing Ranges of Some Animals[25]

6.1.1 Domesticated Animals

Excluding loud impulsive noises, considering the environmental noise levels (the noise levels were not defined, but levels of up to 100 dB were reported), it has been observed that most domesticated animals are generally not bothered by noise and generally can acclimatize relatively quickly to loud noises (Šottník, 2011) [**122**]. Considering the expected wind turbine noise (WTN) levels (well less than 60 dBA at all locations), WTN will not impact on domestic animals (Noise quest, 2010) [**92**].

[25] https://en.wikipedia.org/wiki/Hearing_range

6.1.2 Wildlife

Studies indicated that most animals adapt to noises, and would even return to a site after an initial disturbance, even if the noise is continuous. The more sensitive animals that might be impacted by noise would most likely relocate to a quieter area. Helldin (2012) [**58**] however highlights that the network of access road could be a significant factor impacting on animals. Noise impacts are therefore very highly species-dependent (Blickley and Patricelli, 2010) [**9**], (Cummings, 2012) [**28**], (Cummings, 2009) [**29**], (Łopucki, Klich and Gielarek, 2017) [**78**], (Noise quest, 2010) [**92**], (Rabin, Coss and Owings, 2006) [**110**], but there are also other factors that could impact on animals (such as visibility and increased movement of people and vehicles).

6.1.3 Avifauna

As with other terrestrial faunal species, noise (character of sound or change in level) will impact on avifauna (birds of a particular region and/or habitat). Anthropogenic noises result in physical damage to ears, increased stress, flight or flushing, changes in foraging and other behavioural reactions. Ortega (2012) [**96**] summarized that additional responses (with ecological similar controls) include the avoidance of noisy areas, changes in reproductive success and changes in vocal communication. However, as with other faunal species, there are no guidelines to assess at which sound pressure level avifaunal will start to exhibit any response (Autumn, 2007) [**2**], (Cummings, 2009) [**29**], (Dooling and Popper, 2007) [**35**], (Lohr, Wright and Dooling, 2003) [**76**], (Ortega, 2021) [**96**], (Schaub, Ostwald and Siemers, 2008) [**119**], (Zwart *et al.,* 2014) [**150**].

6.1.4 Concluding Remarks - Noise Impacts on Animals

From these and other studies the following can be concluded:

- To date there are no guidelines or sound limits with regards to noise levels that can be used to estimate the potential significance of noises on animals (Blickley *et al.,* 2010) [**9**].
- Animals respond to impulsive (sudden) noises (higher than 90 dBA) by running away. If the noises continue, animals would try to relocate (Dooling, 2007) [**35**].
- Terrestrial wildlife responses begin at noise levels of approximately 40 dBA, with 20% of papers documenting impacts below 50 dBA (Shannon *et al.* 2015) [**123**].
- Animals start to respond to increased noise levels with elevated stress hormone levels and hypertension. These responses begin to appear at exposure levels of 55 to 60 dBA (Baber, 2010) [**5**], with Helldin *et al.* (2012) [**58**] reporting that levels of 60–75 dBA have been shown to cause stress, e.g., increased respiration and heart rate, increased vigilance, and decreased time for grazing in domestic animals such as sheep and horses.

- Animals of most species exhibit adaptation with noise (Broucek, 2014) [**15**], including impulsive noises, by changing their behaviour.
- There may be a possible impact on the health of animals (Mikolajczak, 2013; Karwowska, 2015) caged very close to an operating WTG (within 500 m) (Karwowska, 2015) [**73**], (Mikolajczak, 2013) [**85**];
- Songbirds may change the spectral character of songs and calls used for communication and defence in areas very close to WTGs. This is similar to the effects of other anthropogenic noise sources such as traffic, which can disrupt bird 'chatter' to the point of being detrimental to reproductive success (Szymański, 2017; Zwart, 2014) [**129** ,**150**];
- More sensitive species would relocate to a quieter 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 (Dooling, 2007; Łopucki, 2017) [**35**, **78**].
- Noises associated with helicopters, motor- and quad bikes significantly impact on animals (startle response). This is due to the sudden and significant increase in noise levels due to these activities [(Autumn, 2007) [**2**, **135**];
- Focusing on small species (rodents and shrews), Łopucki (2016) [**77**] assessed differences between control sites and locations close to wind turbines (the distances from WTG were not defined), concluding no significant differences between the sites;
- Łopucki (2017) [**78**] studied tracks from various species (Roe deer, European hare, Common pheasant and Red fox), from as close as 100m from WTG to 700m away. That study determined that
    - Roe deer and European hare visit the areas closer to WTG less frequently than areas further away,
    - Common pheasant appear to visit the areas closer to WTG more frequently, and
    - Red fox showed the most neutral response to WTG; and
- Helldin *et al*. (2012) [**58**] also report that large terrestrial mammals appear to acclimatise to wind farms during the operational phase, arguing that WF mainly affect large terrestrial mammals through an increase in human activity.

With regard to Low-Frequency Noise (LFN) and Infrasound, it is summarized that:

- There are no scientific papers available in reputable journals highlighting the impact of LFN from WTG on wildlife;
- Animal communication is generally the highest during no and low wind conditions. It has been hypothesised that this is one of the reasons why birds sing so much in the mornings (their voices carry the farthest and there are generally less observable wind);

- Background noise levels (ambient sound levels) in remote areas are not always low in space or time. The site is windy and this generates significant noise itself and also significantly changes the ability of fauna to hear the environmental noises around them;
- Wind is a significant source of natural noise, with a character similar to the noise generated by wind turbines, with a significant portion of the acoustic energy in the low frequency and infrasound range;
- Wind turbines do not emit broad-band sound on a continual basis as the turbines only turn and generate noise when the wind speeds are above the cut-in speed;
- The wind turbines will only operate during periods of higher wind speeds, a period when background noise levels are already elevated due to wind-induced noises; and
- The elevated background noise relating with wind also provide additional masking of the wind turbine noise, with periods of higher winds also correlating with lower faunal activity, particularly with regard to communication.

It should be noted that LFN and Infrasound is present in the environment and is generated by a wide range of natural sources (e.g., wind, waves etc.). In February 2013, the Environmental Protection Authority of South Australia published the results of a study into infrasound levels near wind farms (Evans, 2013). This study measured infrasound levels at urban locations, rural locations with wind turbines close by, and rural locations with no wind turbines in the vicinity. It found that infrasound levels near wind farms are comparable to levels away from wind farms in both urban and rural locations. Infrasound levels were also measured during organized shut-downs of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.

6.2 WHY NOISE CONCERNS COMMUNITIES [3, 14, 19, 24, 29, 49, 74, 91, 108, 124]

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

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

However, it is important to remember that whether a given sound is "noise" depends on the listener or hearer. The driver playing loud rock music on their car radio hears only music, but the person in the traffic behind them hears nothing but noise.

Response to noise is unfortunately not an empirical absolute, as it is seen as a multi-faceted psychological concept, including behavioural and evaluative aspects. For instance, in some cases, annoyance is seen as an outcome of disturbances, and 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 prefer to sleep. Noise impacts are also complex to evaluate as numerous issues could cumulatively contribute to the severity of the impact, as discussed in the following subsections.

How a noise may impact (with this assessment using annoyance about the noise) on a receptor is also very complex to assess for the reasons highlighted in **section 6.2.1** below. Only considering the intensity of a sound (or noise) level, some people may become annoyed without hearing any noise (perceived impacts) where others may not even be reporting noise to be a concern, even when subjected to very high levels.

6.2.1 Noise Annoyance

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 the non-acoustic factors play a major role. Non-acoustic factors that have been identified include age, economic dependence on the noise source, attitude towards the noise source and self-reported noise sensitivity (Bakker *et al.*, 2012) [**4**], (Council of Canadian Academies, 2015) [**23**], (Ellenbogen *et al.*, 2012) [**38**], (Halfwerk *et al.*, 2011) [**54**], (Hanning, 2010) [**55**], (Janssen *et al.*, 2011) [**67**], (Knopper *et al.*, 2014) [**74**], (Merlin *et al.*, 2013) [**82**], (Miedema and Vos, 2003) [**83**], (Minnesota Department of Health, 2009) [**86**], (Nissenbaum, 2012) [**90**], (Pedersen, 2007) [**101**], (Pedersen, 2007) [**102**], (Pedersen, Halmstad and Högskolan, 2003) [**103**], (Pedersen, 2011) [**104**], (Pierpont, 2009) [**106**], (Schmidt and Klokker, 2014) [**120**], (Van den Berg *et al.*, 2008) [**138**], (Van den Berg, Verhagen and Uitenbroek, 2014) [**139**], (World Health Organization, 2009) [**147**].

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 6-2**, are recommended in a European Union position paper published in 2002, stipulating policy regarding the quantification of annoyance. This can be used in 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 levels.

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 and health state of the receptor; and
- The attitude of the receptor about the emitter (noise source).

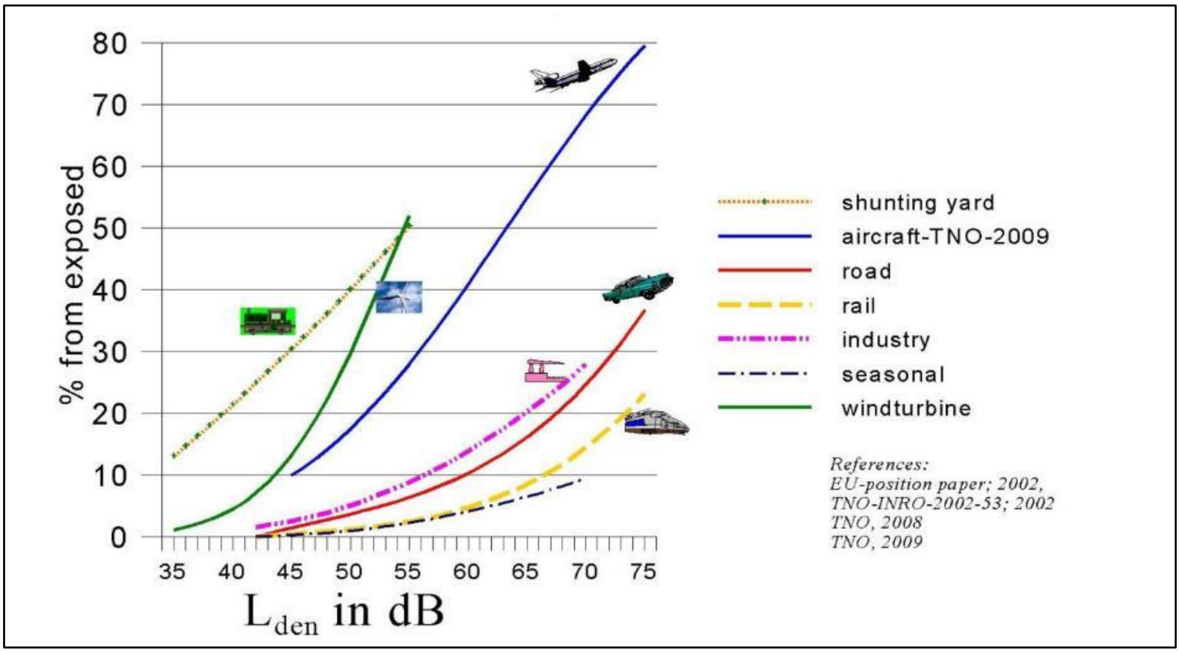

Figure 6-2: Percentage of annoyed persons as a function of the day-evening-night noise exposure at the façade of a dwelling[26]

6.2.1.1 Disturbance to Sleep

Sleep is essential for mental and physical health, and noise is one of the most reported reasons why people may experience sleep interruptions at night. This may be sudden loud

[26] Image from https://rigolett.home.xs4all.nl/ENGELS/topic.htm. Wind Turbine Annoyance curve from Pedersen (2007)

noises, with the WHO (2009) [**147**] reporting that, when maximum noises exceed 60 dBA, with average noise levels exceeding 40 dBA, it may increase the probability of being awakened. People report that quality of life suffer with increased instances of disturbed sleep that may also increase annoyance with a project (Bakker *et al.*, 2012) [**4**], (Van den Berg, Verhagen and Uitenbroek, 2014) [**139**]. It should be noted that Van den Berg (2014) [**138**, **139**] showed an indirect effect between sleep disturbances and annoyance, but not between sleep disturbance and the noise level. It is postulated that this is due to increased annoyance due to the visual impact from WTG.

6.2.1.2 Potential Health Effects from WTN

While there has been a number of complaints about the impact of WTN on the health of people living close to WTG (Halfwerk *et al*., 2011) [**54**], (Hanning, 2010) [**55**], (Janssen *et al.*, 2011) [**67**], (Nissenbaum, 2012) [**90**], (Pierpont, 2009) [**106**], other than annoyance and sleep disturbances, there is no evidence of any direct health effects (Council of Canadian Academies, 2015) [**23**], (Ellenbogen *et al.*, 2012) **38**, (Knopper *et al.*, 2014) [**74**], (Minnesota Department of Health, 2009) [**86**],(MDEP) **81**, (Merlin *et al.*, 2014) [**82**], (Pedersen, Halmstad and Högskolan, 2003) [**103**], (Schmidt and Klokker, 2014) [**120**].

6.2.1.3 Situational and Personal Factors

There are a few other aspects, collectively referred to as non-acoustical factors that may increase annoyance with a project (Miedema, 2003) [**83**], (Pedersen, 2007) [**102**]. These could include:

- Situational factors (visual issues, attractiveness of area) (Merlin *et al.*, 2013) [**82**], (Michaud *et al.*, 2016) [**84**], (Van den Berg *et al.*, 2008) [**138**];
- Socio-economic factors (age, gender, income, level of education) [(Miedema, 2003) **83**, (Michaud *et al.*, 2016) [**84**];
- Social factors (attitude towards the applicant/producer/government, media coverage) [(Pedersen, 2007) **102**, **128**]; and
- Personal factors (fear or worry in relation to noise source, sensitivity to noise, economic benefit from project, existing health condition) [(Miedema, 2003) **83**, **140**].

6.3 IMPACT ASSESSMENT CRITERIA

6.3.1 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; and
- Offensiveness.

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

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

6.3.2 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 of 2014 in terms of the NEMA, SANS 10103:2008, and guidelines from the 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, caused by a new source of noise. With regards to the NCR, an increase of more than 7 dBA is considered a disturbing noise. See also **Figure 6-3**.
- *Zone Sound Levels:* Previously referred to as the acceptable rating levels, sets acceptable noise levels for various areas. See also **Table 6-1**.
- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g. 65 dBA. Anything above this level will be considered unacceptable.

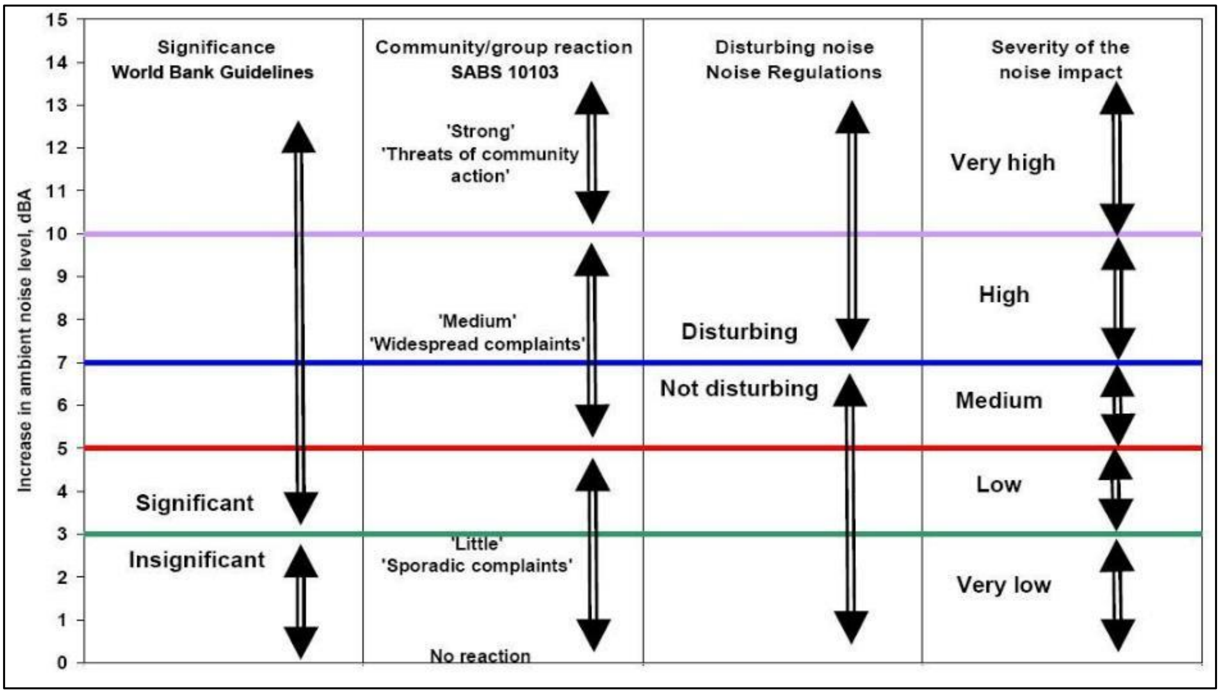

Figure 6-3: Criteria to assess the significance of impacts stemming from noise

In South Africa, the document that addresses the issues concerning environmental noise is SANS 10103:2008 (See also **Table 6-1**). It provides the equivalent ambient noise levels (referred to as Rating Levels), $L_{Req,d}$ and $L_{Req,n}$, during the day and night respectively to which different types of developments may be exposed.

Table 6-1: Acceptable Zone Sound Levels for noise in districts (SANS 10103:2008)

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

6.4 SETTING APPROPRIATE NOISE LIMITS

Onsite ambient sound measurements (**Section 4.3.1**) indicated an area with a potential to be very quiet, with ambient sound levels typical of a rural noise district.

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 considered.

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 ambient sound levels in the environment within which they are heard will probably also be dependent on 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.

6.4.1 Using International Guidelines to set Noise Limits – ETSU-R97

When assessing the overall noise levels emitted by a WEF, 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 most unlikely to cause any greater loss of amenity at higher wind speeds. Turbine noise levels increase only slightly as wind speeds increase; however, background ambient sound levels increase significantly with increasing wind speeds due to the force of the wind.

Available data indicates that wind-induced noises start to increase at wind speeds 3 – 4 m/s, becoming a 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 building, rustling of leaves in trees, rattling noises, etc) could start to drown other noises, including that being generated by wind turbines[27].

Sound level vs. wind speed data is presented in **Figure 4-33**[28]. It is based on approximately 38,000 measurements collected at various quiet locations in South Africa (locations further than 10 km from the ocean). Also indicated are around 1,000 and 500 actual day- and night-time measurements collected within, or close to the PFA, of the proposed WEF. There was a lack of very high wind speeds during the site visit, but as with other sites, ambient sound levels are expected to increase as the surrounding wind speed increase. This has been found at all locations where measurements have been done for a sufficiently long enough period of time (more than 30 locations comprising of more than 38,000 measurements) with the data agreeing with a number of international studies on the subject.

Considering this data as well as the international guidelines (MOE, see **Table 3-1**; IFC, see **Table 3-2**), 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 – does not differentiate between day and night-time periods, although this is assumed to be for the night-time period).

6.4.2 Considering the latest WHO (2018) recommendations

The WHO (2018) [**148**] recommends a guideline night-time noise level of 38.7 dBA (based on the 45 dBA L_{DEN} level) to minimize sleep-disturbance and receptors being highly-annoyed (see **section 3.5.9**).

6.4.3 Using the National and Provincial NCR to set noise limits

Noise limits as set by the National and the Western Cape NCRs (GN R154 of 1992 – **section 3.2.1** and the PN.200 of 2013 – **section 3.2.2**) defines a "**disturbing noise**" as the Noise Level which exceeds the ambient sound level at the same measuring point by 7 dBA or more.

[27] It should be noted that this does not mean that the wind turbines are inaudible.
[28] 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.

Based on the ambient sound level measurements:

- The daytime rating level (zone sound level) would be typical of a rural noise district (45 dBA), setting a maximum noise limit of 52 dBA during the day; and
- The night-time rating level (zone sound limit) is typical of a rural noise district (35 dBA), setting a maximum noise limit of 42 dBA at night (construction phase).

As can be observed from **Figure 4-33**, if ambient sound levels were measured at increased wind speeds, ambient sound levels will be higher as wind-induced noises increase. 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 6-2** will be recommended.

Table 6-2: Proposed ambient sound levels and acceptable rating levels

10 m Height Wind Speed (m/s)	Estimated ambient sound levels (night-time) (dBA)	MoE Sound Level Limits of Class 3 areas (Table 3-1) (dBA)	ETSU-R97 limit for project participants (dBA)	Night-time Zone Sound Level (SANS 10103:2008) (dBA)	Proposed Night Rating Level (dBA)
4	37.6	40	45	35 (at low wind speeds, this will increase as wind speeds increase)	40
5	38.6	40	45		40
6	39.5	40	45		40
7	40.5	43	45		43
8	41.5	45	45		45
9	42.5	49	45		45
10	43.5	49	45		45
11	44.5	49	45		45
12	45.0	49	45		45

6.5 DETERMINING THE SIGNIFICANCE OF THE NOISE IMPACT

6.5.1 Impact Assessment criteria

The level of detail as depicted in the EIA Guidelines (CSIR, 2002) [**26**] was fine-tuned by assigning specific values to each impact, considering the impact rating methodology developed by the EAP. 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. Being a comparative assessment, it should be noted that this review use the same EIA criteria used in the 2022 ENIA (Sivest, 2022 [121]).

This scale takes into consideration the following variables:

- **Nature of Impact**: The type of effect that the activity will have on the environment.
- **Status**: Whether the impact would be positive, negative or neutral.
- **Extent:** the spatial scale defines the physical extent of the impact.
- **Probability:** The likelihood of impacts taking place as a result of project actions arising from the various alternatives.
- **Reversibility:** The extent to which the impacts/risks are reversible at the end of project life.
- **Irreplaceability of resource:** The degree to which the impact may cause a loss of an irreplaceable resource at the end of the life cycle.
- **Duration:** The temporal scale defines the significance of the impact at various time scales, as an indication of the duration of the impact.
- **Consequence (Magnitude):** The severity or intensity of the impact on the surrounding receptors.
- **Significance**: The criteria in **Table 6-8** are used to determine the overall significance of an activity. The impact effect (which includes duration; extent; consequence and probability) and the reversibility/mitigation of the impact are estimated using the criteria as defined before, and after the implementation of the potential mitigation measures.

The impact significance is determined by multiplying the sum of scores of Consequence (**Table 6-7**), Duration (**Table 6-3**) and the Spatial Extent (**Table 6-4**) with the Probability score (**Table 6-5**) to obtain the final Impact Significance as defined in the equation below. It should be noted that while intensity can be calculated to an extent, probability of an impact occurring, or a receptor being annoyed is difficult to determine with this assessment making use an empirical method as defined in **Table 6-5**.

$$Significance\ Rating = (Extent + Probab. + Revers. + Irreplace. + Duration)\ x\ Probability$$

Table 6-3: Impact Assessment Criteria - Duration

The lifetime of the impact that is measured in relation to the lifetime of the proposed development (construction, operational and closure phases). Will the receptors be subjected to increased noise levels for the lifetime duration of the project, or only infrequently.		
Rating	**Description**	**Score**
Short	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of	1

	a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years)	
Medium	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).	2
Long	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).	3
Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).	4

Table 6-4: Impact Assessment Criteria – Spatial extent

Classification of the physical and spatial scale of the impact		
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 / District	The impact could affect the local area or district.	2
Province / Regional	The impact could affect the region or province.	3
National or International	The impact could have an effect that expands throughout the country (South Africa) or more.	4

Table 6-5: Impact Assessment Criteria – Probability

This describes the likelihood of a noise impact (receptors being annoyed) 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**
Unlikely	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
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. In a rural environment, once noise levels exceed 38.7 dBA (see also **section 3.5.9**) at night.	2
Probable	There is a possibility that the impact will occur to the extent that provisions must be made. Noise levels exceeding 45 dBA at night.	3
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. Any noise levels higher than 50 dBA at night.	4

Table 6-6: Impact Assessment Criteria – Irreplaceability of Resource

The degree to which resources will be irreplaceably lost as a result of a proposed activity.		
Rating	**Description**	**Score**
No loss	The impact will not result in the loss of any resources	1
Marginal	The impact will result in marginal loss of resources	2
Significant	The impact will result in significant loss of resources	3

Complete	The impact is result in a complete loss of all resources	4

Table 6-7: Impact Assessment Criteria – Intensity / Magnitude

This defines the impact as experienced by any receptor. In this report, the NSR is defined as any resident in the area but excludes faunal species (because guideline levels are not available for animals).		
Rating	**Description**	**Score**
Low	Increase in average sound pressure levels between 0 and 3 dB from the expected ambient sound levels. Ambient sound levels are defined by average fast-weighted ambient sound levels recorded during measurement dates.	1
Medium / Moderate	Increase in average sound pressure levels between 3 and 5 dB from the expected or measured ambient sound levels.	2
High	Increase in average sound pressure levels between 5 and 7 dB from the expected or measured ambient sound levels. Sporadic complaints expected.	3
Very High	Increase in expected or measured ambient sound pressure levels higher than 10 dBA. Medium to widespread complaints expected.	4

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned probabilities, resulting in a Significance Rating ("SR") value for each impact (prior to the implementation of mitigation measures) as highlighted in **Table 6-8**.

Table 6-8: Impact Assessment Criteria – Significance without Mitigation

SR<24	Low (L)	The anticipated impact will have negligible negative effects and will require little to no mitigation
24<**SR** <43	Medium (M)	The anticipated impact will have moderate negative effects and will require moderate mitigation measures
43<**SR** <62	High (H)	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact
63<**SR** <80	High (H)	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws"

7 METHODS: CALCULATION OF NOISE LEVELS

7.1 POINT[29] AND AREA[30] NOISES – CONSTRUCTION AND OPERATIONAL ACTIVITIES

The noise emissions from various sources were calculated in detail for the conceptual construction and operational activities by using the sound propagation algorithms described by the ISO 9613-2 model. The following were considered:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receivers 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;
- Screening corrections where applicable;
- Topographical layout; and
- Acoustical characteristics of the ground.

Potential operational cycles were not considered and a worst-case scenario was evaluated, assuming that all activities and equipment generate the maximum noise level 100% of the time.

The ISO 9613-2 noise propagation model is used, as it is the noise model most recommended to calculate WTN. The uncertainties and limitations of the ISO 9613 model is well defined; and while there are a number of different noise propagation models that one can use, all of them have uncertainties and limitations.

Therefore, the ISO 9613 noise propagation model is the model most frequently recommended, with this noise propagation model preferred in Australia (EPA, 2009) [**40**], the United Kingdom (IOA, 2013) [**65**], Canada (CanWEA, 2007) [**17**], United States of America (NARUC, 2011) [**89**] and the European Union (Directive 2002/49/EC)[31] [**25**, **36**].

[29] Typically a WTG, or a stationary noise generating activity or piece of equipment.
[30] Such as a large surface vibrating, up to a defined area where equipment is moving around. It can include an industrial project where the locations of noise generating activities or equipment cannot be defined. This is used as a worst-case, as the inclusion of a large area source(s) tend to over model noise levels.
[31] This directive does not recommend but actually stipulate the use of this noise model for industrial noise sources.

7.2 ROAD TRAFFIC NOISE LEVELS

The noise emission into the environment due to project road traffic (mainly construction traffic) will be estimated using a simplified noise propagation model described in SANS 10210:2004. It mainly considers the distance of receptor from the road as well as average speeds of travel. Factors that are not considered include:

- Topography and barrier effects (noise levels could be over-estimated);
- Road construction material (noise levels could be over-estimated);
- Types of vehicles used (noise levels could be under-estimated);
- Road gradient (noise levels could be over- or under-estimated); and
- Ground acoustical conditions (noise levels could be over-estimated).

8 ASSUMPTIONS AND LIMITATIONS

8.1 LIMITATIONS - ACOUSTICAL MEASUREMENTS AND ASSESSMENTS

Ambient sound levels are the cumulative effects of innumerable sounds generated at various instances both far and near. A high measurement may not necessarily mean that the area is always noisy. 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 day, dependant on faunal characteristics (such as mating season or dawn chorus[32]) early hours of the morning, temperature etc.), vegetation in the area and meteorological conditions (especially wind).

Selecting an ideal measurement location could be difficult, with various criteria assessed to identify the viability of a certain location as a point to define ambient sound levels. When selecting a measurement location, the most important criteria would be:

1. Security of the instrument (minimise risk to the technician; prevent theft; sabotage of the equipment);
2. Safety of the equipment (ensure that it does not prevent, interfere or limit typical agricultural or household activities; ensure that the instrument are not in a location where an animal could damage the instrument); and lastly,
3. The suitability of the measurement location to define ambient sound levels (the presence of certain trees or equipment, wetland or other water resources will influence ambient sound level significantly).

As such, after ensuring that the instrument is safe and secure, there are various environmental factors that could influence ambient sound levels measured. These constraints and limitations are discussed below and could include:

- Seasonal changes in the surrounding environment can influence typical ambient sound levels, as many faunal species are more active during warmer periods than the colder periods. As an example, cicada is usually only active during warmer periods. Certain cicada species can generate noise levels up to 120 dB for mating or distress purposes, sometimes singing in synchronisation magnifying noise levels they produce from their tymbals[(33)];
- Defining ambient sound levels using the result of one 10-minute measurement may be very inaccurate (very low confidence level in the results) relating to the reasons mentioned above, and measurements over a longer-term period is critical;

(32) Environ. We Int. Sci. Tech. *Ambient noise levels due to dawn chorus at different habitats in Delhi*. 2001. Pg. 134.
(33) Clyne, D. *"Cicadas: Sound of the Australian Summer, Australian Geographic"* Oct/Dec Vol 56. 1999.

- Some equipment that could influence measurements may be missed when deploying instruments, or, the equipment may not the audible. This could include equipment such as hidden water pumps and associated pipelines and outflows, ESKOM stepdown transformers, hidden compressors, inverters, condensers or other electrical equipment, etc. While not audible during deployment, such equipment may significantly influence ambient sound levels during quiet periods;
- Type, the number and sizes of trees in the vicinity of the instrument, as well as the distances between the microphone and these trees. Certain trees, especially fruiting trees could attract birds and other animals that will significantly impact on ambient sound levels;
- Type and number of animals in the vicinity of the microphone. Dogs, chickens, geese, etc. generate different noises randomly both night and day, and other livestock (sheep, goats, cattle, horses, etc.) kept in enclosures will also raise noise levels, especially if these animals are penned in large numbers;
- Measurements over wind speeds of 3 m/s could provide data influenced by wind-induced noises. However, when determining the ambient sound levels associated with increased wind speeds, it is desired to measure ambient sound levels at higher wind speeds;
- Ambient sound levels recorded near rivers, streams, wetlands, trees and bushy areas can be high due to faunal activity which can dominate the sound levels around the measurement point (specifically during summertime, rainfall event or during dawn chorus of bird songs). This generally is still considered naturally quiet and accepted as features of the natural environment, and in various cases sought after and pleasing. Ambient sound level data measured in such area however should not be used to develop an opinion in the potential prevailing ambient sound levels in the larger area;
- Exact location of a sound level meter in an area in relation to structures, infrastructure, vegetation, wetlands and external noise sources will influence measurements. It may determine whether you are measuring anthropogenic sounds from a receptors dwelling, or environmental ambient baseline contributors of significance (faunal, roads traffic, railway traffic movement etc.); and

  As a residential area develops the presence of people will result in increased dwelling related 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 an area matures.

8.2 CALCULATING NOISE EMISSIONS – ADEQUACY OF PREDICTIVE METHODS

Limitations due to the calculations of the noise emissions into the environment include the following:

- Many sound propagation models do not consider sound characteristics as calculations are based on an equivalent level (with the appropriate correction implemented e.g. tone or impulse). These other characteristics include intrusive sounds or amplitude modulation;
- Most sound propagation models do not consider refraction through the various temperature layers (specifically relevant during the night-times);
- Most sound propagation models do not consider the low frequency range (third octave 16 Hz – 31.5 Hz). This would be relevant to facilities with a potentially low frequency issue;
- Many environmental models consider sound to propagate in hemi-spherical way. Certain noise sources (e.g., a speaker, exhausts, fans) emit sound power levels in a directional manner;
- 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;
- Many environmental models are not highly suited for close proximity calculations; and
- Acoustical characteristics of the ground are over-simplified, with ground conditions accepted as uniform.

8.3 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 is 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.

8.4 UNCERTAINTIES ASSOCIATED WITH MITIGATION MEASURES

Any noise impact can be mitigated to have a low significance; however, the cost of mitigating this impact may be prohibitive, or the measure may not be socially acceptable (such as the relocation of an NSR). These mitigation measures may be engineered, technological or due to management commitment.

For the purpose of the determination of the significance of the noise impact mitigation measures were selected that are feasible, mainly focussing on management of noise impacts using rules, policy and require a management commitment. This, however, does not mean that noise levels cannot be reduced further, only that to reduce the noise levels further may require significant additional costs (whether engineered, technological or management).

It was assumed the mitigation measures proposed for the construction phase, if any is included and proposed in this report, will be considered during the planning phase, implemented during the construction phase and continued during the operational phase.

8.5 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:

- It is technically difficult and time-consuming to improve the measurement of spectral distribution of large equipment in an industrial setting. This is due to the many correction factors that need to be considered (e.g., other noise sources active in the area, adequacy of average time setting, surrounding field non-uniformity etc.[34] as per SANS 9614-3:2005);
- 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 are 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 worst-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

[34] SANS 9614-3:2005. "Determination of sound power levels of noise sources using sound intensity – Part 3: Precision method for measurement by scanning".

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 likely be over-estimated;

- Modelling cannot capture the potential impulsive character of a noise that can increase the potential nuisance factor, nor the potential effect of the modulation of amplitude of the noise;
- The XYZ topographical information is derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer ("ASTER") Global Digital Elevation Model ("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;
- Receiver height will be assumed at a 4m height above surface level as recommended by the Institute of Acoustics (IOA, 2013) [**65**] for the operational phase;
- Atmospheric conditions relating to an air temperature of 10°C and a 70% air humidity will be used to minimize the effect of air absorption (Bass *et al.*, 1996) [**6**], (IOA, 2013) [**65**], (Kaliski and Duncan, 2008) [**70**]; and
- Acoustical characteristics of the ground are over-simplified with ground conditions accepted as uniform. Seventy-five percent (75%) hard ground conditions will be assumed for the operational modelling, representing a potential worst-case scenario (Bass *et al.*, 1996) [**6**], (IOA, 2013) [**65**], (Kaliski and Duncan, 2008) [**70**].

Due to the uncertainties highlighted in section **8.2** and **8.5**, modelling generally could be out with as much as +10 dBA (the potential noise level is over-modelled), although realistic values ranging from 3 dBA to less than 5 dBA are more common in practice.

8.6 CONDITIONS TO WHICH THIS STUDY IS SUBJECT

This study is subject to the conditions as defined in **section 13**.

9 PROJECTED NOISE RATING LEVELS

9.1 Conceptual Scenarios – Noise due to Future Construction Activities

A noise model was developed considering the conceptual construction activities as discussed in **Section 5.1**. The proposed layout as provided by the applicant for the Koup 1 WEF is presented in **Figure 9-1**. As can be seen from this layout, a number of different activities might take place close to potential NSR, each with a specific potential impact.

As it is unknown where the different activities may take place, it was selected to model:

- the potential impact of road construction (or upgrading) activities, assuming a SPL of 103.5 dBA (re 1 pW), with potential noise levels plotted against distance as illustrated in **Figure 9-3**;
- the potential impact from construction traffic (road traffic noises) passing NSR, with potential noise levels plotted against distance as illustrated in **Figure 9-2**[35]; and
- the impact of the noisiest activity (laying of foundation totalling 113.6 dBA (re 1 pW) cumulative noise impact – various equipment operating simultaneously – see **Table 5-1**) at all locations where wind turbines may be erected, calculating how this may impact on noise levels at NSR[36] (see **Figure 9-3**).

The projected noise levels relating to the various construction activities are defined in

- **Appendix F, Table 2** for the construction of the access roads;
- **Appendix F, Table 3** relating to the noise from construction traffic;
- **Appendix F, Table 4** for daytime construction activities; and,
- **Appendix F, Table 5** for night-time construction activities (even though night-time activities may be unlikely to occur).

[35] Sound level at a receiver set at a certain distance from a road.
[36] The potential cumulative (worst-case) noise level due to construction activities at an NSR are plotted against the distance from the NSR and a potential construction activity.

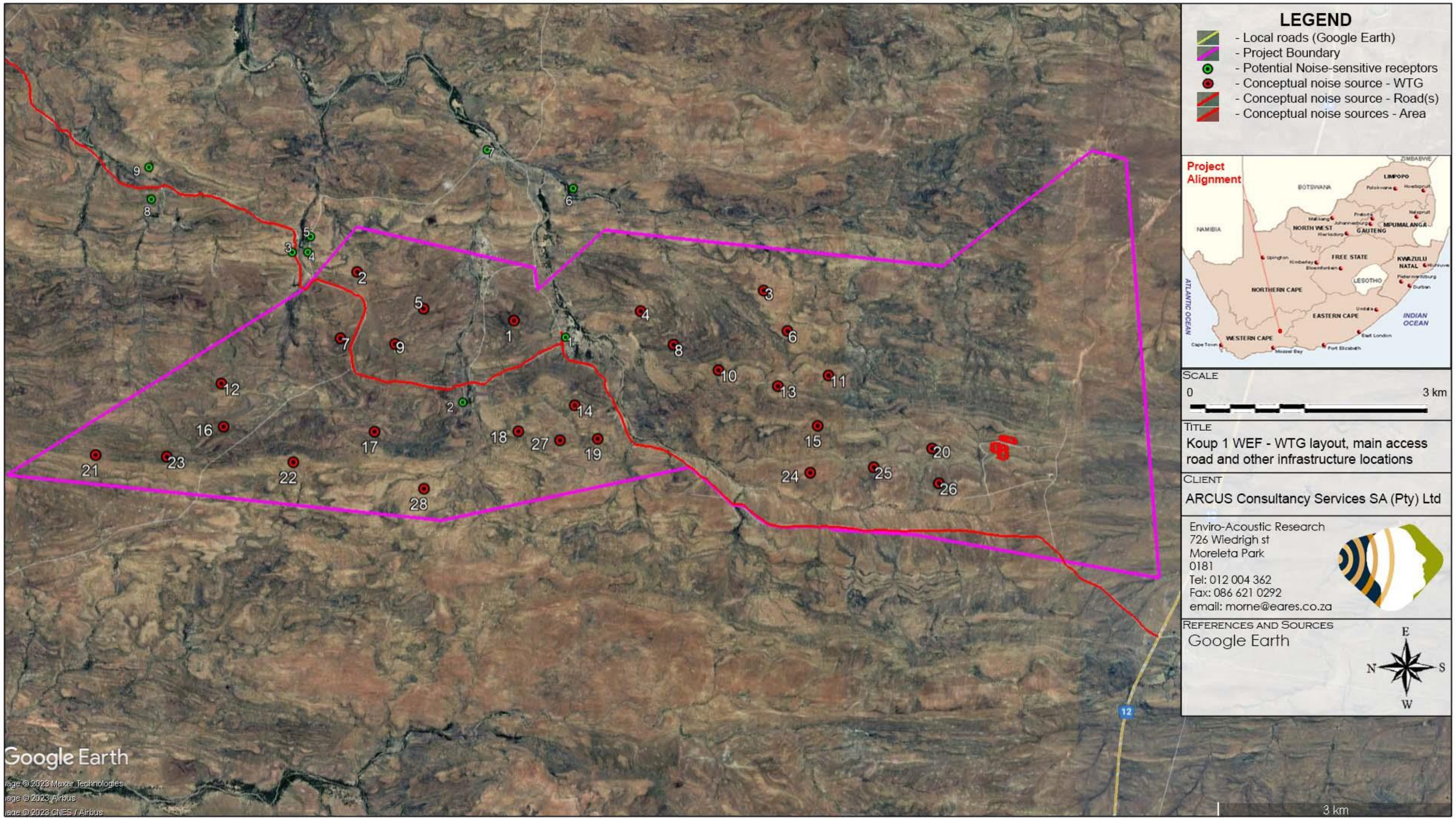

Figure 9-1: WTG locations and associated infrastructure for the proposed Koup 1 WEF

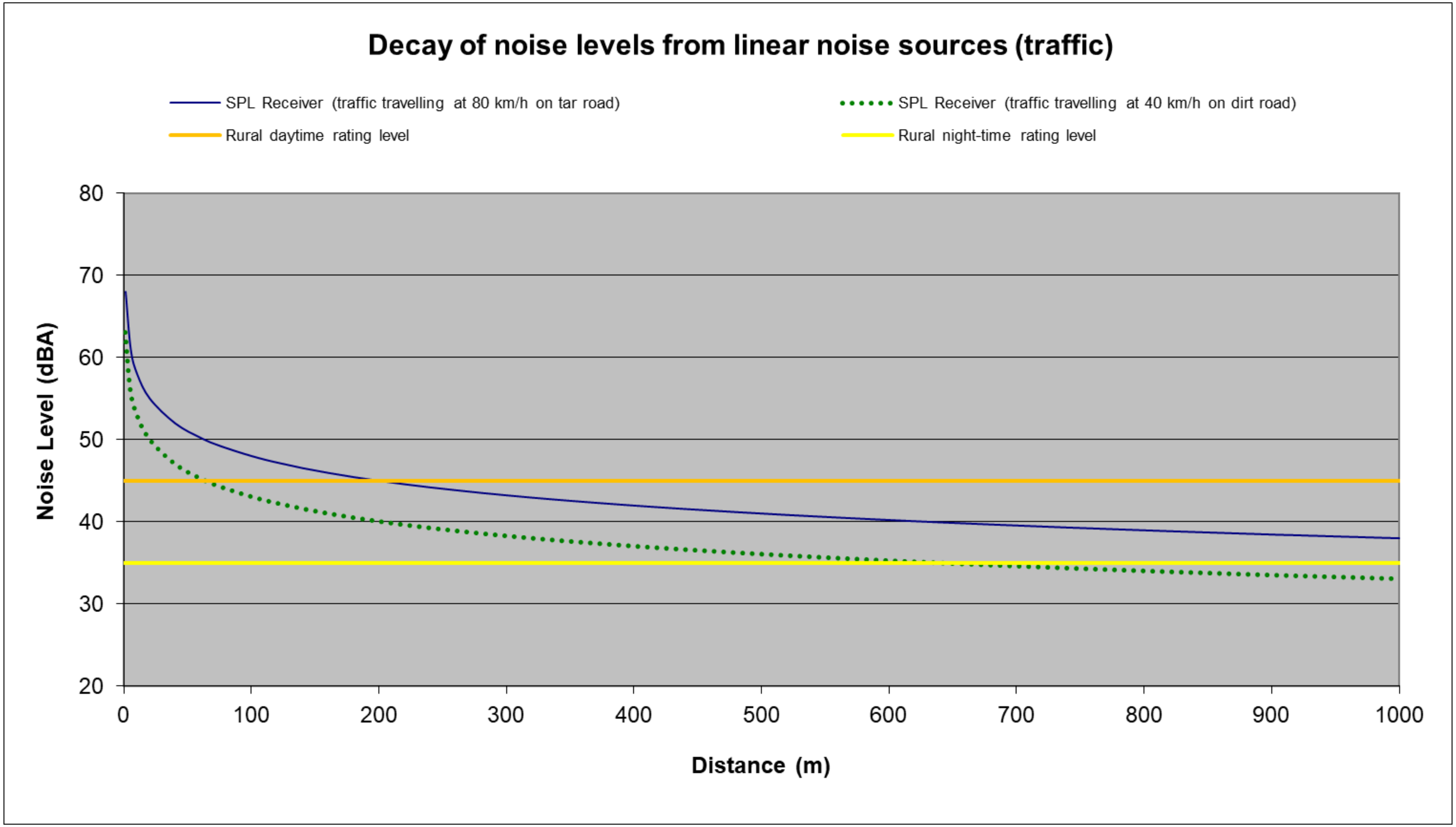

Figure 9-2: Projected conceptual construction noise levels – Decay over distance from linear activities (roads)

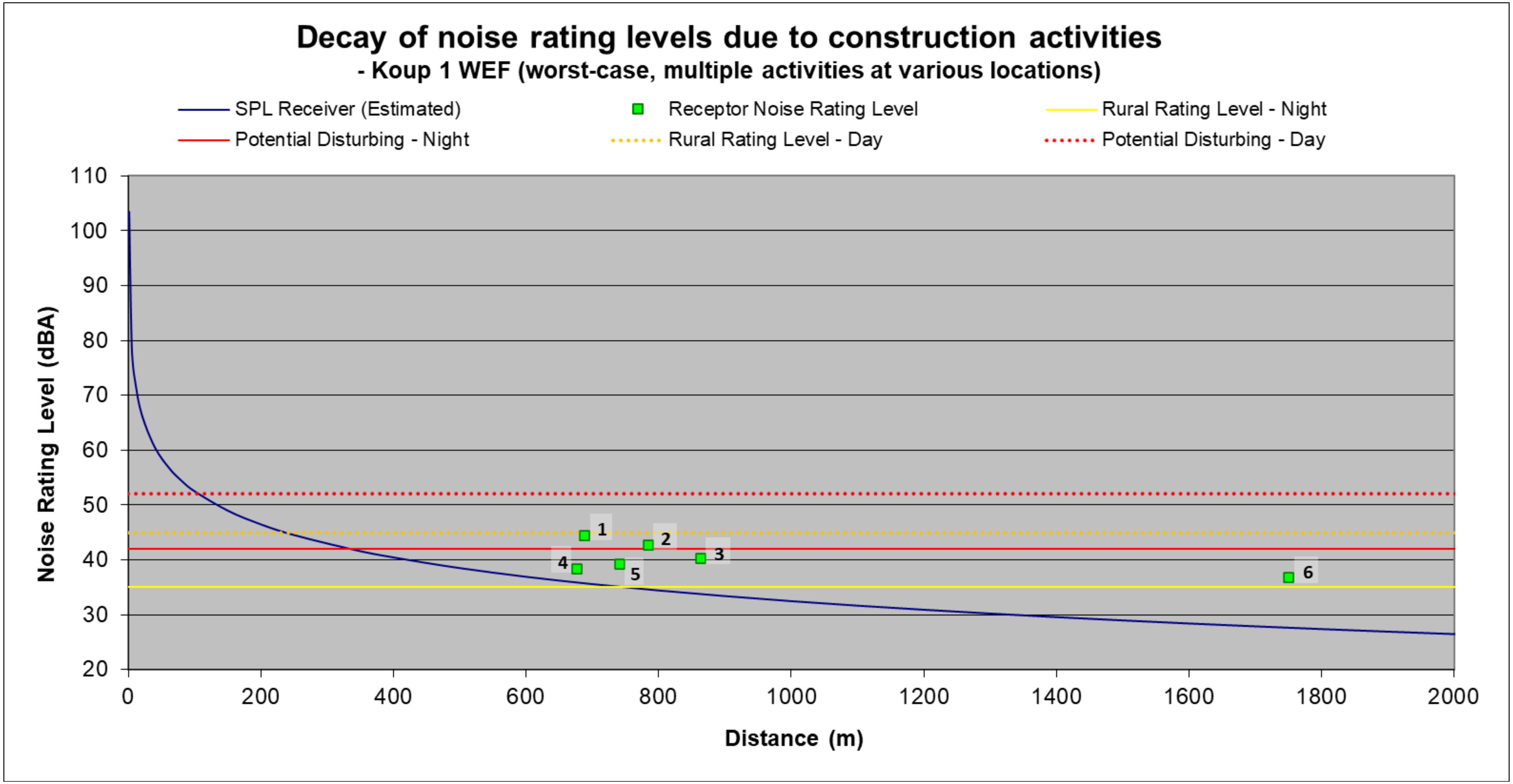

Figure 9-3: Projected conceptual construction noise levels for the proposed Koup 1 WEF

9.2 CONCEPTUAL SCENARIOS – NOISE DUE TO FUTURE OPERATIONAL ACTIVITIES

While the significance of daytime noise impacts was 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 during the night-time period is critical. It should be noted that maintenance activities normally take place during the day, but normally involve a few light-delivery vehicles moving around during the course of the day, an insignificant noise source. As such maintenance activities will not be considered.

Noise models were developed considering the conceptual operational activities as discussed in **Section 5.2**, with the potential noise rating level contours illustrated in **Figure 9-4** for a worst-case WTG (using a WTG with an SPL of 112.2 dBA re 1 pW). Ambient sound levels are assumed to be 43.5 dBA as proposed in **Table 6-2** at a 10 m/s wind speed. The projected worst-case noise levels are defined per NSR in **Appendix F, Table 6**.

The potential noise rating level contours associated with the quieter WTG (with an SPL of 107.1 dBA re 1 pW) is illustrated in **Figure 9-5** with the projected noise levels defined in **Appendix F, Table 7** per NSR.

9.3 POTENTIAL CUMULATIVE NOISE IMPACTS

Cumulative noise impacts generally only occur when noise sources (such as other wind turbines) are closer than 2,000m from each other (World Bank Group, 2015 **[145]**)). The cumulative impact also only affects the area between the wind turbines of the various wind farms and normally only relate to the operational phase.

If the wind turbines of one wind farm are further than 2,000 m from the wind turbines of the other wind farm, the magnitude (and subsequently the significance) of the cumulative noise impact is reduced. If the distance between the wind turbines of two (or more) wind farms are further than 4,000m, cumulative noise impacts are non-existent. This is illustrated in **Figure 9-6**.

The following wind farms are either authorized (but not yet constructed), or proposed within approximately 10 km of the Koup 1 WEF:

- The authorized Beaufort West WEF is located just south-east of the proposed Koup 1 WEF (though there are no NSR situated between the potential area of influence of the Beaufort West and Koup 1 WEFs);
- The authorized Trakas WEF is located south-west of the proposed Koup 1 WEF (just south-west of the authorized Beaufort West WEF);
- Kwagga 1, 2 and 3 WEFs. The exact location of the WTG of these WEFs is not available to the author, with the Renewable Energy EIA Application Database indicating this project boundary approximately 8km to the east of the Koup 1 WEF. The cumulative influence of the Kwagga WEF will be insignificant;
- The Kraaltjies WEF, with its closest WTG located approximately 5km east of the closest WTG of the Koup 1 WEF.

The WTG of the Koup 1, Koup 2, Beaufort West, Trakas and Kraaltjies WEFs were included in the noise model, with the potential cumulative noise rating levels illustrated in **Figure 9-7**, with the noise rating levels defined per NSR in **Appendix F, Table 8** (considering the worst-case scenarios). The noise rating levels were calculated for the area up to 5,000m from the WTG of the Koup 1 WEF.

9.4 POTENTIAL DECOMMISSIONING, CLOSURE AND POST-CLOSURE NOISE LEVELS

The potential for a noise impact to occur during the decommissioning and closure phase will be much lower than that of the construction and/or operational phases. This is because:

- Decommissioning activities normally are limited to the daytime period, due to the lower urgency to complete this phase; and
- Decommissioning activities normally use smaller and less equipment, generating less noise than the typical construction or operational phases.

If required, the noise levels for decommissioning can be compared with the daytime construction phase noise level and the noise impact is similar or less.

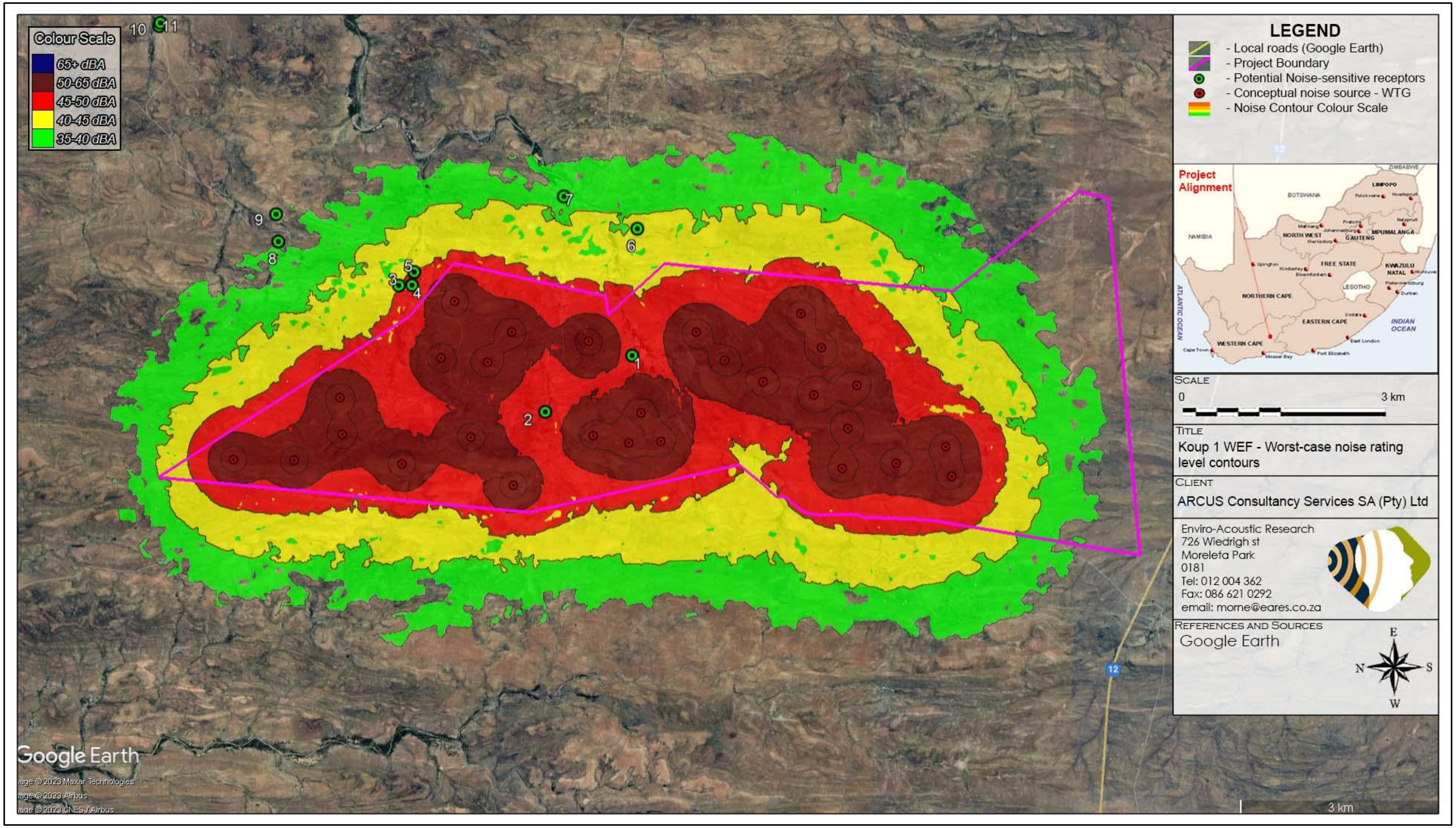

Figure 9-4: Projected future noise rating level contours (worst-case WTG with SPL of 112.2 dBA re 1 pW)

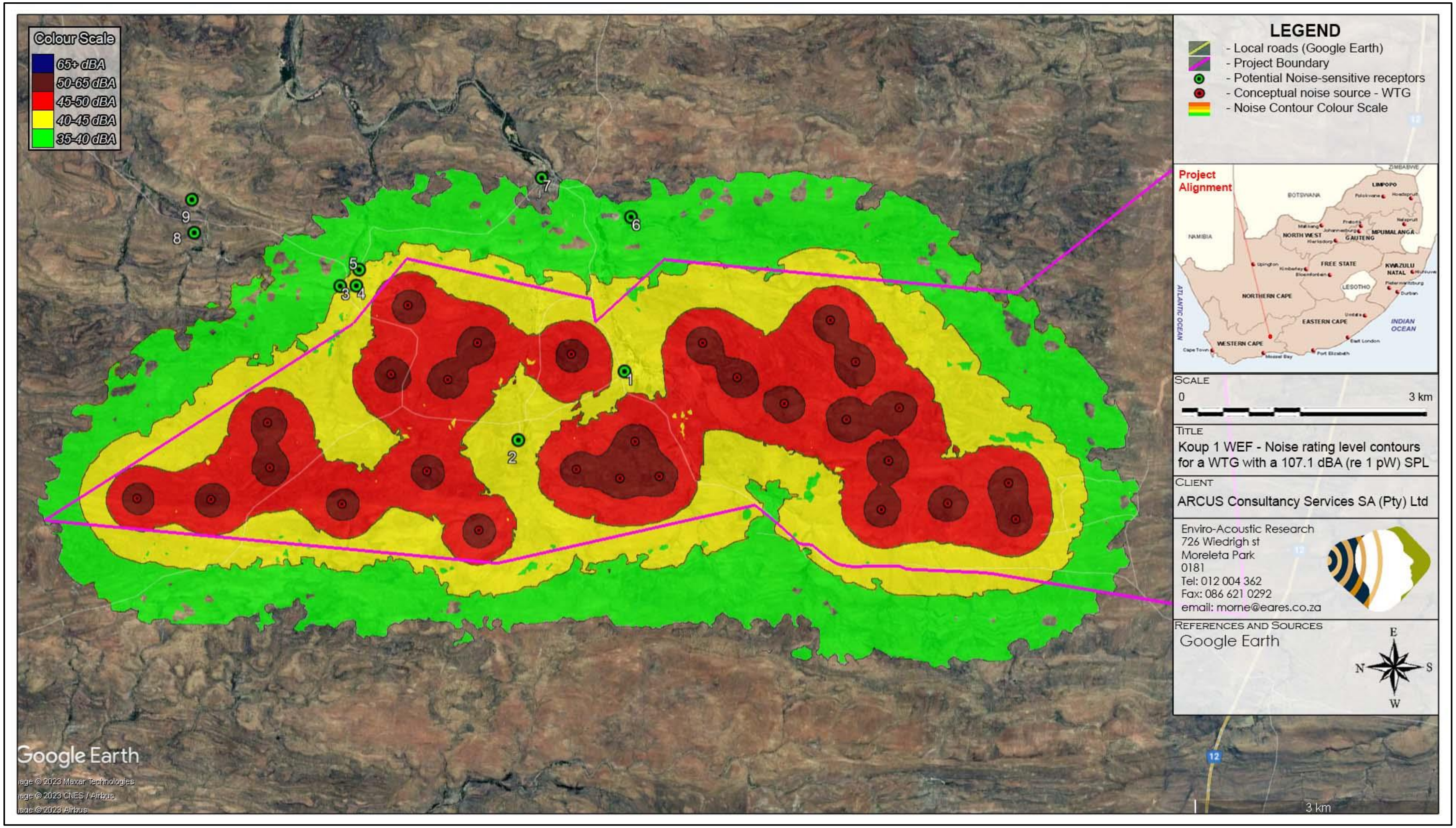

Figure 9-5: Projected future noise rating level contours (WTG with SPL of 107.1 dBA re 1 pW)

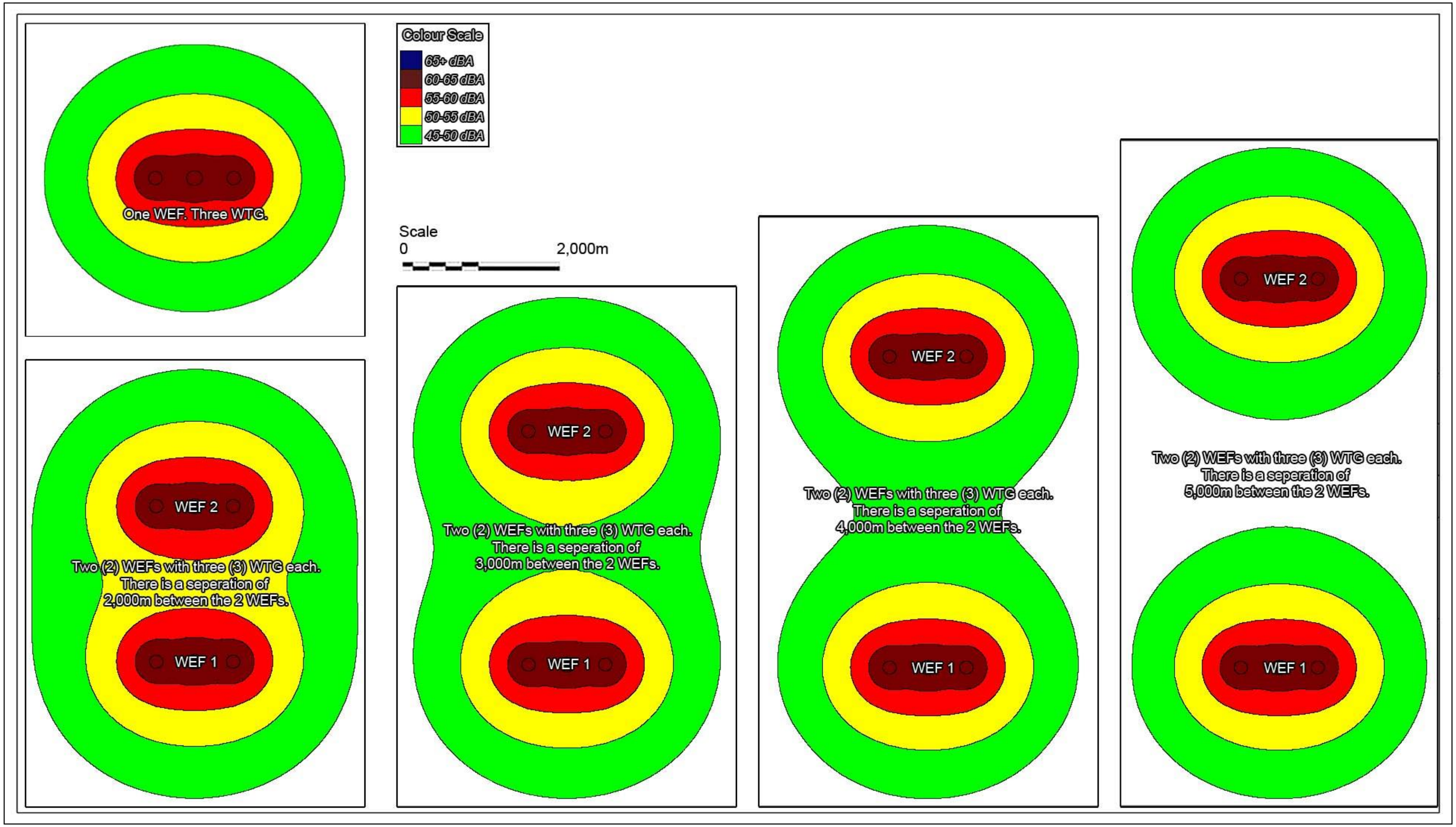

Figure 9-6: Effect of distance between wind turbines – potential cumulative noise

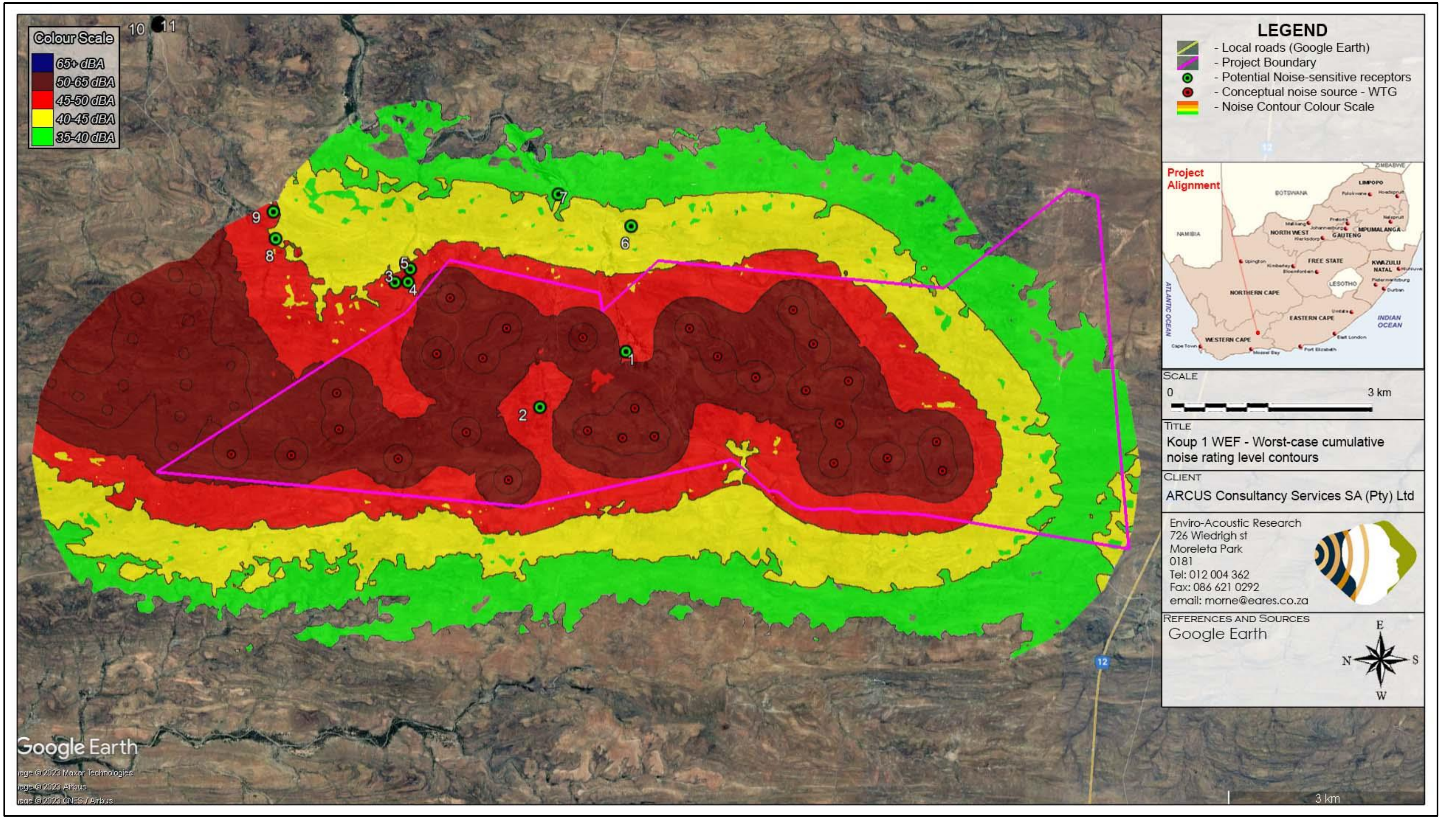

Figure 9-7: Projected future cumulative noise rating level contours (worst-case SPL of 112.2 dBA re 1 pW)

10 SIGNIFICANCE OF THE NOISE IMPACT

10.1 NOISE IMPACT DUE TO FUTURE CONSTRUCTION ACTIVITIES

10.1.1 Noises relating to the Planning and Design Phase

Activities that relate to the planning and design phases are normally limited to surveying and site visits by the applicant and specialists. These activities are normally limited to the daytime period, with the activities having temporary noise impacts of a minor consequence. Noises impacts are generally negligible (insignificant) the potential noise impact associated with the planning and design phase will not be considered in this assessment. The potential impact is summarized in Error! Reference source not found..

However, should the assessment indicate a potential noise impact of medium or high significance for the construction and/or operational phases, appropriate mitigation measures to reduce this noise impact must be designed and/or selected during the planning and design phase.

10.1.2 Noises associated with construction activities

The potential noise levels for the various construction activities (as conceptualised) were calculated in **section 9.1**. The potential significance of the construction noise impacts was:

- estimated per NSR in **Appendix F, Table 2** when considering construction activities associated with access roads, with the potential significance of the daytime noise impact summarized in **Table 10-1** (**sub-section 10.5**);
- estimated per NSR in **Appendix F, Table 3** when considering construction traffic noises, with the potential significance of the daytime noise impact summarized in **Table 10-2** (**sub-section 10.5**);
- calculated per NSR in **Appendix F, Table 4**, with the potential significance of the daytime noise impact summarized in **Table 10-3** (**sub-section 10.5**); and,
- calculated per NSR in **Appendix F, Table 5**, with the potential significance of the night-time noise impacts[37] is summarized in **Table 10-4** (**sub-section 10.5**); (**sub-section 10.5**).

[37] While night-time construction activities are not envisaged, but there may be times when activities may take place after 22:00 at night, or before 06:00 in the mornings. Considering potential delays' relating to civil works (especially concrete pouring that must be undertaken in one go).

10.2 Noise Impact due to Future Operational Activities

The noise levels associated with the operating WTG was calculated in **section 9.2**, with the noise levels illustrated in **Figure 10-1** for different wind speeds and illustrated in **Figure 9-4** for the worst-case WTG (using a SPL of 112.2 dBA re 1 pW) and **Figure 9-5** for a potential mitigated scenario (using a WTG with an SPL of 107.1 dBA re 1 pW).

The potential significance of operational noise impacts was summarized in **Table 10-5** (**sub-section 10.5**) for the daytime period and in **Table 10-6** (**sub-section 10.5**) for the night-time period.

Noise rating levels as well as the significance of a potential noise impact is calculated per NSR in **Appendix F, Table 6** for the unmitigated scenario and in **Appendix F, Table 7** for the mitigated scenario.

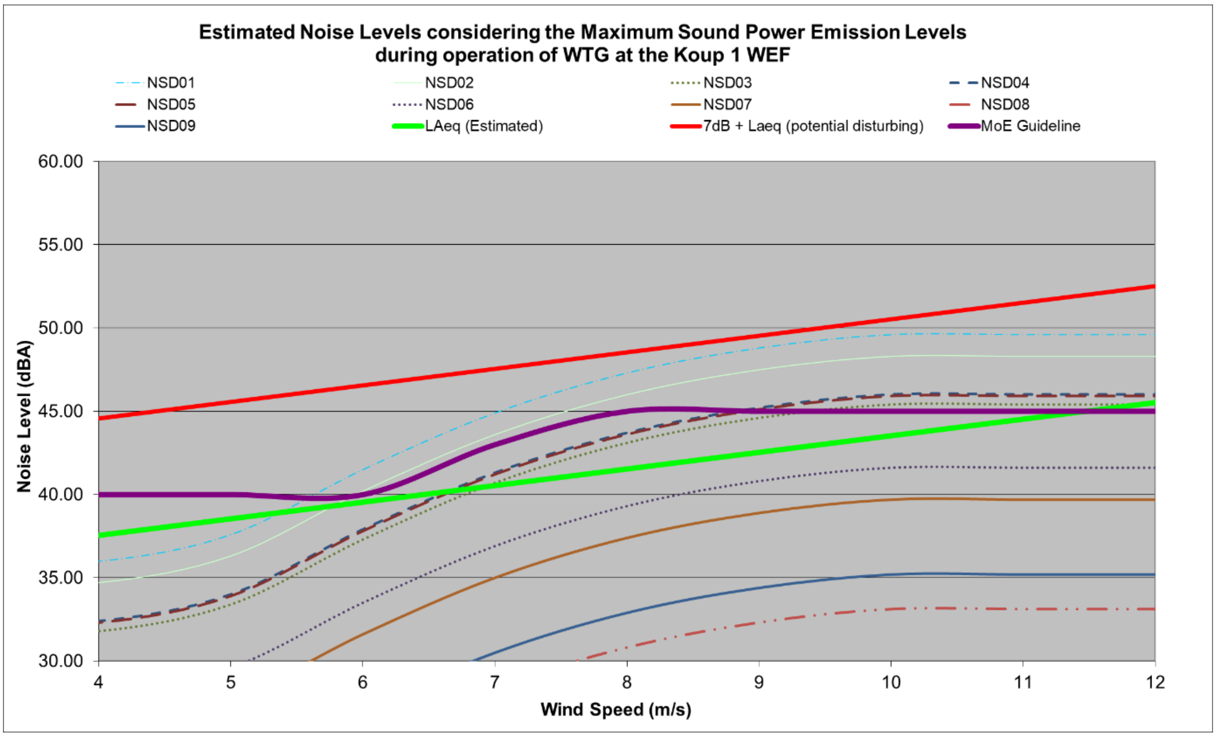

Figure 10-1: Projected noise levels at different wind speeds (worst-case SPL)

10.3 Cumulative Noise Impact from Other WEFs

There is a very low risk of cumulative noises during the construction phase, because it is unlikely that construction activities will take place simultaneously at these different WEFs.

Only NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs, and there is a potential for a cumulative impact at these NSR. Total cumulative noise levels will be higher than 45 dBA at these NSR, with most of acoustic energy originating from the Koup 1 WEF, with the WTG of the Koup 2 WEF contributing less than 2 dBA at these NSR.

Noises from other WEFs within 35 km will have an insignificant influence on the noise levels at the NSR. Potential cumulative noise impacts were calculated per NSR in **Appendix F, Table 8** for a worst-case scenario evaluated (only the night-time period was investigated), with the findings summarized in **Table 10-7**.

10.4 EVALUATION OF ALTERNATIVES

10.4.1 Alternative 1: No-go option

The ambient sound levels will remain as is and the area would keep the rural noise character.

10.4.2Alternative 2: Proposed Renewable Power Generation activities

The proposed renewable energy activities (worst-case evaluated) will slightly raise the noise levels at a number of the closest potential NSR. 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 sustainable layout.

Considering the ambient sound levels measured on-site, the projected noise rating levels will be elevated at the closest NSR, and have a similar or less than the on-site ambient sound levels at NSR located further than 2,000 m from the WTG. It is slightly possible that the noise rating levels could exceed the ambient sound levels during certain periods although it is unlikely to impact on the quality of living (at night) at receptors living further than 2,000m from WTG. Mitigation is available and included to reduce the potential noise impact on NSR identified closer to proposed WTG.

The project however 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.

10.5 Noise Impact Assessment Tables

Table 10-1: Impact Assessment: Construction of access roads

Nature of Impact: Daytime ambient sound levels could range from less than 20dBA to more than 55dBA, averaging at 29.8dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). Road construction activities will increase ambient sound levels due to air-borne noise during quiet periods. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 2** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road upgrading/construction activities will be very temporary (less than 1 year).	**Medium (40)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Very High (4)	The construction of the access road will raise the noise levels to higher than 55 dBA on a temporary basis.	
Probability (Table 6-5)	Definite (4)	It is definite that road construction (or road upgrading) activities will impact on the closest NSR.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Relocating the access roads further than 120m from structures used for residential purposes (during the construction phase) will significantly reduce the significance of the noise impact.			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road upgrading/construction activities will be very temporary (less than 1 year).	**Low (21)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Medium (2)	With management noise levels could be reduced to less than 52 dBA	
Probability (Table 6-5)	Possible (2)	With management the probability of the noise impact can be reduced to possible.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-2: Impact Assessment: Construction traffic noises

Nature of Impact: Daytime ambient sound levels could range from less than 20dBA to more than 55dBA, averaging at 29.8dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). Construction traffic passing NSR could increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 3** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road upgrading/construction activities will be very temporary (less than 1 year).	**Medium (32)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	

Magnitude (Table 6-7)	Very High (4)	Construction traffic passing NSR may increase noise levels higher than the rural rating level.	
Probability (Table 6-5)	Possible (4)	It is definite that road construction (or road upgrading) activities will impact on the closest NSR.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required. Relocating the access roads further than 120m from structures used for residential purposes (during the construction phase) will significantly reduce the significance of the noise impact.			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road traffic passing NSR will be temporary to short term.	**Low (16)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Medium (2)	With management noise levels could be reduced to less than 52 dBA	
Probability (Table 6-5)	Possible (2)	With management the probability of the noise impact can be reduced to possible.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-3: Impact Assessment: Daytime WTG construction activities

Nature of Impact: Daytime ambient sound levels could range from less than 20dBA to more than 55dBA, averaging at 29.8dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). Various construction activities (development of laydown areas and the hard standing areas, excavation of foundations, concreting of foundations and the assembly of the wind turbines tower and components, as well as construction of other infrastructure) taking place simultaneously during the day will increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 4** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Medium (28)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Very High (4)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential measures could include: • Applicant to minimize simultaneous construction activities when working within 1,000m from NSR (such as limiting construction activities at one WTG location); • Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life.			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Low (21)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	

Magnitude (Table 6-7)	High (3)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-4: Impact Assessment: Night-time WTG construction activities

Nature of Impact: Night-time ambient sound levels could range from less than 20dBA to more than 39dBA, averaging at 23.3dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). While unlikely to take place, various construction activities (likely limited to the pouring of concrete as well as erection of WTG components) taking place simultaneously at night will increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 5** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Medium (40)**
Extent (Table 6-4)	Local (2)	Construction noises may extent from the site, especially during quiet periods.	
Magnitude (Table 6-7)	Very High (4)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Possible (2)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential measures could include: • Applicant to minimize simultaneous construction activities when working within 2,000m from NSR (such as limiting construction activities at one WTG location); • Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life; • The Applicant to minimize night-time activities when working within 2,000m from any structure used for residential purposes where possible. Work should only take place at one WTG location to minimize potential night-time cumulative noises (when working at night within 2,000m from NSR used for residential purposes); • The applicant must notify the NSR when night-time activities will be taking place within 2,000m from the NSR (including construction traffic passing NSR); and • The applicant must plan the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period (even though it is expected that it is highly unlikely that this may take place at night).			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Low (20)**
Extent (Table 6-4)	Local (2)	Construction noises may extent from the site, especially during quiet periods.	
Magnitude (Table 6-7)	Medium (2)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Possible (2)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-5: Impact Assessment: Daytime operation of WTG considering the worst-case SPL

Nature of Impact: WTG will only operate during period with increased winds, when ambient sound levels are higher than periods with no or low winds. As discussed and motivated in **section 6.4** (as proposed in **Table 6-2** and illustrated in **Figure 4-33**), ambient sound levels will likely be higher, with this assessment assuming an ambient sound level of 43.5 dBA (for a 10 m/s wind speed). Numerous WTG of the Koup 1 WF operating simultaneously during the day will increase ambient sound levels due to air-borne noise from the WTG. Ambient sound levels are normally higher during the daytime period, with receptors generally more active and distracted which would decrease the probability of an impact occurring (when compared to the night-time period). The projected noise levels and the potential change in ambient sound levels is defined for the identified NSR in **Appendix F, Table 6**.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**Medium (44)**
Extent (Table 6-4)	Local (2)	The noise impact would extent from the site, potentially as far as 1,000 from WTG.	
Magnitude (Table 6-7)	Very High (4)	Operational noise may be audible at the closest NSR.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime operational noises will impact on NSR in the area.	
Mitigation / Management Measures			

Mitigation:
Significance of the daytime operational noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential mitigation measures would include:
• The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA); **or**
• The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR. For the currently layout, noise levels less than 45dBA would be possible when relocating:
  ○ WTG 1 and 14 further than 2,500m from NSR01; **and**
  ○ WTG 17, 18 and 28 further than 2,500m from NSR02; **and**
  ○ WTG 2 further than 2,500m from NSR04.
• The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.			

Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**Low (16)**
Extent (Table 6-4)	Local (2)	The noise impact would extent from the site, potentially as far as 1,000 from WTG.	
Magnitude (Table 6-7)	Medium (2)	Operational noise may be audible at the closest NSR.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime operational noises will impact on NSR in the area.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the operational noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-6: Impact Assessment: Night-time operation of WTG considering the worst-case SPL

Nature of Impact: WTG will only operate during period with increased winds, when ambient sound levels are higher than periods with no or low winds. As discussed and motivated in **section 6.4** (as proposed in **Table 6-2** and illustrated in **Figure 4-33**), ambient sound levels will likely be higher, with this assessment assuming an ambient sound level of 43.5 dBA (for a 10 m/s wind speed).

Numerous WTG of the Koup 1 WF operating simultaneously at night will increase ambient sound levels due to air-borne noise from the WTG. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 6** (worst-case scenario) and summarized in this table. The potential noise level (and significance) when using a quieter WTG (such as a WTG with an SPL of 107.2 dBA re 1 pW) is also presented in **Appendix F, Table 7**.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**High (44)**
Extent (Table 6-4)	Local (2)	The noise impact would extent from the site, likely further than 1,000 from WTG.	
Magnitude (Table 6-7)	Very High (4)	Operational noise will be audible and likely be at a disturbing level at the closest NSR.	
Probability (Table 6-5)	Probable (3)	It is probable that night-time operational noises will impact on NSR in the area.	
Mitigation / Management Measures			

Mitigation:
Significance of the daytime operational noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential mitigation measures would include:
• The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA); **or**
• The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR. For the currently layout, noise levels less than 45dBA would be possible when relocating:
  o WTG 1 and 14 further than 2,500m from NSR01; **and**
  o WTG 17, 18 and 28 further than 2,500m from NSR02; **and**
  o WTG 2 further than 2,500m from NSR04.
• The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.			

Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**Low (20)**
Extent (Table 6-4)	Local (2)	The noise impact could extent from the site, potentially further than 1,000 from WTG.	
Magnitude (Table 6-7)	Medium (2)	Operational noise will be audible at the closest NSR.	
Probability (Table 6-5)	Possible (2)	It is possible that night-time operational noises will impact on NSR in the area.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the operational noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-7: Impact Assessment: Potential Cumulative Noise Impacts

Aspect / Impact pathway: Wind turbines from various WEFs operating simultaneously at night. Increases in ambient sound levels due to air-borne noise from all the wind turbines in area. The addition of the Koup 1 WEF will not cumulatively add to the noise levels in the area.		
Nature of potential impact: Increase in ambient sound levels.		
	Overall impact of the proposed project considered in isolation (post mitigation) – see Appendix F, Table 8	**Cumulative impact of the project and other projects in the area (post mitigation)**
Duration (Table 6-3)	Long (3)	Long (3)
Extent (Table 6-4)	Local (2)	Local (2)
Magnitude (Table 6-7)	Very High (4)	Very High (4)
Probability (Table 6-5)	Probable (3)	Probable (3)
Significance	**High (44)**	**High (44)**
Status (+ or -)	Negative	Negative
Reversibility	High	High

Loss of resources?	No	No
Can impacts be mitigated?	Yes	Yes
Mitigation: The significance of the potential cumulative noise impact is **high**, though this mainly relate to the noises from the Koup 1 WEF project (the contribution from the Koup 2 WEF is less than 1 dBA).		
Residual Risks: There is no risk of any residual noises.		

11 MITIGATION OPTIONS

This study considers the potential noise impact on the surrounding environment due to the construction, operational and future decommissioning activities associated with the Koup 1 WEF project. It was determined that the potential noise impacts, without mitigation, would be:

- of a **medium significance** for the construction of access roads (or upgrading of existing roads). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** relating to noises from construction traffic. This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the assembly of the WTG and other infrastructure). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a potential **medium significance** for the night-time construction activities (the potential pouring of concrete, erection of WTG). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for daytime operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level; and
- of a **high significance** for night-time operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available and included in this assessment that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level.

There is a slight potential for a cumulative noise impact to occur during the operational phase. NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs and there is a slight cumulative impact at these NSR. Total cumulative noise levels are higher than 45 dBA at these NSR, but this noise impact mainly relates to noises from operating WTG of the Koup 1 WEF (potential noise levels due to the WTG of the Koup 2 WEF will be less than 40 dBA). Due to the **high significance** of the noise impact for the operational phase, the significance will remain high for the cumulative scenario.

The project 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 will be inaudible due to existing high ambient sound levels. The magnitude of the sound 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).

The developer must implement a line of communication (i.e., a help line where complaints could be lodged). All potential sensitive receptors should be made aware of these contact numbers. The proposed WEFs should maintain a commitment to the local community (people staying within 2,000 m from construction or operational activities) and respond to noise concerns in an expedient fashion. Sporadic and legitimate noise complaints could be raised. For example, sudden and sharp increases in sound levels could result from mechanical malfunctions or perforations or slits in the blades. Problems of this nature can be corrected quickly and it is in the developer’s interest to do so.

11.1 Mitigation options available to reduce Noise Impact during the Construction Phase

The significance of the noise impact will be of a **medium** significance for both day- and night-time activities and additional mitigation measures are required or recommended.

Night-time activities especially may generate noises at sufficient level to be annoying to some NSR and the following measures could reduce annoyance with construction activities. Potential measures could include:

- The applicant can relocate the access road further than 120m from structures used for residential purposes during the construction period;
- Applicant to minimize simultaneous construction activities when working within 2,000m from NSR (such as limiting construction activities at one WTG location);
- Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life;
- The Applicant to minimize night-time activities when working within 2,000m from any structure used for residential purposes where possible. Work should only take place at one WTG location to minimize potential night-time cumulative noises (when working at night within 2,000m from NSR used for residential purposes);
- The applicant must notify the NSR when night-time activities will be taking place within 2,000m from the NSR (including construction traffic passing NSR); and
- The applicant must plan the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period (even though it is expected that it is highly unlikely that this may take place at night).

11.2 MITIGATION OPTIONS AVAILABLE TO REDUCE NOISE IMPACT DURING OPERATION

The significance of the noise impact during the operation phase could be **medium** for daytime activities, but of a **high** significance for night -time operations. Operating WTG however will be clearly audible at closest NSR, especially at night. Potential measures could include:

- The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA re 1 pw) – the scenario illustrated in **Figure 9-5**; **or**
- The applicant can relocate one or NSR located within the 45dBA noise rating level contours;
- The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR[38].
- The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from

- For the currently layout, noise levels less than 45dBA would be possible when relocating:
  - WTG 1 and 14 further than 2,500m from NSR01; **and**
  - WTG 17, 18 and 28 further than 2,500m from NSR02; **and**
  - WTG 2 further than 2,500m from NSR04.

NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.

To ensure that noise does not become an issue for future residents, landowners or the local communities, it is recommended that the applicant get written agreement from current landowners/community leaders that no new residential dwellings will be developed within areas enveloped by the 42dBA noise level contour (of the Koup 1 WEF). Dwellings and structures located within the 45dBA noise rating level contour should not be used for permanent residential activities.

11.3 Mitigation options available to reduce Noise Impact during decommissioning

The potential significance of the noise impact would be similar as the construction phase (medium significance at worst), though it is likely that it would be of a low significance because:

- Decommissioning activities normally are limited to the daytime period, due to the lower urgency to complete this phase; and
- Decommissioning activities normally use smaller and less equipment, generating less noise than the typical construction or operational phases.

Mitigation recommended for the construction phase would be applicable for the decommissioning phase.

11.4 Mitigation and Management conditions to be included in the EMPr and Environmental Authorization

It is recommended that the project applicant:

1. re-evaluate the noise impact should the layout be revised where:
    a. any WTG, located within 1,500 m from a confirmed NSR, are moved closer to the NSR;
    b. the number of WTG within 2,500m from an NSR are increased.
2. re-evaluate the noise impact once the final make and model of WTG was selected (if the project proceed, if the final make and model of the WTG is different from the WTG assessed in this report, considering the latest WTG layout as well as the specific characteristics of the selected WTG) to ensure that the projected maximum noise level will be less than 45 dBA;
3. design and implement a noise monitoring program, measuring ambient sound levels before construction activities start, as well as during the operational phase

(recommended at NSR01, NSR02 and NSR04). If any of these structures are not used for residential purposes, noise monitoring at these locations can be removed;

4. ensure that mobile heavy equipment is well maintained and fitted with the correct and appropriate noise abatement measures. 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;
5. include a component covering environmental noise in the Health and Safety Induction to sensitize all employees and contractors about the potential impact from noise, especially those employees and contractors that have to travel past receptors at night, or might be required to do work close (within 2,000m) to NSR at night. This should include issues such as minimising the use of vehicle horns;
6. investigates any reasonable and valid noise complaint if registered by a receptor staying within 2,000m from the location where construction activities are taking place, or where night-time construction activities are required, or where an operational WTG are located. A complaint register, keeping a full record of the complaint, must be kept by the applicant;
7. discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life;
8. with regard to unavoidable noisy night-time construction activities in the vicinity of NSR (closer than 2,000m from any identified NSR), the contractor and Environmental Control Officer (ECO) must liaise with local NSR on how best to minimise impact and the NSR must be kept informed of the nature and duration of intended activities; and
9. where practicable, mobile equipment should be fitted with broadband (white-noise generators/alarms [39] [40]), rather than tonal reverse alarms.

[39] White Noise Reverse Alarms: http://www.brigade-electronics.com/products.
[40] https://www.constructionnews.co.uk/home/white-noise-sounds-the-reversing-alarm/885410.article - White noise sounds the reversing alarm

12 ENVIRONMENTAL MONITORING PLAN

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

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

Active noise monitoring is recommended because the projected noise levels are more than 38.7dBA (the level defined by the WHO where noise levels from WTG may become annoying) for the layout and WTG as assessed in this report. Noise levels may be higher than 45dBA at certain NSR for a WTG with an SPL exceeding 107.5dBA (re 1 pW).

In addition, should a reasonable and valid noise complaint be registered, the Applicant should investigate the noise complaint as per the guidelines in **sub-section 12.1** and **12.2**. These guidelines should be used as a rough guideline as site-specific conditions may require that the monitoring locations, frequency or procedure be adapted.

12.1 MEASUREMENT LOCALITIES AND FREQUENCY

The applicant must develop and implement an environmental noise monitoring programme before the construction phase starts, conducting active night-time noise measurements at NSR01, NSR02 and NSR04.

The applicant must repeat the environmental noise monitoring during the operational phase (once the WEF is fully operational) at the same locations at least once. Ambient sound levels must be measured at these NSR before the development of the WEF, with the measurements repeated after the first year of operation. Should any of these locations not being used for residential purposes, measurements at these NSR would not be required.

In addition, should there be a valid and reasonable noise complaint, once-off 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.

The noise specialist employed to do the noise monitoring must recommend and motivate the need (or not) for continued noise monitoring.

12.2 MEASUREMENT PROCEDURES

Ambient sound 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 48 hours, covering at least a full day- (06:00 – 22:00) and two full night-time (22:00 – 06:00) periods (though longer measurements are highly recommended).

13 ENVIRONMENTAL MANAGEMENT

Environmental Management Objectives are difficult to be defined for noise because ambient sound levels would slowly increase as developmental pressures increase in the area. This is due to increased traffic associated with increased development, human habitation, agriculture and even eco-tourism. While these increases in ambient sound levels may be low (and insignificant) it has the effect of cumulatively increasing the ambient sound levels over time.

The moment the WEF facility stops operation, ambient sound levels will drop to levels similar to the pre-WEF levels, or to new levels (typical of other areas with a similar developmental character) if other developments have occurred in the interim.

For the purpose of this report potential environmental management objectives would be:

- That the development of the WEF project should not result in noise levels exceeding 55dBA during the day;
- That the development of the WEF project should not result in noise levels exceeding 42dBA at night during the construction phase; and
- That the development of the WEF project should not result in noise levels exceeding 45dBA at night during the operational phase.

As noise levels will not exceed 55dBA during both the construction and operational phases, Environmental Management is mainly focusing on the night-time period as summarized in:

- **Table 13-1** for the planning phase (to ensure that noise levels are with the acceptable limits during the future operational phase:
- **Table 13-2** for night-time activities during the construction phase; and
- **Table 13-3** for the operational of the WTG.

Table 13-1: Environmental Management for planning phase

Objective: Future project activities not to result in disturbing noises		
Project Components:	Future construction activities and operation of WTG	
Potential Impact:	No noise impact during the planning phase	
Activity/Risk source	Future construction activities and operation of WTG	
Mitigation: Target	Night-time noise levels less than 42 dBA (construction phase) and 45 dBA (operational phase) at locations used for residential purposes	
Mitigation: Action / Control	**Responsibility**	**Timeframe**
Applicant to re-evaluate the noise impact should the layout be revised where any new WTG are introduced within 1,500 m from an NSR	Applicant	Planning phase, before development of WEF
Applicant to re-evaluate the noise impact should the layout be revised where the number of WTG within 2,500 m from an NSR are increased	Applicant	Planning phase, before development of WEF

Applicant to select and implement mitigation measures to ensure that operational noise levels are less than 45dBA at all verified NSR (if the dwellings will be used for residential purposes during the operational phase)		Applicant	Planning phase, before development of WEF
Applicant to re-evaluate the noise impact once the WTG layout and WTG specifications was finalised		Applicant	Planning phase, before development of WEF
Design and implementation of a noise monitoring programme to define current ambient sound levels at selected NSR before the construction phase start.		ECO	Before the construction phase start
Performance Indicator	Calculated noise levels should be less than 42 dBA at NSR (at night during the construction phase) and less than 45 dBA (at night during the operational phase) at structures used residential purposes		
Monitoring	No monitoring required during planning phase		

Table 13-2: Environmental Management for night-time construction activities

Objective: Project activities not to result in noise levels exceeding night-time noise levels of 42 dBA			
Project Components:	Construction activities and construction equipment generating disturbing and nuisance noises		
Potential Impact:	Night-time noise levels impacting on the quality of living of people living at NSR		
Activity/Risk source	Construction activities		
Mitigation: Target	Night-time noise levels less than 42 dBA at locations used for residential purposes		
Mitigation: Action / Control		**Responsibility**	**Timeframe**
ECO to ensure that equipment is well maintained and fitted with the correct and appropriate noise abatement measures;		ECO	Ongoing during construction phase
ECO to include a component covering environmental noise in the Health and Safety Induction to sensitize all employees and contractors about the potential impact from noise;		ECO	Ongoing during construction phase
ECO to notify NSR before night-time construction activities are to take place within 2,000m from any NSR (if the structures are used for residential activities during the proposed construction period).		ECO	Construction activities within 1,500 m from NSR, if NSR is used for residential purposes
Performance Indicator	Night-time noise levels less than 42 dBA		
Monitoring	Noise level monitoring before the construction phase start at NSR03 and NSR04. Inspection of equipment by ECO.		

Table 13-3: Environmental Management for night-time operational period

Objective: Project activities not to result in noise levels exceeding 45 dBA			
Project Components:	Operation of WTG within 2,000 m from structures used for residential purposes		
Potential Impact:	Noise levels impacting on the quality of living of people living at NSR		
Activity/Risk source	Operation of WTG		
Mitigation: Target	Night-time noise levels less than 45 dBA at locations used for residential purposes		
Mitigation: Action / Control		**Responsibility**	**Timeframe**
ECO to conduct noise monitoring when a reasonable and valid noise complaint are received from an NSR living within 2,000m from a WTG of the project.		ECO	Within 2 months after a noise complaint is registered
Noise monitoring to confirm that noise levels associated with operating WTG are less than 45 dBA at all NSR		ECO	During the first year once the project is operational. Noise specialist to confirm need for future measurements.
Performance Indicator	Night-time noise levels less than 45 dBA		

14 CONCLUSIONS AND RECOMMENDATIONS

This report is a comparative Environmental Noise Impact Assessment of the noise impacts due to the proposed development, operation and decommissioning of the Koup 1 WEF (and associated infrastructure) south of Beaufort West in the Western Cape Province. It considers an updated layout, as well as a WTG with a higher SPL.

This review assessment 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 was determined that the potential noise impacts, without mitigation, would be:

- of a **medium significance** for the construction of access roads (or upgrading of existing roads). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** relating to noises from construction traffic. This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the assembly of the WTG and other infrastructure). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a potential **medium significance** for the night-time construction activities (the potential pouring of concrete, erection of WTG). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for daytime operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level; and

- of a **high significance** for night-time operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available and included in this assessment that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level.

There is a slight potential for a cumulative noise impact to occur during the operational phase. NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs and there is a slight cumulative impact at these NSR. Total cumulative noise levels are higher than 45 dBA at these NSR, but this noise impact mainly relates to noises from operating WTG of the Koup 1 WEF (potential noise levels due to the WTG of the Koup 2 WEF will be less than 40 dBA). Due to the **high significance** of the noise impact for the operational phase, the significance will remain high for the cumulative scenario.

Active noise monitoring is recommended because the projected noise levels are more than 38.7 dBA (the level defined by the WHO where noise levels from WTG may become annoying) for the layout and WTG as assessed in this report. Noise levels is projected to be higher than 45 dBA at NSR for a WTG with an SPL of 107.5 dBA (re 1 pW).

From an acoustic perspective the WTG layout is considered acceptable should the applicant select to use a WTG with a SPL less than 107.5 dBA (re 1 pW). Should the applicant select to use a WTG with an SPL exceeding 107.5 dBA (re 1 pW), additional mitigation measures must be implemented to ensure that total noise levels are less than 45 dBA at verified NSR (locations where residential activities would be taking place during the operational phase), with the potential mitigation measures highlighted in this review assessment.

Subject to the condition that the applicant limit total noise levels to less than 45 dBA at the NSR, it is recommended that the Koup 1 WEF be authorized (from an acoustic perspective).

It is also highlighted that the applicant re-evaluates the noise impact:

1. should the layout be revised where:
    a. any WTG, located within 1,500 m from any NSR are moved closer;
    b. the number of WTG within 2,500 m from any NSR are increased; and
2. should the applicant make use of a wind turbine with a maximum SPL exceeding 112.2 dBA re 1 pW.

If the project is to be developed in the future, the final layout and sound power emission levels of the selected WTG **<u>must</u>** be re-accessed to ensure the noise levels are less than

45 dBA at verified NSR (if the applicant changed the layout or the WTG as assessed in this report).

To ensure that noise does not become an issue for future residents, landowners or the local communities, it is recommended that the applicant get written agreement from current landowners/community leaders that no new residential dwellings will be developed within areas enveloped by the 42dBA noise level contour (of the Koup 1 WEF). Dwellings and structures located within the 45dBA noise rating level contour should not be used for permanent residential activities.

15 REFERENCES

In this report reference was made to the following documentation:

1. Ambrose, SE and Rand, RW, 2011. *The Bruce McPherson Infrasound and Low Frequency Noise Study: Adverse health effects produced by large industrial wind turbines confirmed*. Rand Acoustics, December 14, 2011.
2. Autumn, Lyn Radle, 2007: *The effect of noise on Wildlife: A literature review*
3. Atkinson-Palombo, C and Hoen, B. 2014: *Relationship between Wind Turbines and Residential Property Values in Massachusetts – A Joint Report of University of Connecticut and Lawrence Berkley National Laboratory.* Boston, Massachusetts
4. Bakker, R.H., Pedersen, E., van den Berg, G.P., Stewart, R.E., Lok,W., Bouma, J. 2012: *Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress*. Sci. Total Environ. **15** (425), 42–51
5. Barber, J.R., K.R. Crooks, and K. Fristrup. 2010. *The costs of chronic noise exposure for terrestrial organisms*. Trends Ecology and Evolution 25(3): 180–189
6. Bass JH *et al*, 1996: *Development of a wind farm noise propagation prediction model.* JH Bass, AJ Bullmore, E Sloth. Contract JOR3-CT95-0051. Renewable Energy Systems Limits, Hoare Lea & Partners Acoustics, Acoustica A/S
7. Bastasch, M; van Dam, J; Søndergaard, B; Rogers, A. 2006: *Wind Turbine Noise - An Overview*. Canadian Acoustics Vol. 34(2). pp. 7-15
8. Bayne EM *et al*, 2008: *Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest*. Conservation Biology 22(5) 1186-1193.
9. Blickley, J.L. and Patricelli, G.L. 2010. *Impacts of Anthropogenic Noise on Wildlife: Research Priorities for the Development of Standards and Mitigation*. Journal of International Wildlife Law & Policy, 13:274–292.
10. Bolin et al, 2011: *Infrasound and low frequency noise from wind turbines: exposure and health effects.* Environ. Res. Lett. 6 (2011) 035103
11. Bowdler, D. 2005: *ETSU-R-97 Why it is Wrong,* Internet White Paper, New Acoustics, Dunbartonshire, Scotland, July 2005
12. Bowdler, Dick, 2008: *Amplitude modulation of wind turbine noise: a review of the evidence*
13. Bowdler, D. Bullmore, A. Davis, B. Hayes, M. Jiggens, M. Leventhall, G. McKenzie, A. 2009: *Prediction and Assessment of Wind Turbine Noise – Agreement about relevant factors for noise assessment from wind energy projects*. Acoustics, Vol 34, No 2. March/April 2009

14. Bray, W and James, R. 2011. *Dynamic measurements of wind turbine acoustic signals, employing sound quality engineering methods considering the time and frequency sensitivities of human perception*. Noise-Con 2011.
15. Broucek, J. 2014. *Effect of Noise on Performance, Stress and Behaviour of Animals.* Slovak J. Anim. Sci., 47, 2014 (2): 111-123
16. BWEA, 2005*: Low Frequency Noise and Wind Turbines – Technical Annex*
17. CanWEA, 2007: *Wind Turbines and Sound: Review and Best Practice Guidelines*. Canadian Wind Energy Association.
18. Chapman *et al*. 2013: *Spatio-temporal differences in the history of health and noise complaints about Australian wind farms: evidence for the psychogenic, "communicated disease" hypothesis*. Sydney School of Public Health, University of Sydney
19. Chief Medical Officer of Health, 2010: *The Potential Health Impact of Wind Turbines*, Canada
20. Conrady, K; Bolin, K; Sjöblom, A; Rutgersson, A. 2019: *Amplitude modulation of wind turbine sound in cold climates*. Applied Acoustics, Vol 158, 15 January 2020.
21. Cooper, 2012: *Are Wind Farms too close to communities*, The Acoustic Group (date posted on Wind-watch.org: Referenced on various anti-wind energy websites)
22. Cooper, S. Chan, C. 2020: *Determination of Acoustic Compliance of Wind Farms*. Acoustics **2020**, 2, 416–450; doi:10.3390/acoustics2020024
23. Council of Canadian Academies, 2015: Understanding the Evidence: Wind Turbine Noise. Ottawa (ON): The Expert Panel on Wind Turbine Noise and Human Health. Council of Canadian Academies
24. Crichton *et al*. 2014: *Can expectations produce symptoms from infrasound associated with wind turbines?. Health Psychology, Vol 33(4), Apr 2014, 360-364*
25. CSES, 2016: *Evaluation of Directive 2002/49/EC relating to the assessment and management of environmental noise*. The Centre for Strategy & Evaluation Services, European Commission, Brussels.
26. CSIR, 2002: *Integrated Environmental Management Information Series: Information Series 5: Impact Assessment*. Issued by the Department of Environmental Affairs and Tourism, Pretoria
27. CSIR, 2015: *The Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa.* Issued by the Department of Environmental Affairs and Tourism, Pretoria
28. Cummings, J. 2012: *Wind Farm Noise and Health: Lay summary of new research released in 2011*. Acoustic Ecology Institute, April 2012 (online resource:

http://www.acousticecology.org/wind/winddocs/AEI_WindFarmsHealthResearch2011.pdf)

29. Cummings, J. 2009: *AEI Special Report: Wind Energy Noise Impacts*. Acoustic Ecology Institute, (online resource: http://acousticecology.org/srwind.html)
30. DEFRA, 2003: *A Review of Published Research on Low Frequency Noise and its Effects*, Report for Defra by Dr Geoff Leventhall Assisted by Dr Peter Pelmear and Dr Stephen Benton
31. DEFRA, 2007: *Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report*
32. DELTA, 2008: *EFP-06 project: Low Frequency Noise from Large Wind Turbines, a procedure for evaluation of the audibility for low frequency sound and a literature study*. Danish Energy Authority
33. Derryberry EP *et al*, 2016: *Patterns of song across Natural and Anthropogenic Soundscapes suggest that White-Crowned Sparrows minimize acoustic masking and maximize signal content*. PLOS ONE| DOI: 10.1371/journal.pone.0154456, April 29, 2016
34. Dooling, R. 2002. *Avian Hearing and the Avoidance of Wind Turbines*. National Renewable Energy Laboratory, NREL/TP-500-30844
35. Dooling R. J., and A. N. Popper. 2007. *The effects of highway noise on birds*. Report to the California Department of Transportation, contract 43AO139. California Department of Transportation, Division of Environmental Analysis, Sacramento, California, USA
36. Directive 2002/49/EC of the European Parliament and of the Council relating to the assessment and management of environmental noise
37. Duncan, E. and Kaliski, K. 2008: *Propagation Modelling Parameters for Wind Power Projects*
38. Ellenbogen, J.M., Grace, S., Heiger-Bernays,W.J., Manwell, J.F., Mills, D.A., Sullivan, K.A., Santos, S.L. 2012: *Wind Turbine Health Impact Study. Report of Independent Expert Panel*. Prepared for: Massachusetts Department of Environmental Protection. Massachusetts Department of Health
39. Enertrag, 2008: *Noise and Vibration*. Hempnall Wind Farm (http://www.enertraguk.com/technical/noise-and-vibration.html)
40. EPA, 2009: *Wind Farms Environmental Noise Guidelines*. Environmental Protection Authority, Adelaide, South Australia (Updated November 2021)
41. EPA, 2011: *Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licences Sites (NG3).* Environmental Protection Agency, Office of Environmental Enforcement,

42. ETSU R97: 1996. '*The Assessment and Rating of Noise from Wind Farms: Working Group on Noise from Wind Turbines*'
43. Evans Tom, Cooper Jonathan, 2012: *Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms*. Acoustics Australia, Vol. 40, No. 1, April 2012.
44. Evans, T. Cooper, J. Lenchine, V. 2012: *Infrasound Levels near Windfarms and in other Environments. Resonate Acoustics in conjunction with Environment Protection Authority, South Australia*
45. Fégeant, O. 2002: *Masking of Wind Turbine Noise: Influence of Wind Turbulence on Ambient Noise Fluctuations*.
46. Francis, C.D. et al, 2011: Different behavioural responses to anthropogenic noise by two closely related passerine birds. Biol. Lett. (2011) 7, 850-852 doi:10.1098 / rsbl.2011.0359
47. Francis, C.D. et al, 2012: Noise pollution alters ecological services: enhanced pollination and disrupted seed dispersal. Proc. R Soc. B doi: 10.1098 / rsbl.2012.0230
48. Garrad Hassan, 2013: *Summary of results of the noise emission measurement, in accordance with IEC 61400-11, of a WTGS of the type N117/3000. Doc.* GLGH-4286 12 10220 258-S-0002-A (extract from GLGH-4286 12 10220 258-A-0002-A)
49. Gibbons, S. 2014: *Gone with the Wind: Valuing the Visual Impacts of Wind turbines through House Prices*, Spatial Economics Research Centre
50. Goldwind, 2020: *Description of GW155-4.5 Acoustic Performance*. Edition: C No.: GSC-08AP.a0002
51. Goldwind. 2021: *Goldwind GW165-6.0 V42R01C100 Wind Turbine Noise Manual*. Document No. GW17XW.0145. Goldwind Technology Co., Ltd
52. Goldwind. 2023: *Personal communication (awaiting reference)*
53. Guillaume Dutilleux. *Anthropogenic outdoor sound and wildlife: it's not just bioacoustics!*. Soci´et´e Fran¸caise d'Acoustique. Acoustics 2012, Apr 2012, Nantes, France
54. Halfwerk, W. *et al*. 2011: *Low-frequency songs lose their potency in noisy urban conditions*. PNAS, August 30, 2011, vol. 108, no. 35, 14549-14554.
55. Hanning, 2010: *Wind Turbine Noise, Sleep and Health*. (referenced on a few websites, especially anti-wind energy. No evidence that the study has been published formally.)
56. Hartley, J.C., 1991: *Can Bush Crickets Discriminate Frequency?* University of Nottingham.
57. Havas, M and Colling, D. 2011: *Wind Turbines Make Waves: Why Some Residents Near Wind Turbines Become Ill*. *Bulletin of Science Technology & Society published online 30 September 2011*

58. Helldin, J.O., Jung, J., Neumann, W., Olsson, M., Skarin, A. and Widemo, F. 2012. *The impacts of wind power on terrestrial mammals: a synthesis*. Report 6510. Swedish Environmental Protection Agency.
59. Hessler, D. 2011: *Best Practices Guidelines for Assessing Sound Emissions From Proposed Wind Farms and Measuring the Performance of Completed Projects*. Prepared for the Minnesota Public Utilities Commission, under the auspices of the National Association of Regulatory Utility Commissioners (NARUC)
60. HGC Engineering, 2006: *Wind Turbines and Infrasound*, report to the Canadian Wind Energy Association
61. HGC Engineering, 2007: *Wind Turbines and Sound*, report to the Canadian Wind Energy Association
62. HGC Engineering, 2011: *Low frequency noise and infrasound associated with wind turbine generator systems: A literature review*. Ontario Ministry of the Environment RFP No. OSS-078696.
63. IFC, 2007: '*Environmental, Health, and Safety General Guidelines*'. International Finance Corporation, Washington
64. IFC, 2015: '*Environmental, Health, and Safety Guidelines for Wind Energy*'. International Finance Corporation, Washington
65. IOA, 2013: *A good practice guide to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*. Institute of Acoustics.
66. ISO 9613-2: 1996. '*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*'
67. Janssen, S.A., Vos, H., Eisses, A.R., Pedersen, E. 2011: *A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources*. J. Acoust. Soc. Am. **130**(6), 3746–53 (2011)
68. Jeffery *et al*, 2013: *Adverse health effects of industrial wind turbines*, Can Fam Physician, 2013 May. 59(5): 473-475
69. Journal of Acoustical Society of America, 2009: *Response to noise from modern wind farms in the Netherlands*
70. Kaliski K & Duncan E, 2008: *Propagation modelling Parameters for Wind Power Projects.*
71. Kaliski K & Wilson DK. 2011: *Improving predictions of wind turbine noise using PE modelling*. Noise-con 2011.
72. Kamperman GW & James RR, 2008: *The "How to" guide to siting wind turbines to prevent health risks from sound*
73. Karwowska, M. *et al*. 2015: *The effect of varying distances from the wind turbine on meat quality of growing-finishing pigs*. Ann. Anim. Sci., Vol. 15, No. 4 (2015) 1043–1054 DOI: 10.1515/aoas-2015-0051

74. Knopper, L.D., Ollson, C.A.,McCallum, L.C.,Whitfield Aslund, M.L., Berger, R.G., Souweine, K., McDaniel, M. 2014: *Wind turbines and human health*. Front. Public Health **19**(2), 63
75. Kroesen & Schreckenberg, 2011. *A measurement model for general noise reaction in response to aircraft noise*. J. Acoust. Soc. Am. 129 (1), January 2011, 200-210
76. Lohr, B. Wright, TF. Dooling, RJ. 2003: *Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal*. Animal Behavior 65:763-777
77. Łopucki, R. Klich, D. Gielarek, S. 2016: An assessment of non-volant terrestrial vertebrates response to wind farms – a study of small mammals. Environ Monit Assess (2016) 188: 122
78. Łopucki, R. Klich, D. Gielarek, S. 2017: *Do terrestrial animals avoid areas close to turbines in functioning wind farms in agricultural landscapes?* Environ Monit Assess (2016) 188:122
79. McCunney, R.J., Mundt, K.A., Colby, W.D., Dobie, R., Kaliski, K.,Blais, M. 2014: *Wind turbines and health: a critical review of the scientific literature*. J. Occup. Environ. Med. **56** (11), e108–30
80. McMurtry RY, 2011: *Toward a Case Definition of Adverse Health Effects in the Environs of Industrial Wind Turbines: Facilitating a Clinical Diagnosis*. Bulletin of Science Technology Society. August 2011 vol. 31 no. 4 316-320
81. MDEP: Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health. Wind Turbine Health Impact Study: Report of Independent Expert Panel
82. Merlin, T., Newton, S., Ellery, B., Milverton, J., Farah, C. 2013: Systematic review of the human health effects of wind farms. National Health & Medical Research Council, Canberra
83. Miedema, H.M., Vos, H. 2003: *Noise sensitivity and reactions to noise and other environmental conditions*. J. Acoust. Soc. Am. **113**(3), 1492–504
84. Michaud, D.S., Keith, S.E., Feder, K., Voicescu, S.A., Marro, L., Than, J., Guay,M., Bower, T., Denning, A., Lavigne, E., Whelan, C. 2016: *Personal and situational variables associated with wind turbine noise annoyance*. J. Acoust. Soc. Am. **139**(3), 1455–66
85. Mikolajczak, J. *et al*. 2013: *Preliminary studies on the reaction of growing geese (Anser anser f. domestica) to the proximity of wind turbines*. Pol J Vet Sci. 2013;16(4):679-86. doi: 10.2478/pjvs-2013-0096.
86. Minnesota Department of Health, 2009: *Public Health Impacts of Wind Farms*
87. Ministry of the Environment, 2008: *Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*

88. Møller H, 2010: *Low-frequency noise from large wind turbines*. J. Acoust. Soc. Am, 129(6), June 2011, 3727 - 3744
89. NARUC, 2011: *Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects*. National Association of Regulatory Utility Commissioners. US Department of Energy
90. Nissenbaum A, 2012: *Effects of industrial wind turbine noise on sleep and health*. Noise and Health, Vol. 14, Issue 60, p 237 – 243.
91. Noise-con, 2008: *Simple guidelines for siting wind turbines to prevent health risks*
92. Noise quest, Aviation Noise Information & Resources, 2010: https://www.noisequest.psu.edu/noiseeffects-animals.html
93. Norton, M.P. and Karczub, D.G.: *Fundamentals of Noise and Vibration Analysis for Engineers*, Second Edition, 2003
94. Nordex. 2022 : *Noise Level, Power curves, Thrust curves – Nordex N163/5.X*. Document ref. F008_276_A12_EN, Revision 07. Nordex Energy SE & Co., Hamburg
95. O'Neal, *et al*. 2011: *Low frequency noise and infrasound from wind turbines*. Noise Control Eng. J. 59 (2), March-April 2011
96. Ortega, CP. 2012. *Ornithological Monographs. Chapter 2: Effects of noise pollution on birds: A brief review of our knowledge*. 74(1), pp.6-22.
97. Oud, M. 2012: *Low-frequency noise: a biophysical phenomenon* (http://www.leefmilieu.nl/sites/www3.leefmilieu.nl/files/imported/pdf_s/2012_OudM_Low-frequency%20noise_0.pdf) (unpublished webresource)
98. Parnell, J. 2015: "*The Generation and propagation of noise from large coal mines, and how it is managed in NSW*". NSW Department of Planning and Environment, Sydney NSW, Australia
99. Parris, M. Schneider, A. 2009: *Impacts of traffic noise and traffic volume on birds of roadside habitats*. Ecology and Society 14(1): 29
100. Parry, G. 2008: *A review of the use of different noise prediction models for wind farms and the effects of meteorology*. The Journal of the Acoustical Society of America **123**, 3535 (2008); https://doi.org/10.1121/1.2934501
101. Pedersen, T. H. 2007: *The "Genlyd" Noise Annoyance Model*. DELTA report AV 1102/07
102. Pedersen, E., Hallberg, L.M., Persson, W.K. 2007: *Living in the vicinity of wind turbines—a grounded theory study*. Qual. Res. Psychol. **4**(1–2), 49–63
103. Pedersen, Eja; Halmstad, Högskolan I, 2003: '*Noise annoyance from wind turbines: a review*'. Naturvårdsverket, Swedish Environmental Protection Agency, Stockholm
104. Pedersen, E. 2011: "*Health aspects associated with wind turbine noise—Results from three field studies",* Noise Control Eng. J. 59 (1), Jan-Feb 2011

105. Phillips, CV, 2011: *"Properly Interpreting the Epidemiologic Evidence About the Health Effects of Industrial Wind Turbines on Nearby Residents"*. Bulletin of Science Technology & Society 2011 31: 303 DOI: 10.1177/0270467611412554

106. Pierpont, N. 2009: *"Wind Turbine Syndrome: A Report on a Natural Experiment",* K Select Books, 2009

107. Pollet, AP, Kordich, MM. 2000. "*User's guide for the Sound Intensity Prediction System (SIPS) as installed at the Naval Explosive Ordnance Disposal Technology Division (Naveodtechdiv)*". Systems Department. DTIC.mil

108. Punch, *et al*. 2010: *Wind Turbine Noise. What Audiologists should know.* Audiology Today. JulAug2010

109. Quinn, J.L., M.J. Whittingham, S.J. Butler, and W. Cresswell. 2006*. Noise, predation risk compensation and vigilance in the chaffinch Fringilla coelebs*. Journal of Avian Biology 37: 601-608

110. Rabin, L.A., R.G. Coss, D.H. Owings. 2006. *The effects of wind turbines on antipredator behavior in California ground squirrels (Spermophilus beecheyi)*. Biological Conservation 131: 410-420

111. Renewable Energy Research Laboratory, 2006: *Wind Turbine Acoustic Noise*

112. RenewableUK, 2013: *Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect.*

113. SANS 10103:2008. '*The measurement and rating of environmental noise with respect to annoyance and to speech communication*'.

114. SANS 10181:2003. 'The Measurement of Noise Emitted by Road Vehicles when Stationary'.

115. SANS 10210:2004. '*Calculating and predicting road traffic noise*'.

116. SANS 10328:2008. '*Methods for environmental noise impact assessments*'.

117. SANS 10357:2004. *The calculation of sound propagation by the Concave method*'.

118. Saurenman, H. Chambers, J. Sutherland, LC. Bronsdon, RL. Forschner, H. 2005: "*Atmospheric effects associated with highway noise propagation*". Final Report 555. Arizona Department of Transportation, US Dept of Transport. Federal Highway Administration.

119. Schaub, A, J. Ostwald and B.M. Siemers. 2008. "*Foraging bats avoid noise*". The Journal of Experimental Biology 211: 3174-3180

120. Schmidt, J.H., Klokker,M. 2014: *Health effects related to wind turbine noise exposure: a systematic review*. PLoS ONE **9**(12), e114183

121. SiVEST, 2022: *Environmental Noise Impact Assessment - Proposed construction of the Koup 1 Wind Energy Facility and associated Grid Infrastructure, near Beaufort West, Western Cape Province, South Africa*. Enviro-Acoustic Research, Pretoria

122. Šottník, J. 2011: Influence of noise and object noisiness on animal breeding.. Šiška, B. – Hauptvogl, M. – Eliašová, M. (eds.). Bioclimate: Source and Limit of Social Development International Scientific Conference, 6th – 9th September 2011, Topoľčianky, Slovakia

123. Shannon, G., McKenna, M.F., Angeloni, L.M., Crooks, K.R., Fristrup, K.M., Brown, E., Warner, K.A., Nelson, M.D., White, C., Briggs, J., McFarland, S. and Wittemyer, G. 2015. *A synthesis of two decades of research documenting the effects of noise on wildlife*. Biological Reviews.

124. Sheperd, D and Billington, R. 2011: *Mitigating the Acoustic Impacts of Modern Technologies: Acoustic, Health, and Psychosocial Factors Informing Wind Farm Placement*. *Bulletin of Science Technology & Society* published online 22 August 2011, DOI: 10.1177/0270467611417841

125. Shepherd. D *et al*. 2011: *Evaluating the impact of wind turbine noise on health related quality of life*. Noise & Health, September-October 2011, 13:54,333-9.

126. Smith. M (*et al*) (2012): "*Mechanisms of amplitude modulation in wind turbine noise*"; Proceedings of the Acoustics 2012 Nantes Conference

127. Stigwood, M. Large, S. Stigwood, D. 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

128. Superior Health Council, 2013: *Public health effects of siting and operating onshore wind turbines*. Publication of the Superior Health Council No. 8738

129. Szymański, P. *et al*. 2017: *The song of Skylarks Alauda arvensis indicates the deterioration of an acoustic environment resulting from wind farm start-up*. https://doi.org/10.1111/ibi.12514

130. Tachibana, H (*et al*) (2013): "*Assessment of wind turbine noise in immission areas*"; Paper presented at the 5th International Conference on Wind Turbine Noise, Denver 28 – 30 August 2013

131. The Scottish Government, 2011. Planning Advice Note PAN 1/2011: Planning and Noise. https://www.gov.scot/publications/planning-advice-note-1-2011-planning-noise/pages/5/

132. Thorne et al, 2010: *Noise Impact Assessment Report Waubra Wind Farm Mr & Mrs N Dean Report No 1537 - Rev 1*

133. Thorne, 2010: *The Problems with "Noise Numbers" for Wind Farm Noise Assessment*. Bulletin of Science Technology and Society, 2011 31: 262

134. UK Department for Communities and Local Government, 2013: Planning practice guidance for renewable and low carbon energy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attach

ment_data/file/225689/Planning_Practice_Guidance_for_Renewable_and_Low_Carbon_Energy.pdf

135. USEPA, 1971: *Effects of Noise on Wildlife and other animals*.
136. Van den Berg, G.P., 2003. '*Effects of the wind profile at night on wind turbine sound'.* Journal of Sound and Vibration
137. Van den Berg, G.P., 2004. *'Do wind turbines produce significant low frequency sound levels?'*. 11th International Meeting on Low Frequency Noise and Vibration and its Control
138. Van den Berg, F., Pedersen, E., Bouma, J., Bakker, R. 2008: *Visual and acoustic impact of wind turbine farms on residents*. Final Rep.
139. Van den Berg, F., Verhagen, C., Uitenbroek, D. 2014: *The relation between scores on noise annoyance and noise disturbed sleep in a public health survey*. Int. J. Environ. Res. Public Health **11**(2), 2314–27
140. Van Kamp, I., Davies, H. 2013: *Noise and health in vulnerable groups: a review.* Noise Health **15**(64), 153
141. Van Riet, W. Claassen, P. van Rensburg, J. van Viegen & L. du Plessis. 1998. *Environmental potential atlas for South Africa*. J.L. van Schaik, Pretoria
142. Vestas, 2023: 'Third octave noise emission EnVentus™ *V162-7.2MW 50/60 Hz*'. DMS no.: 0116-1715_03, Vestas Wind Systems A/S, Denmark
143. Wang, Z. 2011: *Evaluation of Wind Farm Noise Policies in South Australia: A Case Study of Waterloo Wind Farm*. Masters Degree Research Thesis, Adelaide University 2011
144. Whitford, Jacques, 2008: *Model Wind Turbine By-laws and Best Practices for Nova Scotia Municipalities*
145. World Bank Group, 2015: *Environmental, Health, and Safety Guidelines Wind Energy*
146. World Health Organization, 1999: *Protection of the Human Environment; Guidelines for Community Noise*
147. World Health Organization, 2009: *Night Noise Guidelines for Europe*
148. World Health Organization, 2018: *Environmental Noise Guidelines for the European Region*
149. WSP, 2016: *Wind Turbine AM Review – Phase 2 Report*. WSP Parsons Brinckerhoff for the Department of Energy and Climate Change
150. Zwart, M.C *et al.* 2014: *Wind farm noise suppresses territorial defense behavior in a songbird*. Behavioral Ecology arv128(1), July 2014

APPENDIX A

Curriculum Vitae

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 Use License Applications and EIA's), auditing of license 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 20 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 as well as blasting impacts. Since 2007 he has completed more than 400 Environmental Noise Impact Assessments and Noise Monitoring Reports as well as various acoustic consulting services, including amongst others:

Wind Energy Facilities	*Full Environmental Noise Impact Assessments for - 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), Namas (SE), Zonnequa (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), Iziduli (SE), Msenge (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), Boulders (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), Wobben (IWP), Trakas (SiVest), Beaufort West (SiVest)
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), 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), Royal Sheba Project (Cabanga Environmental), Rietkol Silica (Jacana), Gruisfontein Colliery (Jacana), Lehlabile Colliery (Jaco-K Consulting), Bloemendal Colliery (Enviro-Insight), Rondevly Colliery (REC), Welgedacht Colliery (REC), Kalabasfontein Extension (EIMS), Waltloo Power Generation Project (EScience), Buffalo Colliery (Marang), Balgarthen Colliery (Rayten), Kusipongo Block C (Rayten), Zandheuvel (Exigo), NamPower Walvis Bay (GPT), Eloff Phase 3 (EIMS), Dunbar (Enviro-Insight), Smokey Hills (Prescali), Bierspruit (Aurecon)*
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), Riverfarm Development (Terramanzi), Conakry to Kindia Toll Road (Rayten)*
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), Bank of Botswana measurements (Linnspace), Skukuza Noise Measurements (Concor), 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), Twisdraai Colliery (Lefatshe Minerals), SASOL Prospecting (Lefatshe Minerals), South32 Klipspruit (Rayten), Sibanye Stillwater Kroondal (Rayten), Rooiberg Asphalt (Rooiberg Asphalt), SASOL Shondoni (Lefatshe), SASOL Twisdraai (Lefatshe), Anglo Mototolo (Exigo), Heineken Inyaniga (AECOM), Glencore Izimbiwa (Cleanstream) Glencore Impunzi (Cleanstream), Black Chrome Mine (Prescali) Sibanye Stillwater Ezulwini (Aurecon), Sibanye Stillwater Beatrix (Aurecon), Bank of Botshwana (Linspace), Lakeside (Linspace), Skukuza (SiVest), Rietvlei Colliery (Jaco-K Consulting)
Small Noise Impact Assessments	*TCTA AMD Project Baseline (AECOM), NATREF (Nemai Consulting), Christian Life Church (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), Tiegerpoort Wedding Venue (Henwood Environmental), Monavoni Development (Marindzini), Rezoning of Portion 1 (Primo Properties), Tswaing Mega City (Makole), Mabopane Church (EP Architects), ERGO Soweto Cluster (Kongiwe), Fabio Chains (Marang), GIDZ JMP (Marang), Temple Complex (KWP Create), Germiston Metals (Dorean), Sebenza Metals (Dorean)*
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), Paul Puts WEF (ARCUS), Juno WEF (ARCUS), etc.*

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APPENDIX B

Glossary of Terms

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 micro pascals 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 C

Declaration of Independence

APPENDIX D

Site Sensitivity Verification

SITE SENSITIVITY VERIFICATION (IN TERMS OF PART A OF THE ASSESSMENT PROTOCOLS PUBLISHED IN GN 320 ON 20 MARCH 2020

Part A of the Assessment Protocols published in GN 320 on 20 March 2020 (i.e., Site sensitivity verification is required where a specialist assessment is required but no specific assessment protocol has been prescribed) is applicable where the Department of Environment, Forestry and Fisheries Screening Tool has the relevant themes to verify.

In accordance with Appendix 6 of the National Environmental Management Act (Act 107 of 1998, as amended) (NEMA) Environmental Impact Assessment (EIA) Regulations of 2014, a site sensitivity verification has been undertaken in order to confirm the current land use and environmental sensitivity of the proposed project area as identified by the National Web-Based Environmental Screening Tool (Screening Tool). The details of the site sensitivity verification are noted below:

Date of Site Visit	10 to 12 June 2021
Specialist Name	Francois Stephanus de Vries (Noise)
Professional Registration Number (if applicable)	Not applicable, there is no registration body in South Africa that could allow professional registration for acoustic consultants.
Specialist Affiliation / Company	Enviro-Acoustic Research CC

Output from National Environmental Screening Tool

The site was initially assessed using the National Environmental Screening tool, available at, https://screening.environment.gov.za. The output from the National Online Screening tool indicates a number of areas within, and up to 2,000 m from the project boundary is considered to be of a "very high" sensitivity to noise. These potentially "very high" sensitive areas (in terms of noise) are indicated on **Figures D.1** together with the potential noise-sensitive receptors as identified after the site visit.

Description on how the site sensitivity verification was undertaken

The site sensitivity was verified using:

a) *available aerial images (Google Earth®) (See **Figure D.1** for verified potential noise-sensitive receptors);*
b) *the statuses of these structures were defined during the site visit done in June 2021.*

Outcome of the Site Sensitivity Verification

Potential NSR were marked as green dots on **Figure D.1** below, highlighting:

- that the online screening tool identified a number of areas with a "very high" sensitivity to noise in the vicinity of the proposed development. There are permanent or temporary residential activities at the locations marked 1, 2, 3, 4, 5 and 6. These locations are located within 2,000 m from a potential wind turbine and considered to have a "Very High" sensitivity to noise. This report agrees with that finding.
- There are a number of areas identified to have a "Very High" sensitivity to noise. The site assessment highlighted that these are not sensitive to noise, as there are no structures used for residential activities or any other use that are considered to be noise sensitive. This report disputes those areas.

Because a number of these structures are used for residential purposes and considered to be noise-sensitive, the potential impact from noise from the project is assessed in this Noise Specialist Study.

Signature	**Signature**
Morné de Jager	**Francois Stephanus de Vries**
2023 – 06 – 26	**2023 – 06 – 26**

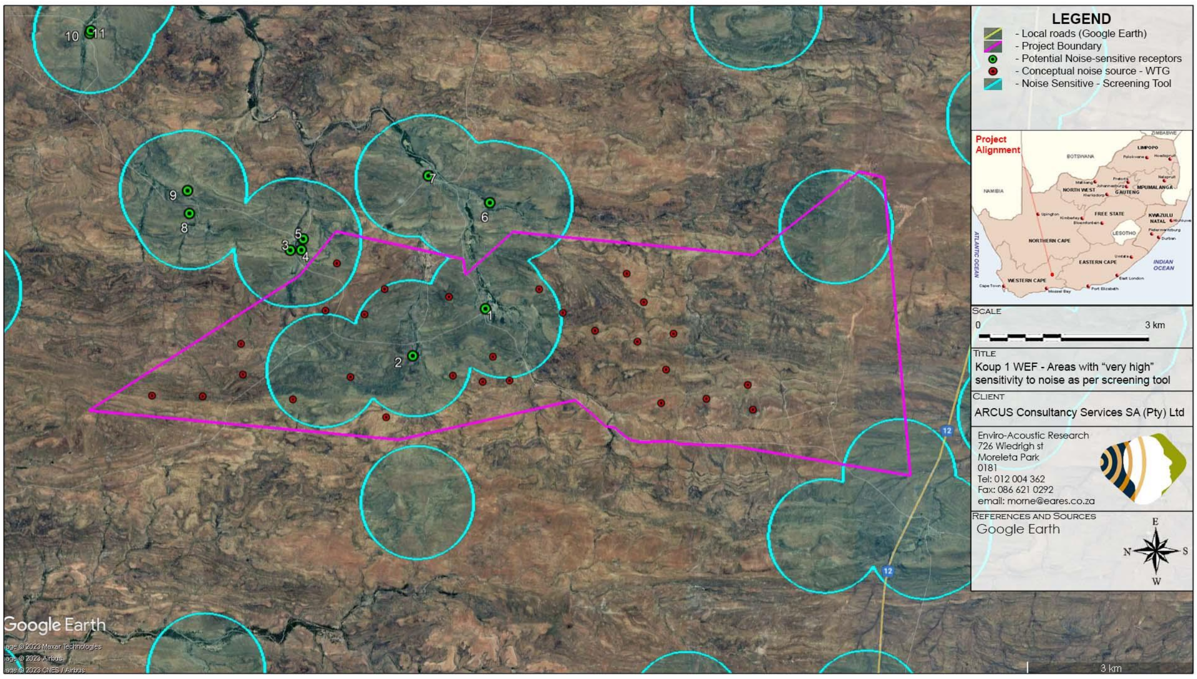

Figure D.1: Areas defined to be of "Very High" sensitivity in terms of noise by the online screening tool

APPENDIX E

Photos of Measurement Locations

Photos E.1: Measurement location at SGEKLTSL01

Photos E.2: Measurement location at SGEKLTSL02

Photos E.3: Measurement location at SGEKLTSL03

Photos E.4: Measurement location at SMKLTSL01

Photos E.5: Measurement location at SMKLTSL02

Photos E.6: Measurement location at SMHLTSL01

Photos E.7: Measurement location at SMHLTSL02

APPENDIX F

Identified NSR, calculated noise levels and significance of noise impact: Criteria of EAP (SiVEST SA (Pty) Ltd)

Appendix F, Table 1: Locations of identified NSR and perceived use of structures

Potential Noise-sensitive development / Receptor(s)	WGS 84 Longitude	WGS 84 Latitude	UTM 34 S X	UTM 34 S Y	Comment
NSR01	22.47223	-32.8556	637760	6363766	Permanent residential use
NSR02	22.45844	-32.863	636458	6362954	Permanent residential use
NSR03	22.43523	-32.8462	634311	6364848	Permanent residential use
NSR04	22.43732	-32.8462	634507	6364850	Permanent residential use
NSR05	22.43768	-32.8444	634543	6365044	Permanent residential use
NSR06	22.47306	-32.8387	637863	6365637	Permanent residential use

Appendix F, Table 2: Projected access road construction noise levels and impact significance

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted, low wind)	Projected Noise Level, Worst-case construction scenario	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	26.1	58.9	32.8	Site - 1	Probable - 3	Completely - 1	Marginal - 2	Short - 1	Very High - 4	**Medium**
NSR02	45	26.1	72.5	46.4	Site - 1	Definite - 4	Completely - 1	Marginal - 2	Short - 1	Very High - 4	**Medium**
NSR03	45	26.1	72.5	46.4	Site - 1	Definite - 4	Completely - 1	Marginal - 2	Short - 1	Very High - 4	**Medium**

Appendix F, Table 3: Projected traffic noise levels and impact significance – Construction traffic passing NSR

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted, low wind)	Projected Noise Level, Worst-case construction scenario	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	26.1	46.2	20.1	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR02	45	26.1	53.0	26.9	Site - 1	Possible - 2	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR03	45	26.1	53.0	26.9	Site - 1	Possible - 2	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**

Appendix F, Table 4: Projected construction noise levels and daytime significance

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	26.1	44.4	18.3	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR02	45	26.1	42.7	16.7	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR03	45	26.1	40.2	14.2	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	**Low**
NSR04	45	26.1	38.4	12.5	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	**Low**
NSR05	45	26.1	39.2	13.3	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	**Low**
NSR06	45	26.1	36.7	10.9	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	**Low**

Appendix F, Table 5: Projected construction noise levels and night-time significance

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	23.3	44.4	21.1	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR02	45	23.3	42.7	19.5	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR03	45	23.3	40.2	17.0	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR04	45	23.3	38.4	15.2	Local - 2	Improbable - 1	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR05	45	23.3	39.2	16.0	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR06	45	23.3	36.7	13.6	Local - 2	Improbable - 1	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**

Appendix F, Table 6: Projected operational noise levels and night-time significance (using a worst-case SPL of 112.2 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level, IFC/WHO)	Potential Existing Ambient Sound Levels (Estimated considering an 10 m/s wind speed)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	43.5	49.6	7.0	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Very High - 4	**High**
NSR02	45	43.5	48.3	6.0	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	High - 3	**Medium**
NSR03	45	43.5	45.4	4.1	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	**Low**

NSR04	45	43.5	46.0	4.4	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR05	45	43.5	45.9	4.4	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR06	45	43.5	41.6	2.2	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low

Appendix F, Table 7: Projected operational noise levels and night-time significance (option - mitigated WTG with an SPL of 107.5 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level, IFC/WHO)	Potential Existing Ambient Sound Levels (Estimated considering an 10 m/s wind speed)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	43.5	44.9	3.8	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR02	45	43.5	43.6	3.1	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR03	45	43.5	40.7	1.8	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR04	45	43.5	41.3	2.0	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR05	45	43.5	41.2	2.0	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR06	45	43.5	36.9	0.9	Local - 2	Improbable - 1	Completely - 1	Marginal - 2	Long -3	Low - 1	Low

Appendix F, Table 8: Projected cumulative operational noise levels and night-time significance (using a worst-case SPL of 112.2 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Potential Existing Ambient Sound Levels (Estimated considering an 10 m/s wind speed)	Projected Noise Level for the Koup 1 WEF operating in isolation (dBA)	Projected Cumulative Noise Level (For all operating WEFs in area)	Potential change in ambient sound level considering Cumulative Noise Level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	43.5	49.6	49.6	7.0	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Very High - 4	High
NSR02	43.5	48.3	48.4	6.1	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	High - 3	Medium
NSR03	43.5	45.4	45.8	4.3	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR04	43.5	46.0	46.4	4.7	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR05	43.5	45.9	46.3	4.6	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR06	43.5	41.6	41.6	2.2	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR07	43.5	39.7	39.7	1.5	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR08	43.5	33.1	43.1	2.8	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR09	43.5	35.2	45.4	4.1	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low

End of Report

Terrestrial Biodiversity Walkdown Report

Koup 1 Wind Energy Facility

Date: 16/05/2023
Version: Final
Author: J. Pote

Terrestrial Biodiversity Walkdown Report

Koup 1 Wind Energy Facility

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1 Introduction & Background

1.1 Project Description

The proposed Koup 1 WEF will comprise up to twenty-eight (28) wind turbines with a maximum total energy generation capacity of approximately 140 MW. The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line. The location of the site, to the south-west of Beaufort West in the Western Cape province, is indicated in Figure 1 below, indicated in red.

Koup 1 is par of a cluster of two WEF facilities namely Koup 1 (indicated in yellow - east) and Koup 2 (indicated in RED - west), which have a shared access road. While the walkdown component of this report pertains specifically to Koup 1, portions of the background components of this report may apply to both facilities, as they share a similar biophysical environment and area of influence.

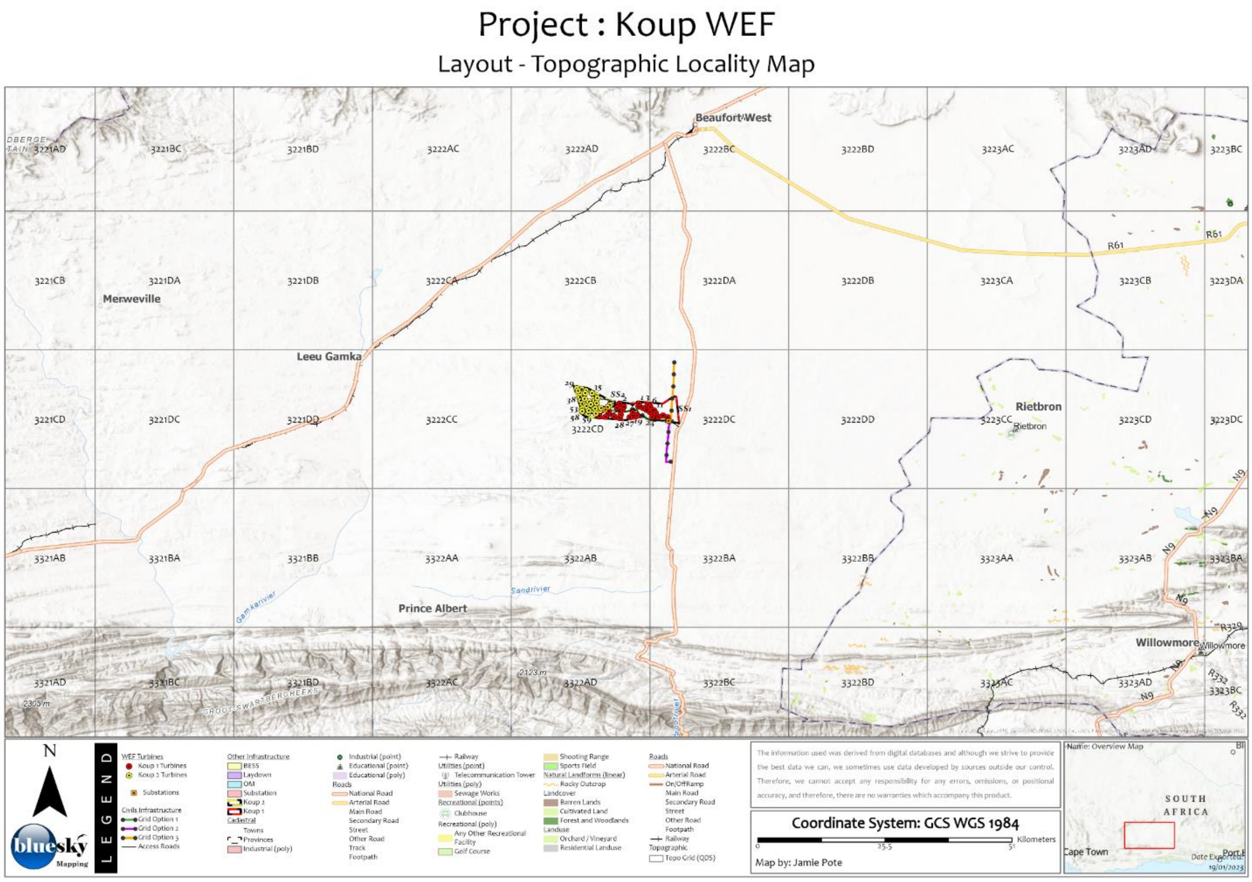


Figure 1: Site Locality (indicated in red)

1.2 Purpose of Report

The Wind Energy Facility Ecological walkdown has been undertaken in fulfilment of specific conditions contained in the environmental authorisation (Reg. No. 14/12/16/3/3/2/2120) dated 12 September 2022 and subsequent amendments issued by Department of Forestry, Fisheries and the Environment for the project, as follows:

- Condition 13: A final site layout plan for the Koup 1 WEF and its associated infrastructure near Beaufort West in the Western Cape Province, as determined by the detailed engineering phase and micro-siting of the wind turbine positions, and all mitigation measures as dictated by the final site layout plan, must be submitted to the Department for approval prior to construction. A copy of the final site layout map must be made available for comments to registered Interested and Affected Parties and the holder of this Environmental Authorisation must consider such comments. Once amended, the final development layout map must be submitted to the Department for written approval prior to commencement of the activity. All available biodiversity information must be used in the finalisation of the layout map. Existing infrastructure must be used as far as possible e.g., roads. The layout map must indicate the following:

13.1. The position of wind turbines and associated infrastructure;
13.2. Internal and access roads indicating width;
13.3. The BESS, substation(s) inverters and / or transformer(s) sites including their entire footprints;
13.4. Connection routes (including pylon positions) to the distribution/transmission network;
13.5. Buildings, including accommodation;
13.6. All existing infrastructure on the site;
13.7. Wetlands, drainage lines, rivers, stream and water crossing of roads and cables;
13.8. All sensitive features e.g., Important Bird Areas, Critical Biodiversity Areas, Ecological Support Areas, heritage sites, wetlands, pans and drainage channels that will be affected by the facility and associated infrastructure; and
13.9. All "no-go" and buffer areas.

- Condition 39: A pre-construction walk through of the approved power line alignment and turbine positions by a bat specialist, avifaunal specialist and ecologist, must be conducted to ensure that the micro-siting of the turbines, pylons and power line alignment have the least possible impact, there are no nests sites of priority species on or close to the construction corridor, and all protected plant species impacted are identified.
- Condition 43: The 'no-go' areas of the development property must be clearly demarcated and must be excluded from the final layout plan.
- Condition 44: All watercourses and associated wetlands are regarded as sensitive. All developments within 500 m of watercourses must comply with the National Water Act.
- Condition 45: No transmission line towers, substations and construction camps will be placed within the delineated water courses as well as their respective buffers without obtaining the required approvals. A 32 m buffer must be applied along all identified watercourses and a 50m buffer must be applied along all identified wetlands.
- Condition 46: A pre-construction survey of the final development footprint must be conducted by a qualified floral specialist to identity protected species affected by the proposed development. Prior to the commencement of construction, a rescue and rehabilitation operation for these species which could survive translocation must be conducted.
- Condition 47: Construction activities must be restricted to demarcated areas to restrict the impact on sensitive environmental features.
- Condition 54: Where roads pass right next to major water bodies, provision shall be made for fauna such as toads to pass under the roads by using culverts or similar structures.
- Condition 55: Bridge design must be such that it minimise impact to riparian areas with minimal alterations to water flow and must allow the movement of fauna and flora.
- Condition 56: The final development area should be surveyed for species suitable for search and rescue, which should be trans-located prior to the commencement of construction.
- Condition 59: Wetlands, rivers and river riparian areas must be treated as "no-go" areas and appropriately demarcated as such.

The primary purpose of the ecological walkdown, as per the EA conditions are to ensure that the micro-siting of the turbines and power line has the least possible impact and all protected plant species impacted are identified. As a secondary outcome a species list of protected species as well as species suited to translocation is provided. Some conditions outlines above are pertinent to aquatic rather than terrestrial environment and are subject to an aquatic specialist walkdown, however the terrestrial and aquatic environment are linked and hence consideration will be given to aquatic aspects where relevant during the walkdown.

This report is one of two undertaken for a pair of adjacent Wind Energy Facility Projects within an overlapping Area of Influence, namely Koup 1 (east) and Koup 2 (west). The general descriptions provided in this report are thus an overview of the broader area and may contain information that has been summarised from separate but contiguous or overlapping site assessments in order to more effectively contextualise the broader environment and the area of influence as well as to better understand the 'bigger picture', since the natural environment is interconnected, and as will become evident the local environment is strongly influenced by the surrounding area.

1.3 Methodology

The site walkdown was undertaken in the time-period between 06 and 20 February 2023. The site walkdown was during late summer after a reasonably good summer rainfall period. While the seasonal response of local flora does vary throughout the year, with certain species flowering during different seasons, the time during which the walkdown was undertaken is deemed to have been undertaken during an adequate seasonal period. It is possible that certain flora was not visible at the time of the walkdown, including certain geophytic species, that are active in spring and early summer may have been dormant or less visible at the time of the walkdown. The main purpose of the walkdown has been to microsite and refine turbines footprints and other infrastructure based on landscape level ecological processes and identification of potentially sensitive habitat that could be avoided. As a secondary measure the original species list(s) have been updated with several additional species in order to better inform permit application and flora and fauna search and rescue requirements but is also informed by the findings of the original assessment.

1.4 Data sources and references

A comprehensive list of references, including data sources is provided in Section 5. Data sources that were utilised for the walkdown and report include the following:

- National (DFFE) Web Based Screening Tool – to generate the sites potential environmental sensitivity.
- National Vegetation Map 2018 (NVM, 2018), Mucina & Rutherford (2006) and National Biodiversity Assessment (NBA, 2019) – description of vegetation types, species (including endemic) and vegetation unit conservation status.
- National and Regional Legislation including Provincial Nature Conservation Ordinance (P.N.C.O). NEM:BA Threatened or Protected Species (ToPS).
- Botanical Database of Southern Africa (BODATSA) and New Plants of Southern Africa (POSA) – lists of plant species and potential species of concern found in the general area (SANBI.)
- International Union for Conservation of Nature (IUCN) - Red List of Threatened Species.
- Animal Demography Unit Virtual Museum (VM) – potential faunal species.
- Global Biodiversity Information Facility (GBIF) – potential faunal species.
- Southern African Bird Atlas Project 2 (SABAP2) – for bird species records.
- National Red Books and Lists - mammals, reptiles, frogs, dragonflies & butterflies.

- National Freshwater Ecosystem Priority Areas assessment (NFEPA, 2011) - important catchments.
- National Protected Areas Expansion Strategy (NPAES, 2018) and South Africa Protected Area database (2020) – protected area information.
- Critical Biodiversity Areas of the Northern Cape (2016) – Bioregional Plan.
- SANBI BGIS – All other biodiversity GIS datasets.
- Aerial Imagery – Google Earth, Esri, Chief Surveyor General (http://csg.dla.gov.za).
- Cadastral and other topographical country data - Chief Surveyor General (http://csg.dla.gov.za).
- Original Ecological conducted for the project, excluding bats and avifauna by Todd (2022)
- Other sources include peer-reviewed journals, regional and local assessments and studies in the general location of the project and its area of influence, landscape prioritization schemes (Key Biodiversity Areas), systematic conservation planning assessments and plans (as above), and any pertinent masters and doctoral theses, among others.

1.5 Assumptions and Limitations

- The site visit was undertaken in late summer 2023, at the end of a reasonable rainy season and it is possible that certain spring flowering flora groups including geophytes may not have been visible. The site visit was deemed adequate however for micro siting purposes, supplemental to other information sources.
- Threatened and protected species are by their nature elusive to find and can be missed when surveying extensive areas. All reasonable measures have been taken to minimise this risk.
- Flora species are known to grow and flower at slightly different times of the year and in some cases do not lower every year, hence it is possible that certain species may not have been representing at the time of survey. The time period of the survey was thus at a time when most species were likely to be visible.

1.6 National Environmental Screening Tool

While the original assessment for this project was undertaken after the requirements for screening where published and implemented, the following section is included to confirm that no changes to the screening tool have come into effect since publication of the assessments.

The DEA Screening Tool (dated 12/12/2022) indicates the following:

- Terrestrial Biodiversity is Very High & Low (Figure 2).
- Plant species sensitivity is Medium (Figure 3).
- Animal Species sensitivity is High & Medium (Figure 4).
- Aquatic Sensitivity is Low & Very High (Figure 5)

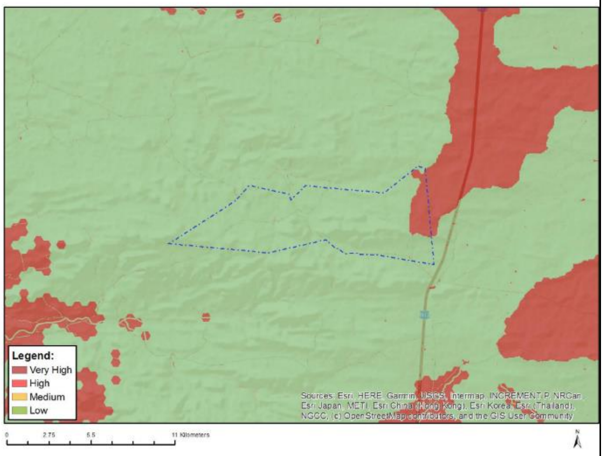


Figure 2: Terrestrial Biodiversity Sensitivity.

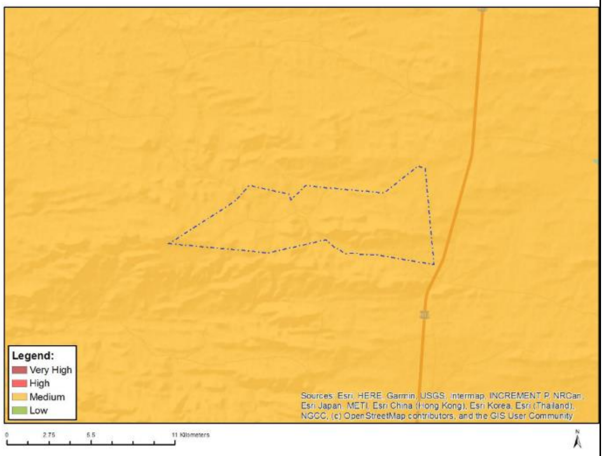


Figure 3: Plant Species Sensitivity.

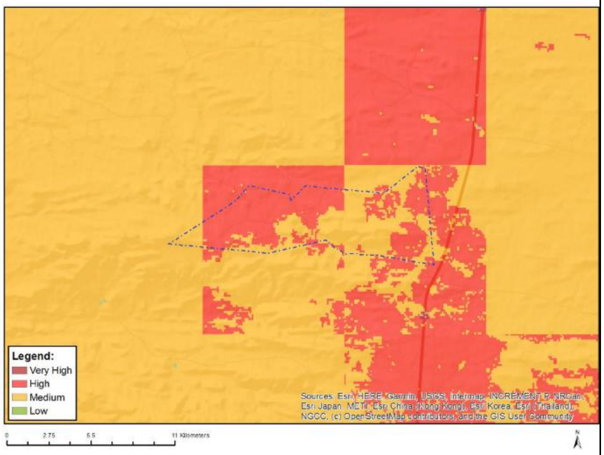


Figure 4: Animal Species Sensitivity.

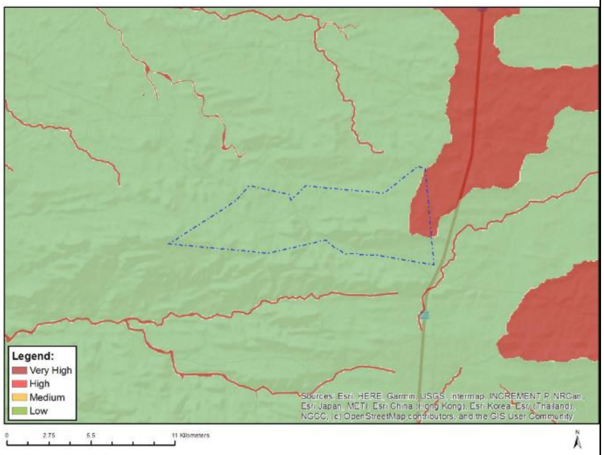


Figure 5: Aquatic Sensitivity.

KOUP 1	
Terrestrial Sensitivity	**Feature(s) in proximity**
Very High	CBA 1, ESA 2, FEPA Sub-catchments
High	None
Medium	None
Low	None
Plant Sensitivity	**Feature(s) in proximity**
Very High	None
High	None
Medium	Sensitive species 383, *Peersia frithii* & *Tritonia florentiae*
Low	Present
Animal Sensitivity	**Feature(s) in proximity**
Very High	None
High	*Neotis ludwigii* & *Polemaetus bellicosus* (birds)
Medium	*Neotis ludwigii, Afrotis afra, Aquila verreauxii* (birds) & *Chersobius boulengeri* (reptile)
Low	Present
Aquatic Sensitivity	**Feature(s) in proximity**
Very High	Aquatic CBAs, Rivers, FEPA quinary catchments
High	None
Medium	None
Low	Present

NOTE: as per point 1.5 of the Terrestrial Biodiversity Specialist Assessment and Minimum Report Content Requirements:

> *'If any part of the proposed development footprint falls within an area of 'very high' sensitivity, the assessment and reporting requirements prescribed for the 'very high' sensitivity apply to the entire footprint, **excluding linear activities** for which impacts on terrestrial biodiversity are temporary and the land in the opinion of the terrestrial biodiversity specialist, based on the mitigation and remedial measures, can be returned to the current state within two years of the completion of the construction phase, in which case a compliance statement applies. Development footprint in the context of this protocol means the area on which the proposed development will take place and includes any area that will be disturbed.'*

Based on the above reporting protocol condition, the entire access roads and OHL grid connection components will fall into the above category, which implies that for a temporary linear activity, such as a pipeline or powerline, the screening tool designated high sensitivity should be reduced to a low sensitivity and only a complicated statement would be required.

The site walkdown has physically screened for the presence of any of the listed, and other possible species or sensitivities that are not identified in the screening tool over and above and above the findings of the original assessments. Not all features are directly affected, but being in proximity, the risks associated with the activity will be investigated further and addressed in the report.

2 General Terrestrial Biodiversity

The site falls within a large basin between the Great Escarpment (Nuweveld Mountains) in the north and northwest and Cape Fold Belt Mountains (mostly Swartberg Mountains) in the south and typically consists of extremely irregular to slightly undulating low lying plains interspersed with hilly and mountainous ridges. The low-lying plains of the site consist of typical Eastern Upper Karoo which is a widespread vegetation type of low overall sensitivity. The slopes of the site are considered generally of moderate to high sensitivity on account of their high biodiversity value for fauna and flora as well as their vulnerability to disturbance and consequent erosion. The plateau areas consist of Upper Karoo Hardeveld elements, which is considered to be generally of moderate sensitivity. The plains and slopes are bisected by a somewhat complex network of seasonal drainage lines and watercourses, having Southern Karoo Riviere vegetation elements. Low lying flat areas often have deeper sandy soils and a grassier karroid vegetation. All of the affected vegetation types are still generally intact, other than evidence of overgrazing and significant erosion in the valleys associated with deeper soils. No significant transformation is evident other than limited cultivated areas, in the valleys also associated with deeper soils.

The fauna of the area is considered to be composed of widespread species, with very few species of conservation concern likely to be present at the site. The most important areas for fauna at the site are the drainage systems and well-vegetated slopes which are largely outside of the development footprint and would not be significantly affected. The major impact on fauna would be habitat loss associated largely with the high-elevation plateau habitat of the site. As there are no species of high conservation concern prevalent in the area, impacts on terrestrial fauna were deemed likely to be relatively low and of local significance only.

2.1 Vegetation Units and Habitats

According to the national vegetation map, four vegetation types occur within the study area (Figure 6); most of the wind farm site falls entirely within the Gamka Karoo vegetation type. Vegetation was confirmed by Todd (2022) to be as designated. Other units in the surrounding area include Southern Karoo Riviere in riverine areas and Upper Karoo Hardeveld on higher lying mountains plains. Elements of these units from the surrounding area may be present within the site in riverine areas and/or elevated areas respectively, which are not reflected on the scale of mapping based on the National Vegetation Map. These different units are briefly described below and then illustrated and characterised as they occur at the site.

Project : Koup WEF

Layout - Vegetation and Status (National)

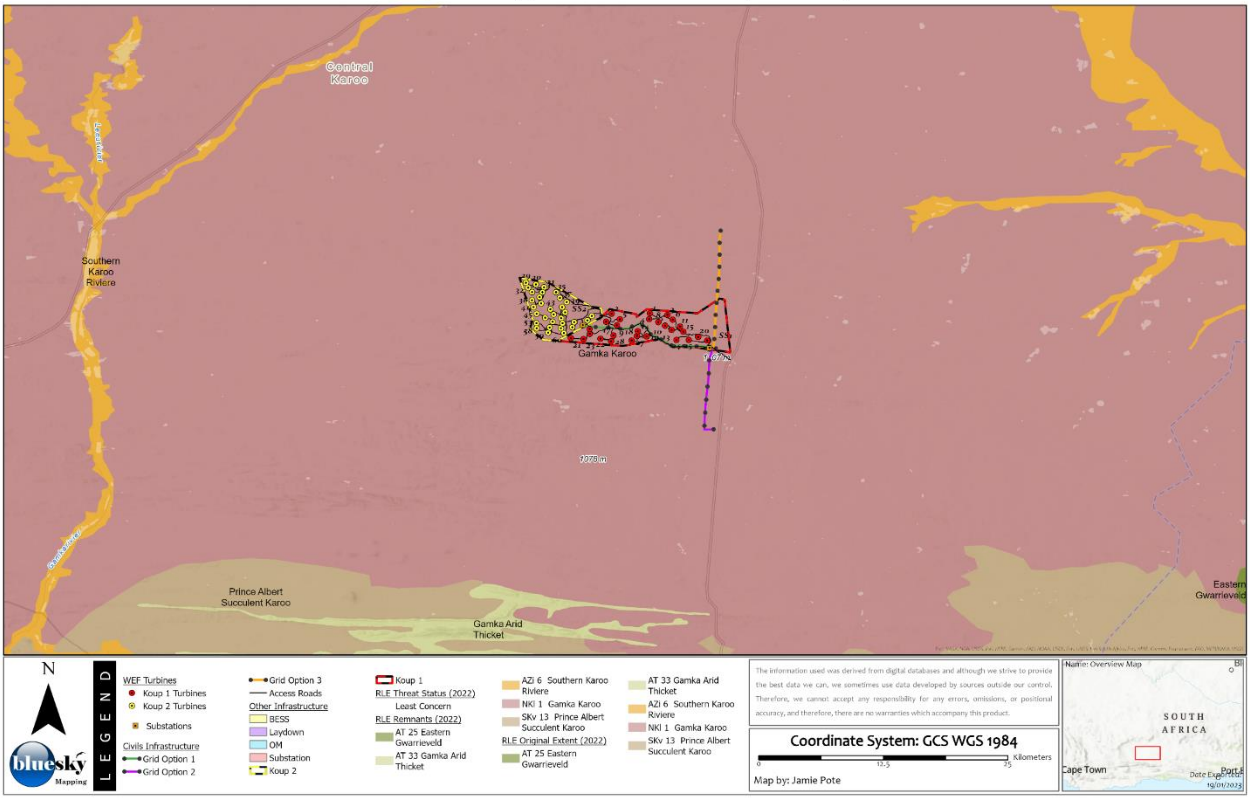


Figure 6: Regional Vegetation Units

As described by Todd (2022), Mucina & Rutherford (2006) designates the vegetation unit for the entire site as Gamka Karoo (Figure 6), with no other vegetation types for some distance from the site. Gamka Karoo occurs in the Western Cape and Eastern Cape Provinces and marginally into the Northern Cape Province. It occupies the large basin between the Great Escarpment (Nuweveld Mountains) in the north and northwest and Cape Fold Belt Mountains (mostly Swartberg Mountains) in the south. From approximately the edge of the Gamka basin catchment area (i.e. of the Dwyka River tributary) in the west to about the Kariega River in the east. The landscape typically consists of extremely irregular to slightly undulating plains covered with dwarf spiny shrubland dominated by Karoo dwarf shrubs with rare low trees (e.g. *Euclea undulata*). Geology is primarily mudstones and sandstones of the Beaufort Group (Adelaide Subgroup) with some Ecca (Fort Brown Formation) shales supporting very shallow and stony soils of the Glenrosa and/or Mispah forms. Mucina et al. (1996) list *Chasmatophyllum stanleyi, Hereroa incurva, Hoodia dregei, Ruschia beaufortensis. Jamesbrittenia tenuifolia, Manulea karrooica* and *Piaranthus comptus* as species endemic to this vegetation type. Gamka Karoo is classified as Least Concern (NBA, 2018) and less than 1% has been lost to transformation. The Conservation status in the more recent NBA (2022) is still designated Least Concern, hence the status has not changed since the original assessment was undertaken.

Within the site and along the power line corridor, two basic communities can be recognised (Todd, 2022), the rocky hills and low ridges and then the plains of the site. The plains tend to be homogenous with few features of significance present and are dominated by low woody and succulent shrubs with occasional areas of calcrete or sandy soils where grasses are more abundant. The rocky hills are more heterogenous and have a higher abundance of larger woody species than the plains and may also contain localised communities of low succulents. In general, the rocky hills are considered more sensitive than the surrounding plains as the diversity of the hills is usually higher than the plains.

Within the site, the areas of Gamka Karoo plains (Table 1) are dominated by *Pentzia incana, Hirpicium alienatum, Ruschia beaufortensis, Lycium cinereum, Stipagrostis ciliata, Stipagrostis obtusa, Aristida congesta, Thesium lineatum, Enneapogon desvauxii, Asparagus capensis, Asparagus glauca, Fingerhuthia africana, Euphorbia mauritanica, Limeum aethiopicum* and *Aloe claviflora*.

Table 1: *Gamka Karoo (NKl 1).*

GROWTH FORM	DESCRIPTION/SPECIES[1]
Geophytic Herbs	*Drimia intricata, Moraea polystachya.*
Grasses	*Aristida congesta (d), A. diffusa (d), Fingerhuthia africana (d), Stipagrostis ciliata (d), S. obtusa (d), Aristida adscensionis, Cenchrus ciliaris, Digitaria argyrograpta, Enneapogon desvauxii, Enneapogon scaber, Eragrostis homomalla, E. lehmanniana, E. obtusa, Tragus berteronianus, T. koelerioides.*
Herbs	*Gazania lichtensteinii (d), Chamaesyce inaequilatera, Dicoma capensis, Galenia glandulifera, Lepidium africanum subsp. africanum, L. desertorum, Lessertia pauciflora var. pauciflora, Leysera tenella, Osteospermum microphyllum, Sesamum capense, Tetragonia microptera, Tribulus terrestris, Ursinia nana.*
Tall Shrubs	*Lycium cinereum (d), L. oxycarpum (d), Rhigozum obovatum (d), Acacia karroo, Cadaba aphylla, Lycium schizocalyx, Rhus burchellii, Sisyndite spartea.*
Low shrubs	*Chrysocoma ciliata (d), Eriocephalus ericoides subsp. ericoides (d), E. spinescens (d), Felicia muricata (d), Galenia fruticosa (d), Limeum aethiopicum (d), Pentzia incana (d), Pteronia adenocarpa (d), Rosenia humilis (d), Aptosimum indivisum, Asparagus burchellii, Blepharis mitrata, Eriocephalus microphyllus var. pubescens, Felicia filifolia subsp. filifolia, F. muricata subsp. cinerascens, Galenia secunda, Garuleum bipinnatum, G. latifolium, Gomphocarpus filiformis, Helichrysum lucilioides, Hermannia desertorum, H. grandiflora, H. spinosa, Melolobium candicans, Microloma armatum, Monechma spartioides, Pentzia pinnatisecta, Plinthus karooicus, Polygala seminuda, Pteronia glauca, P. sordida, P. viscosa, Selago geniculata, Sericocoma avolans, Zygophyllum microcarpum, Z. microphyllum.*
Succulent Shrubs	*Ruschia intricata (d), Aridaria noctiflora subsp. straminea, Crassula muscosa, Drosanthemum lique, Galenia sarcophylla, Kleinia longiflora, Ruschia spinosa, Salsola tuberculata, Sarcocaulon patersonii, Trichodiadema barbatum, Tripteris sinuata var. linearis.*
Semiparasitic Shrub	*Thesium lineatum*
Biogeographically Important Taxa	(*Endemic to Great Karoo Basin)

[1] (d) Dominant

GROWTH FORM	DESCRIPTION/SPECIES[1]
	Succulent Shrubs: *Hereroa latipetala** (also found in Prince Albert Succulent Karoo), *Hereroa odorata** (also found in Koedoesberge-Moordenaars Karoo), *Pleiospilos compactus* (southern and western limits of distribution), *Rhinephyllum luteum**, *Stapelia engleriana**. Geophytic Herb: *Tritonia tugwelliae**. Low Shrub: *Felicia lasiocarpa**. Succulent Herbs: *Piaranthus comptus**, *Tridentea parvipuncta* subsp. *parvipuncta**. Graminoid: *Oropetium capense* (westernmost limit of distribution).
Endemic Taxa	Succulent Shrubs: *Chasmatophyllum stanleyi, Hereroa incurva, Hoodia dregei, Ruschia beaufortensis*. Low Shrubs: *Jamesbrittenia tenuifolia*. Herb: *Manulea karrooica*. Succulent Herb: *Piaranthus comptus*.

Upper Karoo Hardeveld elements (Table 2) are present on the Gamka Karoo stony hills, which have common and dominant species including *Carissa haematocarpa, Euclea undulata, Nenax microphylla, Thesium lineatum, Tragus koelerioides, Hermannia cuneifolia, Hermannia desertorum, Eriocephalus microcephalus, Searsia burchellii, Hirpicium alienatum, Galenia fruticosa, Pteronia glomerata, Dianthus namaquensis, Rhigozum obovatum, Helichrysum zeyheri, Cissampelos capensis, Pegolettia retrofracta, Garuleum bipinnatum, Kleinia longiflora, Cotyledon orbiculata, Enneapogon scaber, Asparagus striatus, Astroloba corrugata* and *Pteronia incana*.

Trees and taller shrubs are not common in the open veld but are usually prevalent around the rocky outcrops which occur scattered across the plateau areas as well as near drainage lines and watercourses, with species such as *Euclea undulata, Lycium cinereum, Acacia karroo and Rhus burchellii.* The abundance of Species of Conservation Concern (SCC) within this habitat is relatively low and no species of high conservation concern were observed, including Sensitive Species 383. Some provincially protected species are however present including *Aloe claviflora*. Rockier areas tend to have elements of Upper Karoo Hardeveld, as described below. A general list of species that are represented in the vegetation type and conservation status characteristics is provided in Table 1.

Table 2: Upper Karoo Hardeveld (NKl 2).

GROWTH FORM	DESCRIPTION/SPECIES[2]
Geophytic Herbs	*Albuca setosa, Androcymbium albomarginatum, Asplenium cordatum, Boophone disticha, Cheilanthes bergiana, Drimia intricata, Oxalis depressa*
Grasses	*Aristida adscensionis (d), A. congesta (d), A. diffusa (d), Cenchrus ciliaris (d), Enneapogon desvauxii (d), Eragrostis lehmanniana (d), E. obtusa (d), Sporobolus fimbriatus (d), Stipagrostis obtusa (d), Cynodon incompletus, Digitaria eriantha, Ehrharta calycina, Enneapogon scaber, E. scoparius, Eragrostis curvula, E. nindensis, E. procumbens, Fingerhuthia africana, Heteropogon contortus, Merxmuellera disticha, Stipagrostis ciliata, Themeda triandra, Tragus berteronianus, T. koelerioides*
Herbs	*Troglophyton capillaceum subsp. capillaceum, Dianthus caespitosus subsp. caespitosus, Gazania krebsiana, Lepidium africanum subsp. africanum, Leysera tenella, Pelargonium minimum, Sutera pinnatifida, Tribulus terrestris.*
Tall Shrubs	*Lycium cinereum (d), Rhigozum obovatum (d), Cadaba aphylla, Diospyros austro-africana, Ehretia rigida subsp. rigida, Lycium oxycarpum, Melianthus comosus, Rhus burchellii.*
Low shrubs	*Chrysocoma ciliata (d), Eriocephalus ericoides subsp. ericoides (d), Euryops lateriflorus (d), Felicia muricata (d), Limeum aethiopicum (d), Pteronia glauca (d), Amphiglossa triflora, Aptosimum elongatum, A. spinescens, Asparagus mucronatus, A. retrofractus, A. striatus, A. suaveolens, Eriocephalus spinescens, Euryops annae, E. candollei, E. empetrifolium, E. nodosus, Felicia filifolia subsp. filifolia, Garuleum latifolium, Helichrysum lucilioides, H. zeyheri, Hermannia filifolia var. filifolia, H. multiflora, H. pulchella, H. vestita, Indigofera sessilifolia, Jamesbrittenia atropurpurea, Lessertia frutescens, Melolobium candicans, M. microphyllum, Microloma armatum, Monechma incanum, Nenax microphylla, Pegolettia retrofracta, Pelargonium abrotanifolium, P. ramosissimum, Pentzia globosa, P. spinescens, Plinthus karooicus, Polygala seminuda, Pteronia adenocarpa, P. sordida, Rosenia humilis, Selago albida, Solanum capense, Sutera halimifolia, Tetragonia arbuscula, Wahlenbergia tenella.*
Succulent Shrubs	*Aloe broomii, Drosanthemum lique, Faucaria bosscheana, Kleinia longiflora, Pachypodium succulentum, Trichodiadema barbatum, Zygophyllum flexuosum.*
Semiparasitic Shrub	*Thesium lineatum (d).*
Endemic Taxa	Succulent Shrubs: *Aloe chlorantha, Crassula barbata subsp. broomii, Delosperma robustum, Sceletium expansum, Stomatium suaveolens*. Low Shrubs: *Cineraria polycephala, Euryops petraeus, Lotononis azureoides, Selago magnakarooica.* Tall Shrub: *Anisodontea malvastroides*. Herbs: *Cineraria arctotidea, Vellereophyton niveum.* Succulent Herbs: *Adromischus fallax, A. humilis.* Geophytic Herbs: *Gethyllis longistyla, Lachenalia aurioliae, Ornithogalum paucifolium subsp. karooparkense.*

[2] (d) Dominant

Although the National Vegetation Map depicts maps only Gamka Karoo in the area, the larger drainage systems of the site with well- developed woody vegetation have Southern Karoo Riviere vegetation elements (Table 3). The Southern Karoo Riviere vegetation type is associated with the rivers of the central karoo such as the Buffels, Bloed, Dwyka, Gamka, Sout, Kariega and Sundays Rivers. About 12% has been transformed as a result of intensive agriculture and the construction of dams. Although it is classified as Least Threatened, it is associated with rivers and drainage lines and as such represents areas that are considered ecologically significant. Typical and dominant species observed from the drainage lines of the site includes *Vachellia karroo, Salsola aphylla, Lycium prunus-spinosa, Atriplex vestita, Zygophyllum retrofractum, Stipagrostis namaquensis, Lycium pumilum, Lycium cinereum, Artemisia africana* and *Deverra denudata*. These areas are generally considered sensitive due to the ecological role that riparian areas and drainage systems play. Although the site falls within the broader range of the Riverine Rabbit, the riparian habitat is sparse and stony with little habitat present that would suggest that the habitat within the site is suitable for this species.

Typical larger drainage line from within the site comprise *Vachellia karroo* dominating the banks and common and dominant species in the drainage lines and within the adjacent floodplain vegetation include *Sporobolus ioclados, Drosanthemum lique, Salsola aphylla, Tribulus terrestris, Felicia muricata, Atriplex vestita, Zygophyllum retrofractum, Cynodon dactylon, Stipagrostis namaquensis, Lycium pumilum, Lycium cinereum, Artemisia africana, Tripteris spinescens* and *Exomis microphylla*.

Table 3: Southern Karoo Riviere (AZi 6).

GROWTH FORM	DESCRIPTION/SPECIES[3]
Important Taxa	**Riparian thickets** Small Trees*: Acacia karroo (d), Rhus lancea (d).* Tall Shrubs*: Diospyros lycioides (d), Tamarix usneoides (d), Cadaba aphylla, Euclea undulata, Grewia robusta, Gymnosporia buxifolia, Melianthus comosus. Low Shrub: Asparagus striatus.*

[3] (d) Dominant

GROWTH FORM	DESCRIPTION/SPECIES[3]
	Succulent Shrubs: *Lycium cinereum (d), Amphiglossa callunoides, Lycium hirsutum, L. oxycarpum.* **Rocky slopes of river canals** Graminoid: *Stipagrostis namaquensis (d).* **Alluvial shrublands & herblands** Low Shrubs: *Ballota africana, Bassia salsoloides, Carissa haematocarpa, Pentzia incana.* Succulent Shrubs: *Malephora uitenhagensis (d), Salsola aphylla (d), S. arborea (d), Drosanthemum lique, Salsola geminiflora, S. gemmifera.* Graminoids: *Cynodon incompletus (d), Cenchrus ciliaris, Cyperus marginatus.* **Reed beds** Megagraminoid: *Phragmites australis (d).*
Endemic Taxa	**Alluvial shrublands & herblands** Graminoid: *Isolepis expallescens.*

2.2 Protected Flora

There is a relatively low number of Species of Conservation Concern (SCC) known from the area (Appendix 1) but given the low number of records it is expected that there would be additional species present as well. Listed and protected species are sometimes confined to specific habitats such as wetlands and rock pavements, outcrops or gravel patches.

Refer to Section 3.2 Flora.

2.3 Faunal Habitat and Communities

Observations made during the walkdown supplemented by previous ecological and biodiversity assessments undertaken by Todd (2022) identify the following faunal attributes:

2.3.1 Mammals

The study area and broad surroundings have not been well-sampled historically for mammals, with the result that the records from the existing databases do not provide a comprehensive picture of the mammalian community of the area. In order to counter this problem, the lists of mammals were extracted for a considerably larger area including the two quarter degree squares north of the site, which are considered to be those most similar to the site. Based on this larger sample area, the mammalian community is estimated at approximately 30 species. Common species observed at the site or on nearby sites that have been previously sampled, include Cape Porcupine, Steenbok, Greater Kudu, Vervet Monkey, Chacma Baboon, Cape Hare, Bat-eared Fox, Cape Fox, Black-backed Jackal, Aardwolf, Caracal, Common Duiker, Yellow Mongoose, Cape Grey Mongoose, Striped Polecat, Common Genet, Meerkat, Aardvark and Ground Squirrel. This represents a typical mammalian community for the Koup area and the lower Nama Karoo in general.

The only mammal species of conservation concern that may be present on the site is the Riverine Rabbit (*Bunolagus monticularis*) which is listed as Critically Endangered. The field assessment of the site indicated that there is minimal suitable habitat for the Riverine Rabbit present within the Koup site. The drainage lines within the Koup site are gravelly or stony in nature with very little floodplain vegetation and a general lack of silty banks with dense vegetation that provide the usual suitable habitat for this species. Specific camera trapping for Riverine Rabbit on the adjacent Beaufort West and Trakas wind farms, which has more suitable habitat than the Koup site did not pick any Riverine

Rabbits indicating that this species is very unlikely to be present. In addition, the EWT Riverine Rabbit records database indicates that there have not been any historical sightings from the site or immediate surrounds. As such, the site is considered low sensitivity for this species and an impact on this species is not expected to occur.

In general, impacts on mammals would occur due to disturbance and habitat loss. During the construction phase there would be significant disturbance at the site due to construction-related activities. During operation, there would be some disturbance at the wind farm due to noise generated by the wind turbines and some disturbance related to more general operational activities. The long-term habitat loss related to the development is estimated at 50 ha, which in context of the surrounding landscape is considered relatively minor. More mobile or disturbance-sensitive species are likely to be displaced during construction but would likely move back into the affected areas once the facility is operational. Many species are likely to become at least partly habituated to the presence and operation of the wind turbines. In general, the major long-term impacts of the development would be about 50 ha of direct habitat loss for the resident mammals and some disturbance associated with noise and human activity associated with turbine construction and operation, which would have a greater extent, dependent on the specific response of the affected species.

A potential but little-known impact may occur as a result of the noise and infra-sound generated by the wind turbines. A major source of background infrasound in the natural environment is wind-generated, with the result that increasing levels of infrasound generated by wind turbines occur simultaneously with increasing levels of natural background noise as the wind speed increases. The contribution of wind turbines to infrasound appears to become undetectable from background levels, even in rural environments within 1.5 km of wind farms (Evans et al. 2013). Apart from the infrasound, audible noise generated by the turbines may have a negative impact on noise-sensitive species. Although this impact has not been well-documented and warrants investigation, it is plausible that species that use sound for prey detection or predator avoidance may be negatively affected by the noise generated by the wind turbines. There are however no species of high conservation concern that are likely to be affected by noise at the site, so this impact is likely to be of limited extent and restricted to a subset of the fauna present. In addition, studies of noise impacts on fauna have demonstrated that many faunal species are able to use various behavioural adaptations to reduce the impact of noise on their activities.

2.3.2 Reptiles

Reptile diversity in the Koup area is expected to be moderate to low, which can be ascribed to the relative homogeneity of the habitats present and the lack of moist, well-vegetated environments or significant escarpment and cliff habitats. Based on the ReptileMap database, approximately 25 species are known from the area. The only species of potential concern known from the area is the Karoo Padloper or Karoo Dwarf tortoise, *Chersobius boulengeri* (Endangered). This small tortoise is seldom observed, even when specifically targeted during herpetofauna surveys as it is usually active for less than 15 minutes a day (or largely entirely inactive during cold or dry conditions). They are associated with dolerite ridges and rocky outcrops of the southern Succulent and Nama Karoo biomes. Threats to this species include habitat degradation due to agricultural activities and overgrazing, and predation by the Pied Crows which in recent decades have expanded in distribution range. The habitat on site is considered broadly unsuitable for the Karoo Padloper, but within some localised koppies and outcrops with sufficient rock cover to provide the shelter that this species requires. The development would however largely avoid the rocky shelter sites of this species with the result that direct habitat loss would be low. In addition, tortoises are one of the few species that have been specifically studied with regards to their responses to wind energy development and no significant negative impacts have been detected within population's resident on wind farms (Agha et al. 2015, Lovich et al. 2011). There is potential concern that the development could result in tortoises, including the Karoo Padloper being run over by vehicles on the site. While this is a potential concern during construction due to the large number of vehicles present, during operation, this impact would be low and restricted to maintenance activities. Although tortoises could be kept off the wind farm roads by fencing or similar structures, this is not recommended as this would also function to limit tortoise movement across the landscape. In addition, the vegetation cover on the site is already very low and the reptile species present are species adapted to low-cover conditions with the result that the open areas created by the roads of the site would be represent significant obstacles for the species present.

In general, the major impacts on reptiles associated with the development would be disturbance and habitat loss during construction. However, there do not appear to be any species that would be especially affected.

The most important areas for reptiles are likely to be the occasional steeper rocky outcrops and the larger drainage lines with some woody vegetation which offer some cover for those species less able to deal with the low vegetation cover of most of the site. The footprint within these areas would be low and as such there do not appear to be any significant limitations or red-flag issues associated with reptiles and the development of the wind farm.

2.3.3 Amphibians

The diversity of amphibians in the study area is relatively low with only six species having being recorded in the area. Species observed at the site include the Karoo Toad and Poynton's River Frog. There are no listed amphibian species known from the area although the Giant Bull Frog *Pyxicephalus adspersus* was previously listed as Near Threatened but has revised to Least Concern. This species is associated with temporary pans in the Karoo, Grassland and Savannah Biomes, but is not commonly recorded in the study area and its presence at the site is considered unlikely as there is no suitable breeding habitat present within the site. Although there is no permanent water within the site, there are a few larger drainage lines present or small earth dams that would have temporary pools that can be used by toads and frogs for seasonal breeding purposes. The impact of the development on these breeding sites would be very low and a direct impact on these habitats is unlikely. Given the localised nature of important amphibian habitats at the site as well as the generally arid nature of the site and the low overall abundance of amphibians, a significant long-term impact on amphibians is unlikely.

2.3.4 Invertebrates

No invertebrate investigations have been undertaken and no invertebrates of conservation concern identified. It is probable that Baboon Spiders and Scorpions are present, both being ToPS protected and thus requiring permits during search and rescue.

2.4 Bioregional Planning

The Western Cape Biodiversity Spatial Plan (WC BSP, 2017) map is depicted below for the study area (Figure 7). This biodiversity assessment identifies CBAs which represent biodiversity priority areas which should be maintained in a natural to near natural state. The CBA maps indicate the most efficient selection and classification of land portions requiring safeguarding in order to maintain ecosystem functioning and meet national biodiversity objectives. The only designated CBA is on the eastern side, to the east of the overhead powerline, where no turbines are situated.

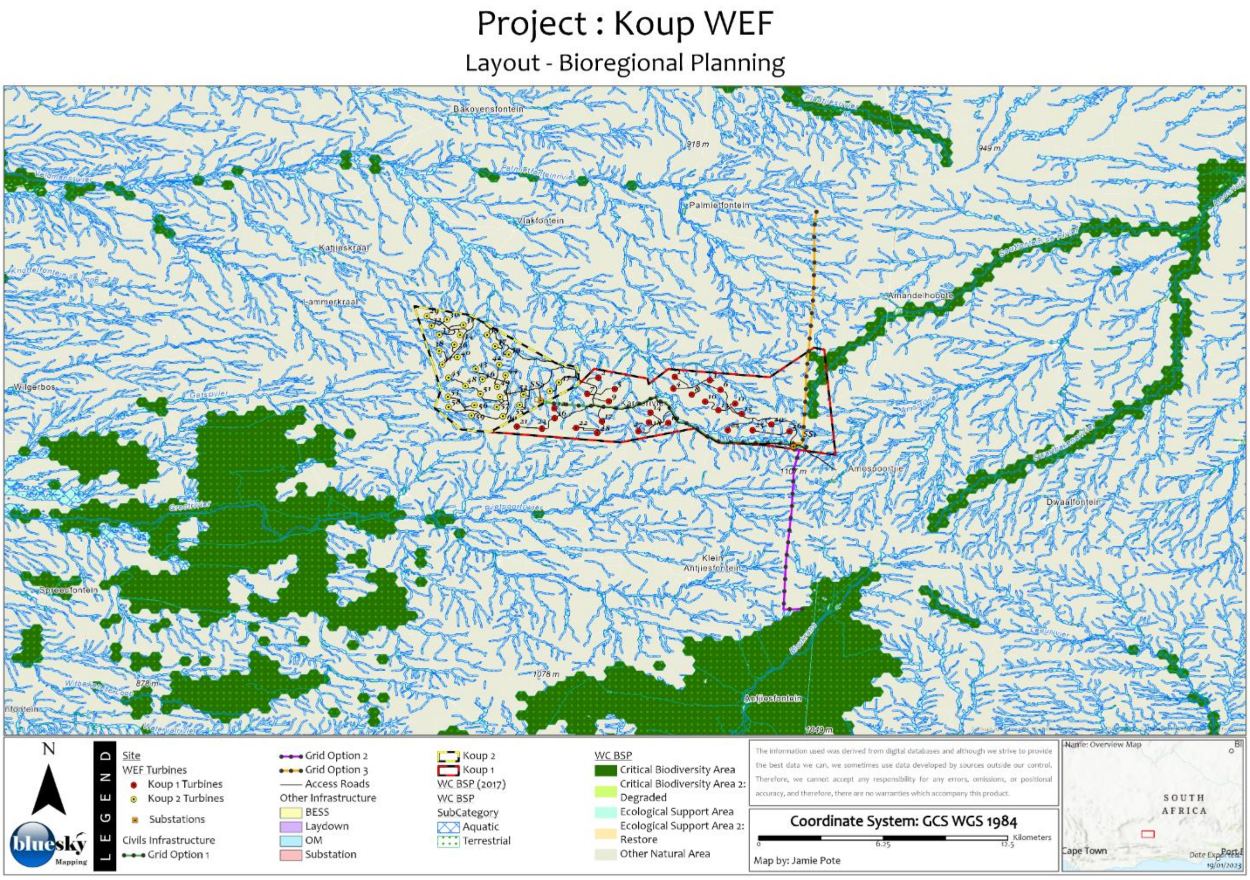


Figure 7: Bioregional Planning (Critical Biodiversity Areas).

2.5 Site Sensitivity Assessment

An ecological sensitivity map of the site was produced by integrating the results of the site visits with the available ecological and biodiversity information in the literature and various spatial databases by Todd (2022), Figure 8. This walkdown process will verify these findings and assess the layout in more depth in order to recommend any minor modifications than should or can be made to reduce the impact further. In general, the initial biodiversity assessment for the EIA phase tends to focus on the broader site, rather than fine scale layout planning and assessment, which usually get refined and addressed at this walkdown stage. The original sensitivity map and walkdown layout are indicated in Figure 9.

As per Todd (2022), sensitive features such as wetlands, drainage lines, rocky hills and steep slopes were mapped and buffered where appropriate to comply with legislative requirements or ecological considerations. Additional sensitive areas were then identified and delineated based on the results of the field assessment and satellite imagery of the site. All the different layers created were then merged to create a single coverage. The ecological sensitivity of the different units identified in the mapping procedure was rated according to the scale as indicated below.

- **Low** – Areas of natural or transformed habitat with a low sensitivity where there is likely to be a negligible impact on ecological processes and terrestrial biodiversity. Most types of development can proceed within these areas with little ecological impact.
- **Medium**- Areas of natural or previously transformed land where the impacts are likely to be largely local and the risk of secondary impact such as erosion low. These areas usually comprise the bulk

of habitats within an area. Development within these areas can proceed with relatively little ecological impact provided that appropriate mitigation measures are taken.

- **High** – Areas of natural or transformed land where a high potential impact is anticipated due to the high biodiversity value, sensitivity or important ecological role of the area. These areas may contain or be important habitat for faunal species or provide important ecological services such as water flow regulation or forage provision. Development within these areas is less desirable and should proceed with caution (such as specific consideration of the footprint within these areas and field verification of the acceptability of development within these potentially sensitive areas) as it may not be possible to mitigate all impacts appropriately.
- **Very High** – Critical and unique habitats that serve as habitat for rare/endangered species or perform critical ecological roles. These areas are essentially no-go areas from a developmental perspective and should be avoided as much as possible.

The sensitivity map for the Koup 2 WEF area is depicted below in Figure 9. Overall, Todd considered the site to be generally favourable for development of the wind farm, which is confirmed. Although there are some areas which should be excluded from development or in which the development footprint should be constrained, there are large tracts of the site that are considered low sensitivity and where development would have a low impact. The mapped no-go and high sensitivity areas have been used to inform the development layout as described in Todd (2022, Table 5). The main feature comprise the very high sensitivity areas considered unsuitable for the placement of turbines, buildings and substations (and associated battery facility) within the site are the major drainage systems. There are also numerous steep slopes present which are considered high sensitivity and which are considered unsuitable for buildings, substations and temporary lay-down areas. These slopes are however considered acceptable for the placement of some turbines and associated access roads subject to the stated limits of acceptable change. Todd (2022) noted that the footprint within the low, medium and high sensitivity areas is well within the limits of acceptable change and that the limit of acceptable change for the Very High sensitivity category is marginally exceeded. However, before this result is discussed in more detail, it is important to note that this does not imply an immediate fatal flaw for the project, as the specific context, the features affected and overall site sensitivity need to be evaluated at the same time to establish the degree and nature of conflict and the presence of options to mitigate or avoid impacts to these areas. Within the very high sensitivity areas, the footprint is marginally higher at 1.15ha than the tolerance of 0.87 ha, however, the difference of 0.25ha is not considered significant for the current site and would occur at drainage crossings and the acceptability of these would be specifically dealt with in the freshwater study. From an ecological perspective, the footprint within the Very High sensitivity areas is considered acceptable given that this would be restricted to river crossings of the wind farm access roads, the potential to mitigate impacts on these features is high and a long-term negative impact on biodiversity within these areas is low.

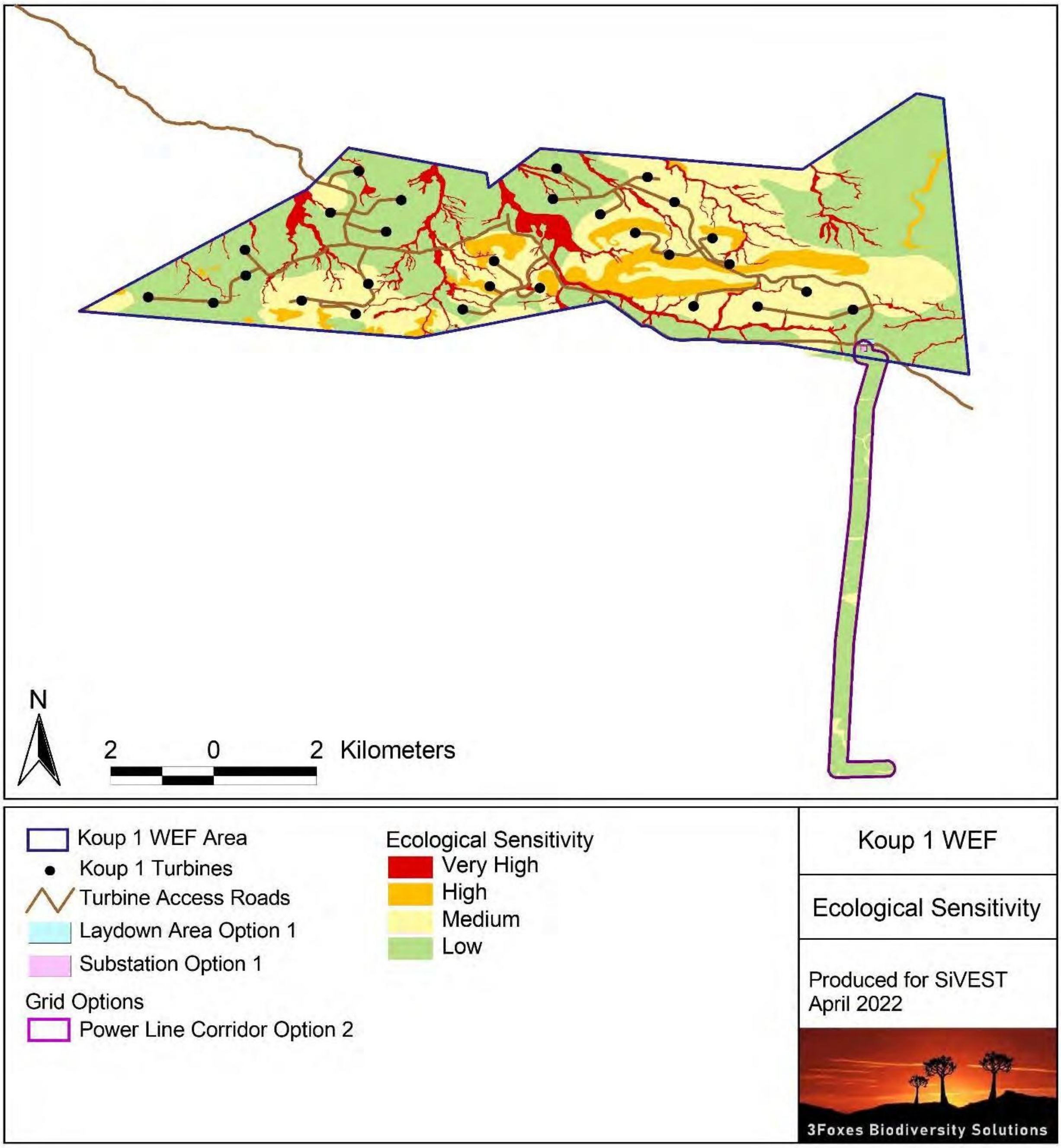


Figure 8: Original assessment site vegetation sensitivity (Todd, 2022).

Project : Koup WEF

Layout - Vegetation Sensitivity

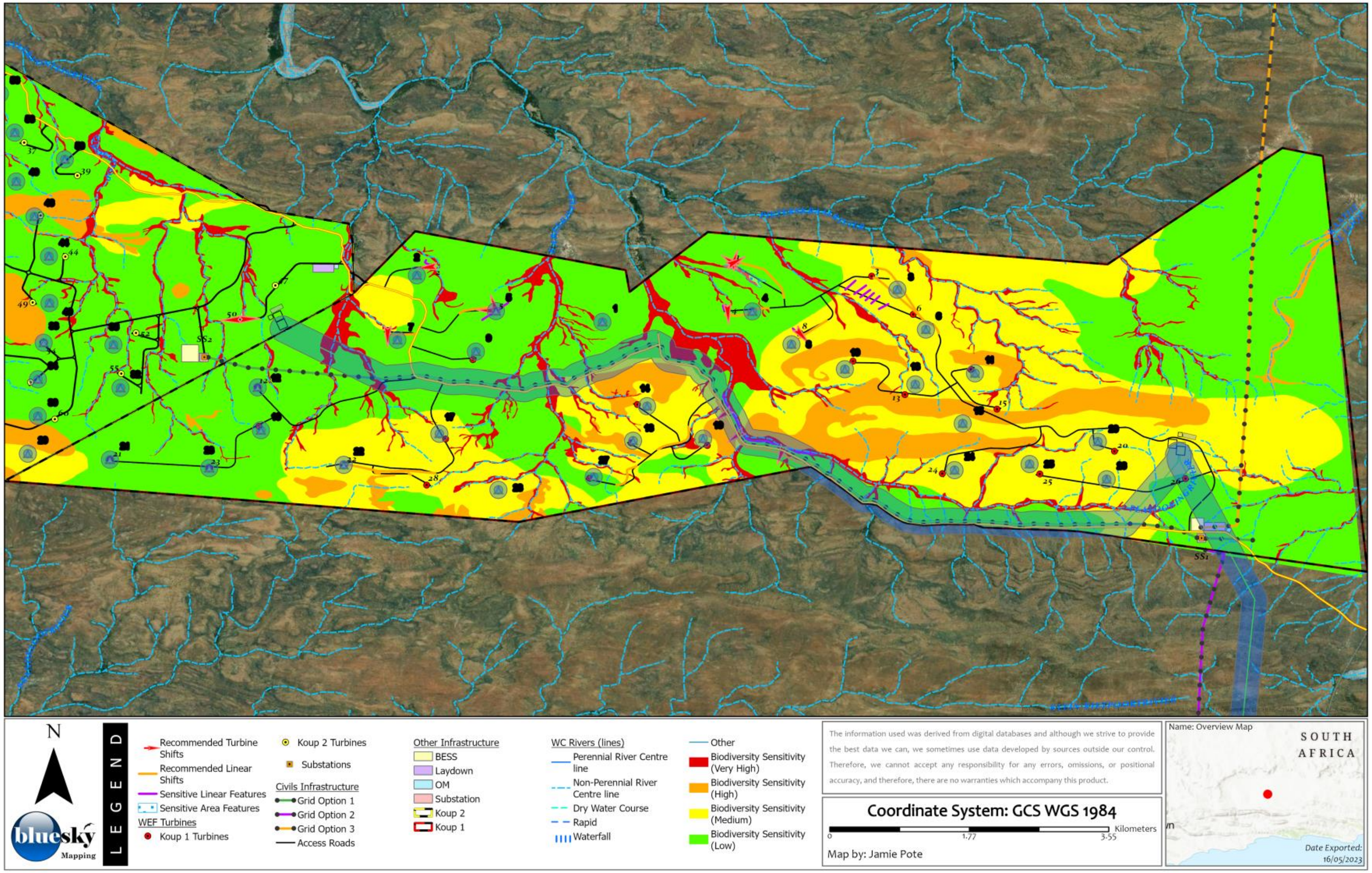


Figure 9: Site Vegetation and Sensitivity overlain on original mapped sensitivity (as per Todd, 2022). Revised positions indicated in blue.

low hills dissected by numerous drainage lines. Vegetation cover is generally very low and dominated by low shrubs and scattered low trees. In general, the vegetation of the Koup 2 site is considered low sensitivity and there are few species of concern present. In terms of fauna, the diversity of mammals, reptiles and amphibians is considered relatively low, even by Karoo standards. Although the site falls within the broad distribution of the Riverine Rabbit, the drainage lines of the site do not have extensive floodplains with dense riparian vegetation that represent the typical habitat of this species in the area. The Koup 2 site is therefore considered unsuitable for this species and the development is considered highly unlikely to have any impact on the Riverine Rabbit. The site also falls within the range of the Karoo Padloper and if present it would be associated with the hills of the site with sufficient loose rock and coarse rubble to provide shelter. The low vegetation cover and paucity of such habitat suggests that the site is not an important area for this species and no evidence of this species was observed on the site. Although there are no CBAs within the site, the smaller drainage features of the site are classified as Ecological Support Areas and it would not be possible to avoid some impact on these features. However, with the appropriate mitigation, the development would not compromise the functioning of the affected ESAs. In terms of cumulative impacts, the wider area currently has a low development impact from renewable energy and the contribution of the Koup 2 WEF to cumulative impact at less than 50ha is considered relatively low and would not generate significant broad-scale impact. The contribution of the grid connection to cumulative impact would be low and considered acceptable.

The fauna of the area is composed of widespread species, with very few species of conservation concern likely to be present in the area. The most important areas for fauna at the site are the drainage systems and the well-vegetated slopes which are largely outside of the development footprint and would not be significantly affected. The rocky outcrops on the plateau were however observed to have a high abundance of reptiles, which relates to the weathering patterns of the mudstones and the resultant abundance of refugia. The major impact on fauna would be habitat loss associated largely with the high-elevation plateau habitat of the site.

The walkdown findings concur broadly with the original assessment. Final micro-siting has led to recommendation relating to several components, locally and based on the recommendation made during the walkdown, several suggestions have been provided that will reduce the loss of very high sensitivity areas, which was indicated by Todd to marginally exceed acceptable limits.

3 Walkdown Findings

3.1 Vegetation

Since the original ecological assessments were undertaken for each of the separate wind energy facility projects, this walkdown has been undertaken for the wider project area and thus it has been possible to refine and better understand the vegetation composition and local distribution of flagged species of conservation concern within the greater area of influence.

3.2 Flora Species of Conservation Concern

Several Species of Conservation Concern were identified during the initial ecological assessments. In addition, with the inclusion of additional available information, observations and surveying during the walkdown, several additional species have been identified. These will be added to the species list for the respective permit applications. A list of flora species of conservation concern that have been identified or recorded previously or during the walkdown is provided in Table 4 below. In general, the species are widespread and are not associated with any specific turbine or WEF infrastructure component. Several geophytic species are also likely to be present but were not recorded during the initial assessment and were not visible during the walkdown, as the season was not favourable. Respective permits will be required before commencement of flora relocation.

Table 4: Status of flora species of conservation concern confirmed to be present as per Todd (2022) with additional walkdown observations.

SCIENTIFIC NAME	FAMILY	STATUS[4]	DESCRIPTION AND DISTRIBUTION
Adromischus fallax	Crassulaceae	Rare	NOT RECORDED. Suitable habitat not present. A rare, range-restricted habitat specialist (extent of occurrence 8 km²) that is not threatened. Known currently from only two subpopulations but likely to occur at a few more.
Aloe chlorantha	Asphodelaceae	Neat Threatened	PRESENT but uncommon. Aloe chlorantha is a rare species, occurring in small, scattered subpopulations. Field observations in the 1980s of a subpopulation near Fraserburg recorded around 25 plants (H.F. Glen pers. comm. 1986), but no recent field data on the population size is available. The species is currently known from seven locations, but it is likely more common as its habitat is botanically very poorly explored.
Anisodontea malvastroides	Malvaceae	Rare.	NOT RECORDED. This species is endemic to the mountains of the Great Karoo, where it occurs in the Nuweveld and Sneeuberg mountains between Beaufort West and Middelburg.
Gethyllis longistyla	Amaryllidaceae	Rare	NOT RECORDED. May be seasonally present, but unconfirmed at times of sampling. A relatively widespread, but rare species, typically occurring in small subpopulations. It is not currently threatened. Gethyllis longistyla is known from only a few records, scattered over a wide area. It is rare, and easily overlooked, as it is cryptic when it is not flowering, and flowers, which appear in late summer, lasts only a few days. Subpopulations are typically small, occurring in subpopulations consisting of 20 or fewer plants.
Lotononis azureoides	Fabaceae	Rare	NOT RECORDED. Suitable habitat not present. A range-restricted species with an extent of occurrence (EOO) of 144 km² and is known from four subpopulations. It has no significant threats and is therefore not in danger of extinction.
Peersia frithii	Aizoaceae	NEST (M), Vulnerable	PRESENT, locally common on poorly vegetated rocky shale gravel areas. A species previously collected widely throughout the southern of the Karoo with an historic extent of occurrence (EOO) of 28913 km². It has only been recorded seven times since 1990 and is suspected to be extant at 6 locations from a current EOO of 690 km². Decline is suspected to be the result of livestock overgrazing and trampling. No historical records near the site but it does fall within east-west distribution range.
Ruschia beaufortensis	Aizoaceae	Vulnerable	NOT RECORDED, may be present in elevated areas but unlikely. A poorly known species recorded only from the

[4] NC - Northern Cape Nature Conservation Act (Act no. 9 of 2009), Schedule 1 or 2; EC – Provincial Nature Conservation Ordinance (No. 19 of 1974).; ToPS – Threatened or Protected Species [NEM:BA]; IUCN: Least Concern (LC), Near Threatened (NT), Critically Endangered (CR), Endangered (EN), Vulnerable (VU); CITIES - Conservation for International trade in Endangered Species.

SCIENTIFIC NAME	FAMILY	STATUS[4]	DESCRIPTION AND DISTRIBUTION
			arid mountains near Beaufort West (extent of occurrence 476 km²). Between two and five locations exist, subpopulations occurring outside of the park are potentially threatened by uranium mining. Site is not within typical habitat but does not exclude possible presence without further investigation.
Sensitive Species 1039	Apocynaceae		PRESENT, Uncommon and localised, more prevalent on Koup 2 site to the east. This taxon occurs in the southern Great Karoo from Aberdeen and Graaff-Reinet southwards to Rietbron and eastwards to Willowmore, Klipplaat and Steytlerville. This taxon is rare, occurring as widely scattered individuals. There are often several hundred meters between plants, one subpopulation east of Willowmore was found to include more than 50 large plants (Bruyns 2005).
Sensitive species 1212	Aizoaceae	Vulnerable	NOT RECORDED. Suitable habitat not abundant within the site. Several marginally suitable areas were surveyed and none were found. EOO <7 000 km², known from fewer than 10 locations and habitat quality and number of mature individuals are declining as a result of livestock (sheep and goat) overgrazing and illegal collection for the succulent plant trade. Potentially threatened at some locations by prospecting for uranium mining. Site is outside of known occurrence range but does not exclude possible presence without further investigation.
Sensitive species 383	Euphorbiaceae	NEST (M), Vulnerable	PRESENT. Ongoing degradation of this species' habitat as a result of livestock overgrazing and the increased intensity and duration of droughts. This species is known from only a few records, from five locations, but it is likely to be more common as it is easily overlooked when it grows sheltered under larger shrubs, and its range is botanically poorly explored.
Tridentea virescens	Apocynaceae	Rare	NOT RECORDED. May be seasonally present, but unconfirmed at times of sampling. A widespread species that occurs as sporadic small subpopulations of up to six plants. No threats are known to impact this species.
Tritonia florentiae	Iridaceae	NEST (M), Vulnerable	NOT RECORDED. May be seasonally present, but unconfirmed at times of sampling. Ongoing degradation of this species' habitat as a result of livestock overgrazing and the increased intensity and duration of droughts. This species is known from only a few records, from five locations, but it is likely to be more common as it is easily overlooked when it grows sheltered under larger shrubs, and its range is botanically poorly explored.

3.3 Fauna Species of Conservation Concern

Fauna species of Conservation Concern typical of the vegetation and site include species listed in Table 5, as per Todd (2016, 2017, 2019) with additional walkdown observations. Respective permits will be required before commencement of fauna relocation. Refer to original assessments Todd (2022) for full list of faunal species.

Table 5: Listed fauna species of conservation concern confirmed to be present as per Todd (2022).

SCIENTIFIC NAME	COMMON NAME	STATUS[5]	OCCURRENCE/COMMENT
MAMMALS			
Bunolagus monticularis	Riverine Rabbit	NEST (M), EN	The Riverine Rabbit is endemic to the semi-arid central Karoo region of South Africa (estimated extent of occurrence (EOO) is 54,227 km^2 and area of occupancy (AOO) is 2,943 km^2). Marginally suitable habitat present but limited to main lower order watercourses. Likely to require specialist confirmation.
Felis nigripes	Black-footed cat	VU	Associated with arid country with MAR 100-500 mm, particularly areas with open habitat that provides some cover in the form of tall stands of grass or scrub. May a be transient species, but not recorded.
BIRDS			
Neotis ludwigii	Ludwig's Bustard	NEST (H), EN (SA), EN (Intl)	Refer to Avifaunal reporting.
Polemaetus bellicosus	~~Martial Eagle~~	~~NEST (M), EN (SA), VU (Intl)~~	Refer to Avifaunal reporting.
Afrotis afra	Southern Black Korhaan	NEST (M), VU (SA), VU (Intl)	Refer to Avifaunal reporting.
Aquila verreauxii			Refer to Avifaunal reporting.
REPTILES			
Psammobates tentorius subsp tentorius	Karoo Tent Tortoise	NT	Tortoises are highly susceptible to collisions with motor vehicles and trucks on new roads. Found throughout the project area but observed to be more common in lowland areas.
Psammobates tentorius veroxii	Bushmanland Tent Tortoise	NT	Tortoises are highly susceptible to collisions with motor vehicles and trucks on new roads. Found throughout the project area but observed to be more common in lowland areas.
Homopus femoralis	Greater Padloper	LC	Found throughout the project area but observed to be more common in lowland areas.
Stigmochelys pardalis	Leopard Tortoise	LC	Found throughout the project area. Common along roads.
Chersobius boulengeri	Karoo padloper or Karoo Dwarf Tortoise	EN	Not recorded in original assessment but possibly present.
AMPHIBIANS			
None			
INVERTEBRATES			
Scorpions		ToPS	Not confirmed during original assessment, but several species

[5]NC - Northern Cape Nature Conservation Act (Act no. 9 of 2009), Schedule 1 or 2; EC – Provincial Nature Conservation Ordinance (No. 19 of 1974).; ToPS – Threatened or Protected Species [NEM:BA]; IUCN: Least Concern (LC), Near Threatened (NT), Critically Endangered (CR), Endangered (EN), Vulnerable (VU); CITIES - Conservation for International trade in Endangered Species.

SCIENTIFIC NAME	COMMON NAME	STATUS[5]	OCCURRENCE/COMMENT
			present. Include in permit applications.
Baboon Spiders		ToPS	Likely present, not confirmed during original assessment. Include in permit applications.

3.4 Sensitive Areas and Species Populations

Sensitive areas identified either in the original biodiversity assessment and/or observed during the walkdown include the following:

- Rocky Outcrops and Ridges on slopes and mountain peaks – outcrops generally have a greater density of succulent species (Aizoaceae and Crassulaceae) that will require relocation.
- Rivers, seeps, watercourses, wetlands and pans – minimise impacts to aquatic processes.
- Sub-populations of flagged species of conservation concern – often associated with rocky areas.
- Slope and mountain edges – excessive cut and fill will elevate impact.

3.5 Turbines, Roads and other Infrastructure

A summary analysis of specific infrastructure risks is provided in Table 6 and indicated in Figure 10.

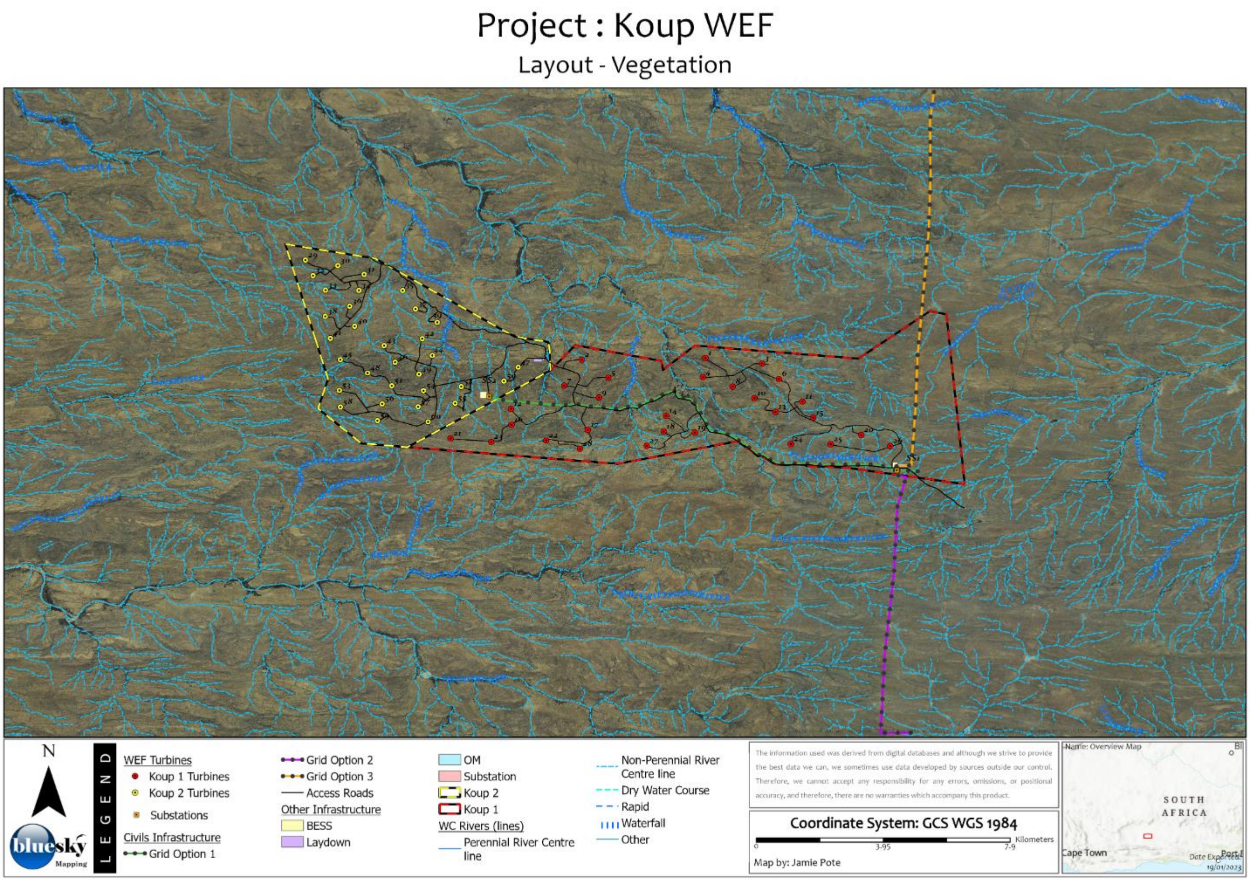


Figure 10: Analysis of turbine positions and other WEF infrastructure (Koup 1 – red, Koup 2 - yellow).

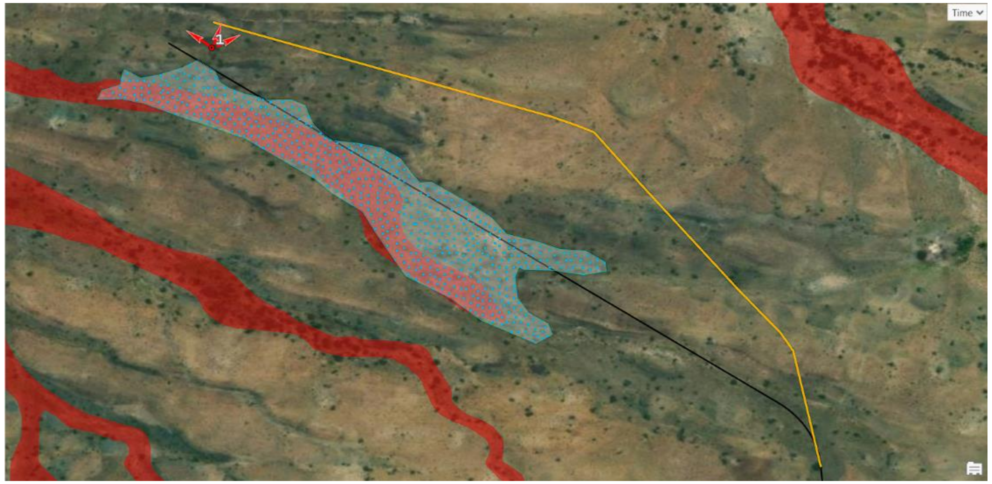
Table 6: Summary of WEF and infrastructure vegetation and sensitivities and recommended layout adjustments.

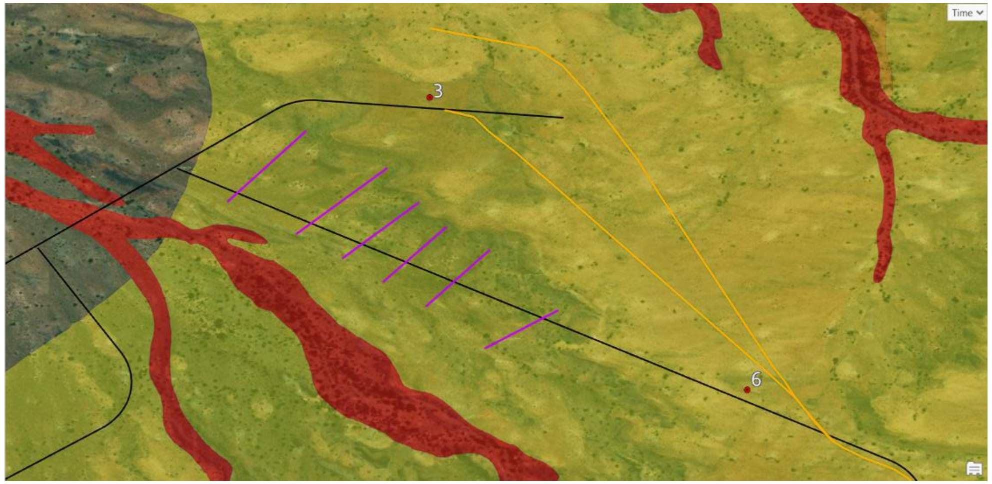
TURBINE	HABITAT[6]	COMMENT
WTG 01	Alluvial Grassland near vlei like grassy area	Turbine footprint near drainage lines and access road passes through grassy vlei like area. Habitat may be important as seasonal faunal habitat. Recommend shifting turning slightly northward and or aligning turbine laydown northward and re-aligning access road towards the north. Road will still cross several peripheral vlei/seep areas to the east, but will not be linear directly through this grassy vlei area.
WTG 02	Rocky Shrubland near watercourse	Turbine footprint to west of minor drainage line. Turbine laydown area to be aligned towards the west or south-west and road should terminate before drainage line.
WTG 03	Rocky Shrubland	Recommend shifting turbine slightly northwards onto plateaux and connect road between turbine 3 & 6 along elevated plateaux to avoid current alignment through drainage area adjacent to watercourse and grassy seasonal vlei area to the south.
WTG 04	Rocky Shrubland near drainage line source	Recommend slight southwards shift of turbine and road to avoid drainage line source.
WTG 05	Alluvial Grassland near vlei like grassy area with watercourse channel	Recommend slight north or west shift of turbine and road to avoid watercourse and vlei like grassland area.
WTG 06	Rocky Shrubland	Recommend aligning road towards turbine 3 along elevated plateaux to avoid current alignment through drainage area adjacent to watercourse and grassy seasonal vlei area to the south.
WTG 07	Rocky Shrubland near watercourse source	Situated on rocky point between watercourse sources. Recommend slight southwards shift of turbine and road to avoid/or reduce impact.
WTG 08	Rocky Shrubland near watercourse source	Situated on rocky point between watercourse sources. Recommend slight southwards shift of turbine and road to avoid/or reduce impact.
WTG 09	Alluvial Grassland and rocky shrubland	Road traverses several minor watercourses and seasonal grassy vlei type areas and turbine in suitable position. No adjustments recommended.
WTG 10	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 11	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 12	Rocky/Grassland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 13	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no adjustments recommended.**
WTG 14	Rocky shrubland	Turbine in rocky shrubland on hilltop, access road through shrubland. Main access road through watercourse, recommend slight re-alignment.
WTG 15	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 16	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 17	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 18	Rocky shrubland	Turbine in rocky shrubland on hilltop, access road through shrubland & watercourse. Main access road through watercourse, recommend slight re-alignment refer WTG 14).

[6] Rocky habitat generally more likely to have more species of conservation concern for relocation as well as reptiles (snakes and lizards).

TURBINE	HABITAT[6]	COMMENT
WTG 19	Rocky shrubland	Turbine in rocky shrubland on hilltop, access road through shrubland & watercourse. Main access road through watercourse, recommend slight re-alignment (refer WTG 14).
WTG 20	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 21	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 22	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, no turbine adjustments recommended. Main access road off edge of mountain, recommend slight southward shift.
WTG 23	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 24	Rocky shrubland	Turbine on rocky shrubland plateaux, no sensitivities. Access road cuts through watercourse. Shift road slightly north to avoid.
WTG 25	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 26	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, **no *adjustments recommended***.
WTG 27	Rocky shrubland	Turbine in rocky shrubland on hilltop, access road through shrubland & watercourse. Access road traverses steep slope with rocky ledge and upper reach of watercourse, recommend re-alignment, possibly northwards. Main access road through watercourse, recommend slight re-alignment (refer WTG 14).
WTG 28	Rocky shrubland	Turbine in rocky shrubland on hilltop, road through shrubland, no turbine adjustments recommended. Main access road off edge of mountain (refer WTG 22), recommend slight access road alignment shit.
BESS	Sandy Grassland	BESS in sandy grassland on low lying plain, no ***adjustments recommended***.
Laydown Area	Sandy Grassland	Laydown Area in sandy grassland on low lying plain, no ***adjustments recommended***
OM	Sandy Grassland	OM in sandy grassland on low lying plain, no ***adjustments recommended***
Substation	Rocky Shrubland	Substation in rocky shrubland on lower slope, no ***adjustments recommended***
Grid Option 2 (South)	Rocky/ Grassland/ Shrubland	Traverses rocky shrubland and sandy grassland, **no *adjustments recommended***.
Main Koup 1 Access Road	Rocky Shrubland & Sandy Grassland	Main access road follows existing gravel access road and traverses numerous watercourses, to be upgraded accordingly to minimise erosion risk..

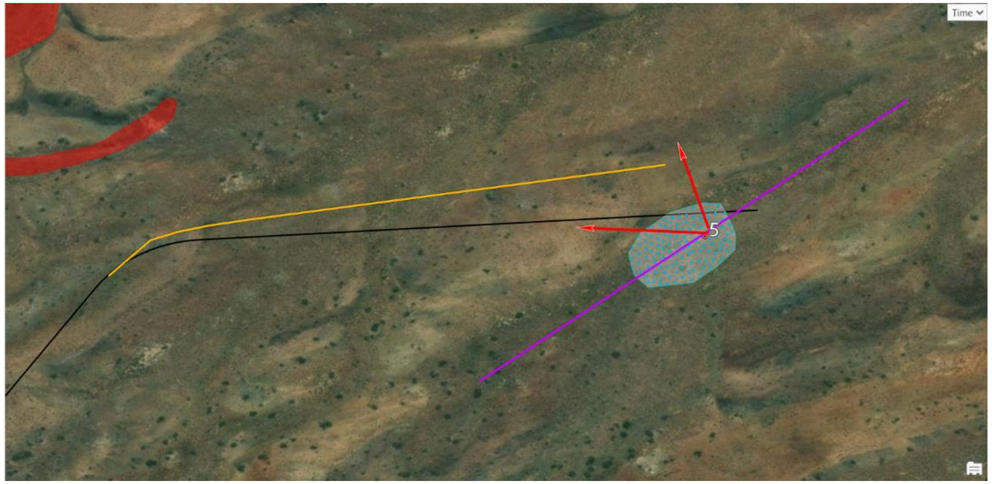
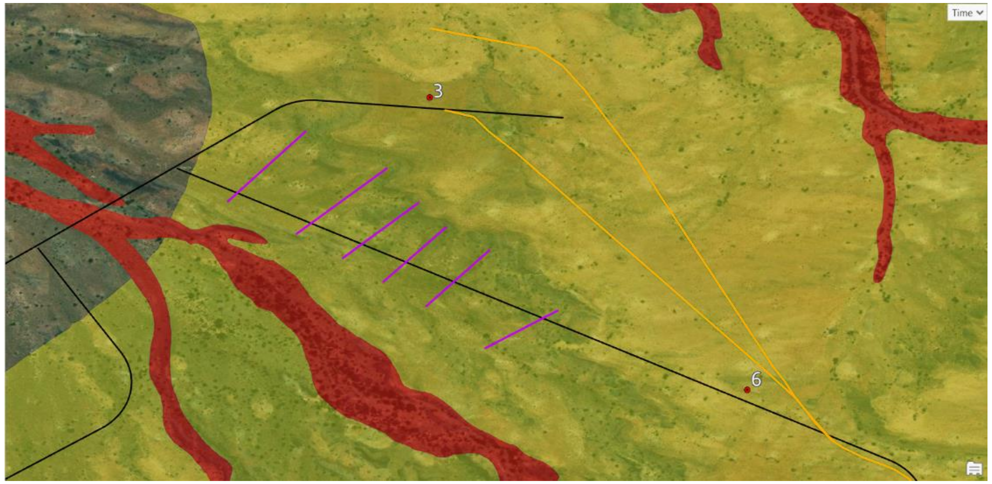
Table 7: Recommended layout adjustment maps and photos.

 WTG 01	
 WTG 02	

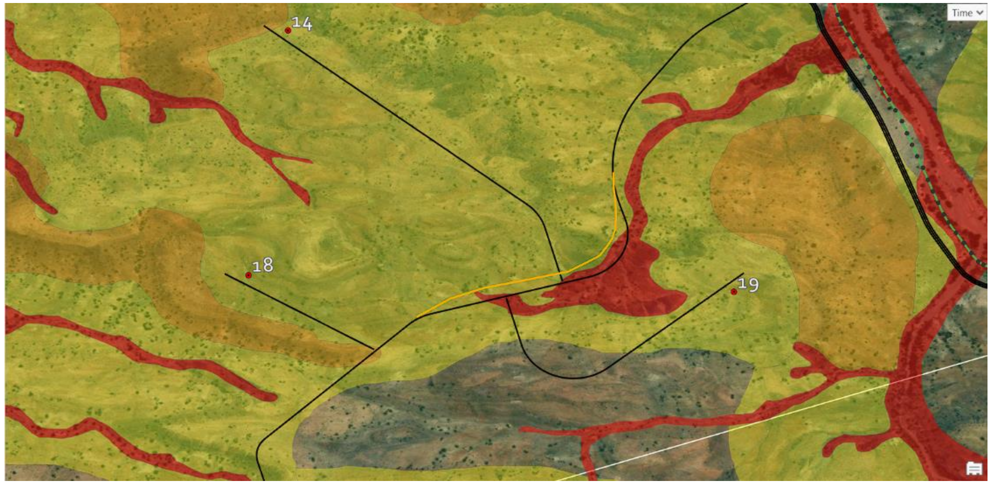


WTG 03

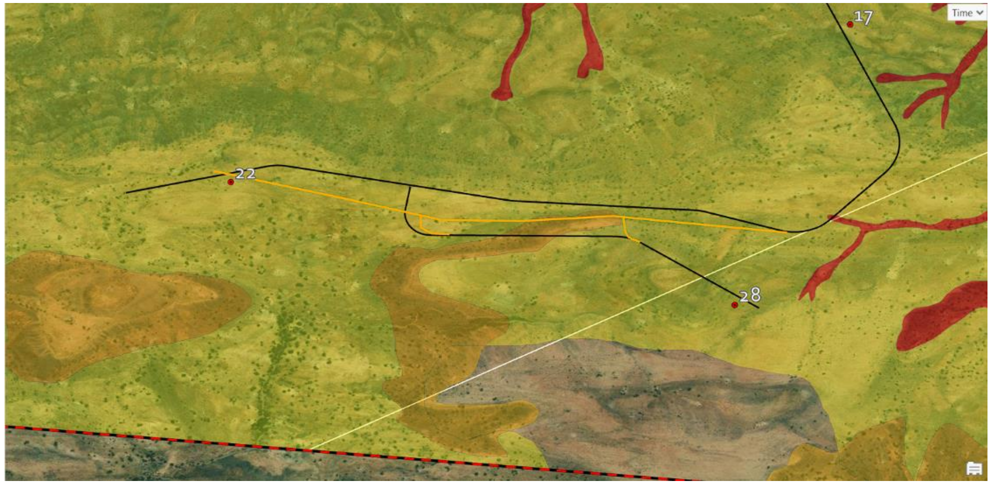
WTG 04

 WTG 05	
 WTG 06	

 WTG 07	
 WTG 08	

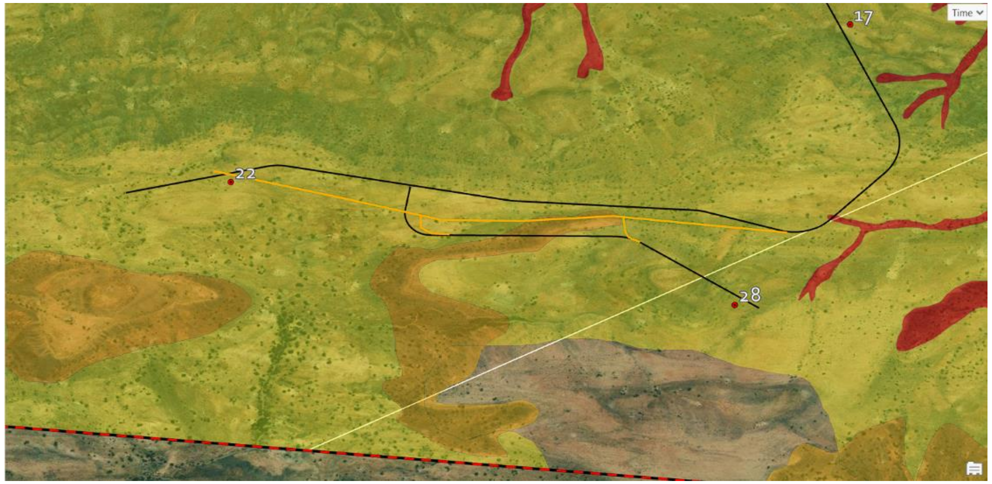


WTG 14, 18 & 19



WTG 22 Access Road

WTG 27 Access Road



WTG 28 Access Road

4 Walkdown Conclusions and Recommendations

The following general recommendations are made based on the findings of the walkdown, with reference to Table 6 & Table 7 and Figure 10:

- No turbine positions were noted to conflict with any sensitive areas as per original assessment.
- Site walkdown determined that several turbines and roads were on or near sensitive features, including several drainage lines, watercourses and grassy veli like areas. While not directly of a terrestrial nature these features do none the less have potential indirect terrestrial habitat sensitivities, being in an arid environment where the aquatic and terrestrial environment are closely linked. Several minor alignment recommendations have been made in this regard. These will also reduce the very high sensitivity footprint slightly.
- Other potential issues that were identified in the walkdown include steep rock faces and access roads being off the edge of a mountain, which can be avoided or significantly reduced by incorporating minor turbine, infrastructure or road alignment adjustments, as recommended. The terrestrial biodiversity impact would be minimised by allowing for reduced cut and fill requirements, hence a slightly reduced terrestrial footprint.
- No specific sensitivities were identified relating to the Grid Connection Option 2 (South) route.
- The following specific recommendations should be included in any updated EMPr for the project.
  - A flora and fauna search and rescue (relocation) must be undertaken before commencement of any vegetation clearing. A comprehensive (updated) list of species for which permits will be required will be included in permit applications, including several species not identified during the initial assessment.
- Where there are further changes/updates to the vertical and horizontal alignments of the road network and site laydown area, such sections/areas may require reassessed in order to determine any further risks and impacts to the ecology and/or species.

5 Appendices

5.1 Appendix 1: References

General Reference Sources

- Acocks, J. P. H. 1988. *Veld Types of South Africa*. Memoirs of the Botanical Survey of South Africa, No 57. Botanical Research Institute, Department of Agriculture and Water Supply, South Africa.
- Atlas and Red List of the Reptiles of South Africa, Lesotho, and Swaziland. 2014. Edited by Michael F. Bates, William R. Branch, Aaron M. Bauer, Marius Burger, Johan Marais, Graham J. Alexander & Marienne S. de Villiers. SANBI, Pretoria.
- Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J. & Marienne S. de Villiers. (Eds). 2014. *Atlas and Red List of the Reptiles of South Africa, Lesotho, and Swaziland.* SANBI, Pretoria.
- Brauneder KM, Montes C, Blyth S, Bennun L, Butchart SH, Hoffmann M, Burgess ND, Cuttelod A, Jones MI, Kapos V, Pilgrim J, Tolley MJ, Underwood EC, Weatherdon LV, Brooks SE, 2018. *Global screening for Critical Habitat in the terrestrial realm*. PloS one, 13(3), p.e0193102. doi:10.1371/journal.pone.0193102
- Bromilow, C. 2001. *Problem Plants of South Africa*. A Guide to the Identification and Control of More than 300 Invasive Plants and Other Weeds. Briza Publications. Pp 258
- Child M.F., Roxburgh L., Do Linh San E., Raimondo D., Davies-Mostert H.T. 2016. *The Red List of Mammals of South Africa, Swaziland, and Lesotho.* South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.
- Council for Scientific and Industrial Research. NFEPA river FEPAs 2011 [vector geospatial dataset] 2011. Available from the Biodiversity GIS website, downloaded on 20 July 2020.
- Council for Scientific and Industrial Research. NFEPA rivers 2011 [vector geospatial dataset] 2011. Available from the Biodiversity GIS website, downloaded on 20 July 2020.
- Council for Scientific and Industrial Research. NFEPA wetland clusters 2011 [vector geospatial dataset] 2011. Available from the Biodiversity GIS website, downloaded on 20 July 2020.
- Council for Scientific and Industrial Research. NFEPA wetlands vegetation 2011 [vector geospatial dataset] 2011. Available from the Biodiversity GIS website, downloaded on 20 July 2020.
- Cowling, R.M., Richardson, D.M. & Pierce, S.M. 1997. Vegetation of Southern Africa. Cambridge University Press.
- Driver, A., Sink, K.J., Nel, J.L., Holness, S., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L. & Maze, K. 2012. *National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis report*. South Africa National Biodiversity Institute and Department of Environmental Affairs, Pretoria.
- Esler, K.J., Milton, S.J. & Dean, W.R.J. 2006. Karroo Veld: Ecology and Management. Briza Publications.
- Fuggle, R. F. & Rabie, M. A. 2003. *Environmental Management in South Africa*. Juta & Co, Johannesburg.
- Germishuizen, G. & Meyer, N.L. (eds). 2003. *Plants of southern Africa: An annotated checklist*. Strelitzia, 14. Pretoria: National Botanical Institute.
- Golding, J. (Ed.) 2002. *Southern African Plant Red Data Lists*. Southern African Botanical Diversity Network Report No 14.
- Henderson, L. 2001. *Alien Weeds and Invasive Plants*. Plant Protection Research Institute Handbook No 12. Agricultural Research Council. Pp 300.
- Hilton-Taylor, C. 1996. *Red Data List of Southern African Plants*. National Botanical Institute.

- Hockey PAR, Dean WRJ and Ryan PG 2005. Roberts - Birds of southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.
- International Finance Corporation. 2012. Performance Standards on Environmental and Social Sustainability.
- International Finance Corporation. 2012. Performance Standards on Environmental and Social Sustainability.
- Low, A.B. & Rebelo, A.G. 1998. *Vegetation of South Africa, Lesotho, and Swaziland*. Pretoria: Department of Environmental Affairs and Tourism.
- M.F. Bate, W.R. Branch, A.M. Bauer, M. Burger, J. Marias, G.J. Alexander and M.S. de Villiers (eds), *Atlas and Red List of Reptiles of South Africa, Lesothos and Swaziland*. Suricata 1. South African National Biodiversity Institute, Pretoria.
- Marnewick MD, Retief EF, Theron NT, Wright DR, Anderson TA. 2015. *Important Bird and Biodiversity Areas of South Africa*. Johannesburg: BirdLife South Africa.
- Martin CS, Tolley MJ, Farmer E, Mcowen CJ, Geffert JL, Scharlemann JPW, Thomas H, van Bochove JH, Stanwell-Smith D, Hutton JM, Lascelles B, Pilgrim JD, Ekstrom JMM, Tittensor DP, 2015. *A global map to aid the identification and screening of Critical Habitat for marine industries*. Marine Policy 53: 45-53. doi:10.1016/j.marpol.2014.11.007 .
- Mecenero, S., Ball, J.B., Edge, D.A., Hamer, M.L., Hening, G.A., Krüger, M., Pringle, R.L., Terblanche, R.F. & Williams, M.C. (Eds). 2013. *Conservation assessment of butterflies of South Africa, Lesotho, and Swaziland:* Red List and atlas. Saftronics (Pty) Ltd., Johannesburg and Animal Demography Unit, Cape Town.
- Minter LR, Burger M, Harrison JA, Braack HH, Bishop PJ & Kloepfer D (Eds). 2004. *Atlas and Red Data book of the frogs of South Africa, Lesotho, and Swaziland.* SI/MAB Series no. 9. Smithsonian Institution, Washington, D.C.
- Minter LR, Burger M, Harrison JA, Braack HH, Bishop PJ & Kloepfer D (eds). 2004. Atlas and Red Data book of the frogs of South Africa, Lesotho, and Swaziland. SI/MAB Series no. 9. Smithsonian Institution, Washington, D.C.
- Mucina, L. & Rutherford, M.C. (Eds). 2006. *The vegetation of South Africa, Lesotho, and Swaziland*, in Strelitzia 19. South African National Biodiversity Institute, Pretoria.
- Myers, N., Mittermeir, R.A., Mittermeir, C.G., De Fonseca, G.A.B. & Kent, J. 2000. *Biodiversity hotspots for conservation priorities*. Nature, 403: 853–858.
- Nel, J., Colvin, C., Le Maitre, D., Smith, J., Haines, I. 2013. Defining South Africa's Water Source Areas. WWF South Africa & Council for Scientific & Industrial Research (CSIR).
- Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., van Deventer, H., Funke, N., Swart, E.R., Smith-Ado, L.B., Mbona, N., Downsborough, L. & Nienaber, S. 2011. *Technical Report for the National Freshwater Ecosystem Priority Areas project.* Report to the Water Research Commission, WRC Report No. 1801/2/11. ISBN 978-1-4312-0149-5.
- Pienaar, K. 2000. *The South African What Flower is That*? Struik Publishers (Pty) Ltd. Cape Town.
- Powrie, L.W. 2013. A database of biodiversity taxon names in South Africa for copy-and-paste into reports or documents. South African National Biodiversity Institute, Cape Town. Obtained from SANBI on 20 July 2020.
- Powrie, L.W. 2013. A list of South African biodiversity terms and common names for spell checking. South African National Biodiversity Institute, Cape Town. Downloaded from www.sanbi.org on 20 July 2020.
- Powrie, L.W. 2013. A list of South African botanical names for spell checking. South African National Biodiversity Institute, Cape Town. Downloaded from www.sanbi.org on 18 July 2020.
- Powrie, L.W. 2013. A list of South African physical feature names for spell checking. South African National Biodiversity Institute, Cape Town. Downloaded from www.sanbi.org on 20 July 2020.

- Powrie, L.W. 2013. A list of South African zoological and other (including fungi and lichen) names for spell checking. South African National Biodiversity Institute, Cape Town. Downloaded from www.sanbi.org on 20 July 2020.
- Rouget, M., Reyers, B., Jonas, Z., Desmet, P., Driver, A., Maze, K., Egoh, B. & Cowling, R.M. 2004. *South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 1: Terrestrial Component.* Pretoria: South African National Biodiversity Institute.
- Samways, M.J. & Simaika, J.P. 2016. *Manual of Freshwater Assessment for South Africa: Dragonfly Biotic Index.* Suricata 2. South African National Biodiversity Institute, Pretoria.
- Samways, M.J. & Simaika, J.P. 2016. Manual of Freshwater Assessment for South Africa: Dragonfly Biotic Index. Suricata 2. South African National Biodiversity Institute, Pretoria.
- Skowno, A.L., Raimondo, D.C., Poole, C.J., Fizzotti, B. & Slingsby, J.A. (Eds.). 2019. *South African National Biodiversity Assessment 2018 Technical Report Volume 1: Terrestrial Realm*. South African National Biodiversity Institute, Pretoria. http://hdl.handle.net/20.
- Snyman-Van der Walt, L. 2019. Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure in South Africa: Nama Karoo, Succulent Karoo and Desert Biomes. Council for Scientific and Industrial Research (CSIR).
- South African National Biodiversity Institute (SANBI). 2019. *National Biodiversity Assessment 2018: The status of South Africa's ecosystems and biodiversity. Synthesis Report.* South African National Biodiversity Institute, an entity of the Department of Environment, Forestry and Fisheries, Pretoria. pp. 1–214.
- Stirton, C. H. 1987. *Plant Invaders: Beautiful, but Dangerous*. The Department of Nature and Environmental Conservation of the Cape Province Administration. Galvin and Sales, Cape Town.
- Taylor, M.R., Peacock, F., and Wanless, R.M. 2015. Eskom Red Data Book of Birds of South Africa, Lesotho, and Swaziland.
- Taylor, P.B., Navarro, R.A., Wren-Sargent, M., Harrison, J.A. & Kieswetter, S.L. 1999. *Coordinated waterbird Counts in South Africa, 1992-1997.* Avian Demography Unit, Cape Town.
- The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. Taylor, MR, Peacock F, Wanless RW (eds). BirdLife South Africa, Johannesburg, South Africa.
- Turpie, J.K., Wilson, G. & Van Niekerk, L. 2012. *National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa*. Anchor Environmental Consulting, Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.
- UN Natural Value Initiative. 2009. *The Ecosystem Services Benchmark,* 2009.
- Van Wyk, A.E. & Smith, G.F. 2001. *Regions of Floristic Endemism*: A Review with Emphasis on Succulents, Umdaus Press.
- Vromans, D.C., Maree, K.S., Holness, S.D. and Skowno, A.L. 2012. The Biodiversity Sector Plan for the Blue Crane Route Municipality. Supporting land-use planning and decision-making in Critical Biodiversity Areas and Ecological Support Areas for sustainable development. Addo Elephant National Park Mainstreaming Biodiversity Project. South African National Parks. Port Elizabeth. South Africa.
- Water Research Commission. *2017 Surface and Groundwater SWSA* [Vector] 2017. Available from the Biodiversity GIS website, downloaded on 25 January 2021.
- Water Research Commission. *2017 SWSA Surface water* [Vector] 2017. Available from the Biodiversity GIS website, downloaded on 25 January 2021.
- Weather Bureau. 1988. Climate of South Africa – Climate statistics up to 1984 (WB40). Government Printer, Pretoria.
- Weather Bureau. 1988. Climate of South Africa – Climate statistics up to 1984 (WB40). Government Printer, Pretoria.

- Young, D.J., Harrison, J.A, Navarro, R.A., Anderson, M.A., & Colahan, B.D. (Eds). 2003. *Big birds on farms: Mazda CAR Report 1993-2001.* Avian Demography Unit: Cape Town.

Western Cape

Web Databases and Sources

- Animal Demographic Unit: http://vmus.adu.org.za
- Conservation International: http://www.biodiversityhotspots.org
- Fitzpatrick Institute of African Ornithology (2022). MammalMAP Virtual Museum. Accessed at http://vmus.adu.org.za/?vm=MammalMAP on 2020-12-12.
- Fitzpatrick Institute of African Ornithology (2022). OrchidMAP Virtual Museum. Accessed at http://vmus.adu.org.za/?vm=OrchidMAP on 2022-12-12.
- Fitzpatrick Institute of African Ornithology (2022). PHOWN Virtual Museum. Accessed at http://vmus.adu.org.za/?vm=PHOWN on 2022-12-12.
- FitzPatrick Institute of African Ornithology (2022). ScorpionMAP Virtual Museum. Accessed at http://vmus.adu.org.za/?vm=ScorpionMAP on 2022-12-12.
- Fitzpatrick Institute of African Ornithology (2022). SpiderMAP Virtual Museum. Accessed at http://vmus.adu.org.za/?vm=SpiderMAP on 2022-12-12.
- Global Biodiversity Information Facility (GBIF): http://gbif.org
- International Union for Conservation of Nature (IUCN) Redlist: http://iucnredlist.org
- IPIECA, https://www.ipieca.org/
- Millennium Ecosystem Assessment (MEA). 2005: https://www.millenniumassessment.org
- National Sustainable Development Strategies (NSDS): https://sdgs.un.org/topics/national-sustainable-development-strategies
- Plants of Southern Africa: http://newposa.sanbi.org
- South African National Biodiversity Institute (SANBI) Redlist: http://redlist.sanbi.org
- South African Bird Atlas Project: http://sabap2.birdmap.africa
- The South African Bat Assessment Association (SABAA): http://www.sabaa.org.za/
- United Nations Environment Programme (UNEP), *A to Z Areas of Biodiversity Importance:* http://www.biodiversitya-z.org
- United Nations Environment Programme (UNEP)-WCMC (2017) *Global Critical Habitat screening layer (Version 1.0)*. Cambridge (UK): UN Environment World Conservation Monitoring Centre. http://data.unep-wcmc.org/datasets/44.
- United Nations Environment Programme (UNEP), *World Database on Protected Areas*, Protected Planet: http://www.protectedplanet.net
- World Resources Institute (WRI): https://www.wri.org

Previous Project Reports

- Todd, S. 2022. *Proposed construction of the Koup 2 Wind Energy Facility and associated grid infrastructure, near Beaufort west, Western Cape province, South Africa: Fauna & flora specialist study*. Report compiled for SiVEST Environmental on behalf of Genesis Enertrag.
- Todd, S. 2022. *Proposed construction of the Koup 1 Wind Energy Facility and associated grid infrastructure, near Beaufort west, Western Cape province, South Africa: Fauna & flora specialist study.* Report compiled for SiVEST Environmental on behalf of Genesis Enertrag.

5.2 Appendix 2: Abbreviations & Glossary

5.2.1 Abbreviations

CARA	Conservation of Agricultural Resources Act, Act 43 of 1983
CBA	Critical Biodiversity Area
DEA	Department of Environmental Affairs (*now DEFF, see below*)
DEDEAT	Department of Economic Development, Environmental Affairs and Tourism
DEFF	The Department of Environmental Affairs was renamed the Department of Environment, Forestry and Fisheries (DEFF) in June 2019, incorporating the forestry and fisheries functions from the previous Department of Agriculture, Forestry and Fisheries.
DEMC	Desired Ecological Management Class
DWS	Department of Water Affairs and Sanitation
DWAF	Department of Water Affairs and Forestry (former department name)
EA	Environmental Authorisation
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMC	Ecological Management Class
EMP	Environmental Management Plan
EMPr	Environmental Management Programme report
ER	Environmental Representative
ESS	Ecosystem Services
IAP's	Interested and Affected Parties
IEM	Integrated Environmental Management
LM	Local Municipality
masl	meters above sea level
MPAH	Maputaland-Pondoland-Albany Hotspot
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act, Act 107 of 1998
NFA	National Forests Act
NEM:BA	National Environmental Management: Biodiversity Act 10 of 2004
NFA	National Forest Act, Act 84 of 1998
PEMC	Present Ecological Management Class
PES	Present Ecological State
PNCO	Provincial Nature and Environment Conservation Ordinance (No. 19 of 1974).
RDL	Red Data List
RHS	Right Hand Side
RoD	Record of Decision
SANBI	South African National Biodiversity Institute
SDF	Spatial Development Framework
SoER	State of the Environment Report
SSC	Species of Special Concern
ToPS	Threatened of Protected Species
ToR	Terms of Reference
+ve	Positive
-ve	Negative

5.2.2 Glossary

Alien Invasive Species (AIS)	An alien species whose introduction and/or spread threaten biological diversity (Convention on Biological Diversity). Note: "*Alien invasive species*" is considered to be equivalent to "*invasive alien species*". An alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity (*IUCN*).
Best Environmental Practice	The application of the most appropriate combination of environmental control measures and strategies (Stockholm Convention).
Best Management Practice	Established techniques or methodologies that, through experience and research, have proven to lead to a desired result (BBOP).
Biodiversity	Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.
Biodiversity Offset	Measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure and ecosystem function and people's use and cultural values associated with biodiversity (BBOP).
Biodiversity Threshold	The target areas (hectares) of biodiversity which must be safeguarded for the component plants and animals to exist and for ecosystems to continue functioning (e.g. pollination, migration of animals) i.e. the target areas comprise the CBA.
Bioremediation	The use of organisms such as plants or microorganisms to aid in removing hazardous substances from an area. Any process that uses microorganisms, fungi, green plants, or their enzymes to return the natural environment altered by contaminants to its original condition.
Boundary	Landscape patches have a boundary between them which can be defined or fuzzy (Sanderson and Harris, 2000). The zone composed of the edges of adjacent ecosystems is the boundary.
Catchment	In relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points.
Connectivity	The measure of how connected or spatially continuous a corridor, network, or matrix is. For example, a forested landscape (the matrix) with fewer gaps in forest cover (open patches) will have higher connectivity.
Corridors	Have important functions as strips of a landscape differing from adjacent land on both sides. Habitat, ecosystems, or undeveloped areas that physically connect habitat patches. Smaller, intervening patches of surviving habitat can also serve as "steppingstones" that link fragmented ecosystems by ensuring that certain ecological processes are maintained within and between groups of habitat fragments.
Critically Endangered (CR)	A category on the IUCN Red List of Threatened Species which indicates a taxon is considered to be facing an extremely high risk of extinction in the wild (*IUCN*).
Cultural Ecosystem Services	The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic

	experience, including, e.g. knowledge systems, social relations, and aesthetic values (Millennium Ecosystem Assessment).
Cumulative Impacts	The total impact arising from the project (under the control of the developer), other activities (that may be under the control of others, including other developers, local communities, government) and other background pressures and trends which may be unregulated. The project's impact is therefore one part of the total cumulative impact on the environment. The analysis of a project's incremental impacts combined with the effects of other projects can often give a more accurate understanding of the likely results of the project's presence than just considering its impacts in isolation (BBOP).
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat(*IUCN*).
Degraded Habitat/Land	Land that has been impacted upon by human activities (including introduction of invasive alien plants, light to moderate overgrazing, accelerated soil erosion, dumping of waste), but still retains a degree of its original structure and species composition (although some species loss would have occurred) and where ecological processes still occur (albeit in an altered way). Degraded land is capable of being restored to a near-natural state with appropriate ecological management.
Disturbance	An event that significantly alters the pattern of variation in the structure or function of a system, while fragmentation is the breaking up of a habitat, ecosystem, or land-use type into smaller parcels. Disturbance is generally considered a natural process.
Ecological Function	How each of the elements in the landscape interacts based on its life cycle events [Producers, Consumers, Decomposers Transformers]. Includes the capacity of natural processes and components to provide goods and services that satisfy human needs, either directly or indirectly.
Ecological Pattern	The contents and internal order of the landscape, or its spatial (and temporal) components. May be homogenous or heterogenous. Result from the ecological processes that produce them.
Ecological Process	Includes *Physical processes* [Climate (precipitation, insolation), hydrology, geomorphology]; *Biological processes* [Photosynthesis, respiration, reproduction]; *Ecological processes* [Competition, predator-prey interactions, environmental gradients, life histories]
Ecological Processes	Ecological processes typically only function well where natural vegetation remains, and where the remaining vegetation is well-connected with other nearby patches of natural vegetation. Loss and fragmentation of natural habitat severely threatens the integrity of ecological processes. Where basic processes are intact, ecosystems are likely to recover more easily from disturbances or inappropriate actions if the actions themselves are not permanent. Conversely, the more interference there has been with basic processes, the greater the severity (and longevity) of effects. Natural processes are complex and interdependent, and it is not possible to predict all the consequences of loss of biodiversity or ecosystem integrity. When a region's natural or historic level of diversity and integrity is maintained, higher levels of system productivity are supported in the long run and the overall effects of disturbances may be dampened.
Ecological Structure	The composition, or configuration, and the proportion of different patches across the landscape. Relates to species diversity, the greater the diversity, the

	more complex the structure. A description of the organisms and physical features of environment including nutrients and climatic conditions.
Ecosystem	All the organisms of a habitat, such as a lake or forest, together with the physical environment in which they live. A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
Ecosystem Services	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Supporting Ecosystem services are those that are necessary for the maintenance of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.
Ecosystem Status	Ecosystem status of terrestrial ecosystems is based on the degree of habitat loss that has occurred in each ecosystem, relative to two thresholds: one for maintaining healthy ecosystem functioning, and one for conserving the majority of species associated with the ecosystem. As natural habitat is lost in an ecosystem, its functioning is increasingly compromised, leading eventually to the collapse of the ecosystem and to loss of species associated with that ecosystem (Millennium Ecosystem Assessment).
Ecotone	The transitional zone between two communities. Ecotones can arise naturally, such as a lakeshore, or can be human created, such as a cleared agricultural field from a forest. The ecotonal community retains characteristics of each bordering community and often contains species not found in the adjacent communities. Classic examples of ecotones include fencerows; forest to marshlands transitions; forest to grassland transitions; or land-water interfaces such as riparian zones in forests. Characteristics of ecotones include vegetational sharpness, physiognomic change, and occurrence of a spatial community mosaic, many exotic species, ecotonal species, spatial mass effect, and species richness higher or lower than either side of the ecotone.
Edge	The portion of an ecosystem near its perimeter, where influences of the adjacent patches can cause an environmental difference between the interior of the patch and its edge. This edge effect includes a distinctive species composition or abundance in the outer part of the landscape patch. For example, when a landscape is a mosaic of perceptibly different types, such as a forest adjacent to a grassland, the edge is the location where the two types adjoin. In a continuous landscape, such as a forest giving way to open woodland, the exact edge location is fuzzy and is sometimes determined by a local gradient exceeding a threshold, as an example, the point where the tree cover falls below thirty-five percent.
Emergent Tree	Trees that grow above the top of the canopy
Endangered (En)	Endangered terrestrial ecosystems have lost significant amounts (more than 60 % lost) of their original natural habitat, so their functioning is compromised. A taxon (species) is Endangered when the best available evidence indicates that it meets any of the criteria for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild (*IUCN*).
Endemic	A plant or animal species, or a vegetation type, which is naturally restricted to a defined region or limited geographical area. Many endemic species have widespread distributions and are common and thus are not considered to be under any threat. They are however noted to be unique to a region, which can include South Africa, a specific province or a bioregion, vegetation type, or a localised area. In cases where it is highly localised or known only from a few or a few localities, and is under threat, it may be red listed either in terms of the

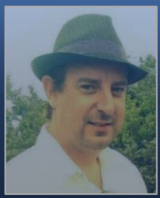
	South Africa Threatened Species Programme, NEMBA Threatened or Protected Species (ToPS) or the IUCN Red List of Threated Species.
Environment	The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group. These circumstances include biophysical, social, economic, historical, and cultural aspects.
Estuary	a partially or fully enclosed body of water - (a) which is open to the sea permanently or periodically; and (b) within which the sea water can be diluted, to an extent that is measurable, with fresh water drained from land.
Evolutionary Processes	Series of actions which enable new species to evolve in response to changing Biodiversity is maintained by ecological processes at the micro-scale (such as in pollination and nutrient cycling via microbial action) through to the mega-scale (natural events e.g. fire, flood; migration of species along river valleys or coastal areas, quality and quantity of water feeding rivers and estuaries; marine sand movement and the seasonal mountain-to-coast migration of birds that pollinate plants).
Exotic	Non-indigenous; introduced from elsewhere, may also be a *weed* or alien *invasive* species. Exotic species may be invasive or non-invasive.
Fragmentation (Habitat Fragmentation)	The 'breaking apart' of continuous habitat into distinct pieces. Causes land transformation, an important current process in landscapes as more and more development occur.
Habitat	The home of a plant or animal species. Generally, those features of an area inhabited by animal or plant which are essential to its survival.
Habitat Banking	A market where credits from actions with beneficial biodiversity outcomes can be purchased to offset the debit from environmental damage. Credits can be produced in advance of, and without ex-ante links to, the debits they compensate for, and stored over time (IEEP).
IFC PS6	International Finance Corporation Performance Standard 6 – A standard guiding biodiversity conservation and sustainable management of living natural resources for projects financed by the International Finance Corporation (IFC)
Indicator	Information based on measured data used to represent an attribute, characteristic, or property of a system.
Indicator species	A species whose status provides information on the overall condition of the ecosystem and of other species in that ecosystem. They reflect the quality and changes in environmental conditions as well as aspects of community composition.
Indigenous	Native; occurring naturally in a defined area.
Indigenous Species (Native species)	A species that has been observed in the form of a naturally occurring and self-sustaining population in historical times (*Bern Convention* 1979). A species or lower taxon living within its natural range (past or present) including the area which it can reach and occupy using its natural dispersal systems (*modified after the Convention on Biological Diversity*)
Indirect Impact	Impacts triggered in response to the presence of a project, rather than being directly caused by the project's own operations (BBOP)
Instream habitat	Includes the physical structure of a watercourse and the associated vegetation in relation to the bed of the watercourse;
Intact Habitat / Vegetation	Land that has not been significantly impacted upon by man's activities. These are ecosystems that are in a near-pristine condition in terms of structure, species composition and functioning of ecological processes.
Intrinsic Value	The inherent worth of something, independent of its value to anyone or anything else.
Keystone Species	Species whose influence on ecosystem function and diversity are disproportionate to their numerical abundance. Although all species interact,

	the interactions of some species are more profound and far-reaching than others, such that their elimination from an ecosystem often triggers cascades of direct and indirect changes on more than a single trophic level, leading eventually to losses of habitats and extirpation of other species in the food web.
Landscape	An area of land that contains a mosaic of ecosystems, including human-dominated ecosystems (Millennium Ecosystem Assessment).
Landscape Approach	Dealing with large-scale processes in an integrated and multidisciplinary manner, combining natural resources management with environmental and livelihood considerations (FAO).
Landscape connectivity	The degree to which the landscape facilitates or impedes movement among resource patches.
Least threatened / Least Concern (LC)	These ecosystems have lost only a small proportion (more than 80 % remains) of their original natural habitat, and are largely intact (although they may be degraded to varying degrees, for example by invasive alien species, overgrazing, or overharvesting from the wild). A taxon (species) is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category (*IUCN*).
Matrix	The "*background ecological system*" of a landscape with a high degree of connectivity.
Natural Forest (Indigenous Forest)	The definition of "*natural forest*" in the National Forests Act of 1998 (NFA) Section 2(1)(xx) is as follows: 'A natural forest means a group of indigenous trees • whose crowns are largely contiguous • or which have been declared by the Minister to be a natural forest under section 7(2) This definition should be read in conjunction with Section 2(1)(x) which states that 'Forest' includes: • A natural forest, a woodland, and a plantation • The forest produce in it; and • The ecosystems which it makes up. The legal definition must be supported by a technical definition, as demonstrated by a court case in the Umzimkulu magisterial district, relating to the illegal felling of Yellowwood (Podocarpus latifolius) and other species in the Gonqogonqo forest. From scientific definitions (also see Appendix B) we can define natural forest as: • A generally multi-layered vegetation unit • Dominated by trees that are largely evergreen or semi-deciduous • The combined tree strata have overlapping crowns, and crown cover is >75% • Grasses in the herbaceous stratum (if present) are generally rare • Fire does not normally play a major role in forest function and dynamics except at the fringes • The species of all plant growth forms must be typical of natural forest (check for indicator species) • The forest must be one of the national forest types
Near Threatened (NT)	A taxon (species) is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future (*IUCN*).
Patch	A term fundamental to landscape ecology, is defined as a relatively homogeneous area that differs from its surroundings. Patches are the basic unit

	of the landscape that change and fluctuate, a process called patch dynamics. Patches have a definite shape and spatial configuration and can be described compositionally by internal variables such as number of trees, number of tree species, height of trees, or other similar measurements.
Protected Area	A clearly defined geographical space, recognised, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.
Range restricted species	Species with a geographically restricted area of distribution. Note: Within the IFC PS6, restricted range refers to a limited extent of occurrence (EOO): • For terrestrial vertebrates and plants, restricted-range species are defined as those species that have an EOO less than 50,000 square kilometres (km2).
Refugia	A location which supports an isolated or relict population of a once more widespread species. This isolation can be due to climatic changes, geography, or human activities such as deforestation and overhunting.
Rehabilitation	Measures taken to rehabilitate degraded ecosystems or restore cleared ecosystems following exposure to impacts that cannot be completely avoided and/ or minimised. Rehabilitation emphasizes the reparation of ecosystem processes, productivity and services, whereas the goals of restoration also include the re-establishment of the pre-existing biotic integrity in terms of species composition and community structure (BBOP).
Resilience	The capacity of a natural system to recover from disturbance (OECD).
Restoration	The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. An ecosystem has recovered when it contains sufficient biotic and abiotic resources to continue its development without further assistance or subsidy. It would sustain itself structurally and functionally, demonstrate resilience to normal ranges of environmental stress and disturbance, and interact with contiguous ecosystems in terms of biotic and abiotic flows and cultural interactions (IFC).
Riparian	Pertaining to, situated on, or associated with the banks of a watercourse, usually a river or stream.
Riparian Habitat	Includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.
River Corridors	River corridors perform several ecological functions such as modulating stream flow, storing water, removing harmful materials from water, and providing habitat for aquatic and terrestrial plants and animals. These corridors also have vegetation and soil characteristics distinctly different from surrounding uplands and support higher levels of species diversity, species densities, and rates of biological productivity than most other landscape elements. Rivers provide for migration and exchange between inland and coastal biotas.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED).
Terrestrial	Occurring on, or inhabiting, land.
Threatened Species	Umbrella term for any species categorised as Critically Endangered, Endangered or Vulnerable by the IUCN Red List of Threatened Species (*IUCN*). Any species that is likely to become extinct within the foreseeable future throughout all or part of its range and whose survival is unlikely if the factors causing numerical decline or habitat degradation continue to operate (EU).

Traditional Ecological Knowledge	Knowledge, innovations, and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds. Traditional knowledge is mainly of a practical nature, particularly in such fields as agriculture, fisheries, health, horticulture, and forestry (CBD).
Transformation	In ecology, transformation refers to adverse changes to biodiversity, typically habitats or ecosystems, through processes such as cultivation, forestry, drainage of wetlands, urban development or invasion by alien plants or animals. Transformation results in habitat fragmentation – the breaking up of a continuous habitat, ecosystem, or land-use type into smaller fragments.
Transformed Habitat/Land	Land that has been significantly impacted upon as a result of human interferences/disturbances (such as cultivation, urban development, mining, landscaping, severe overgrazing), and where the original structure, species composition and functioning of ecological processes have been irreversibly altered. Transformed habitats are not capable of being restored to their original states.
Tributary	A small stream or river flowing into a larger one.
Untransformed Habitat/Land	Land that has not been significantly impacted upon by man's activities. These are ecosystems that are in a near-pristine condition in terms of structure, species composition and functioning of ecological processes.
Vulnerable (Vu)	Vulnerable terrestrial ecosystems have lost some (more than 60 % remains) of their original natural habitat and their functioning will be compromised if they continue to lose natural habitat. A taxon (species) is Vulnerable when the best available evidence indicates that it meets any of the criteria for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild (*IUCN*)..
Watercourse	Natural or man-made channel through or along which water may flow. A river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake, or dam into which, or from which, water flows. and a reference to a watercourse includes, where relevant, its bed and banks;
Weed	An indigenous or non-indigenous plant that grows and reproduces aggressively, usually a ruderal pioneer of disturbed areas. Weeds may be unwanted because they are unsightly, or they limit the growth of other plants by blocking light or using up nutrients from the soil. They can also harbour and spread plant pathogens. Weeds are generally known to proliferate through the production of large quantities of seed.
Wetlands	A collective term used to describe lands that are sometimes or always covered by shallow water or have saturated soils, and where plants adapted for life in wet conditions usually grow.

5.3 Appendix 3: Specialist Profile and Professional Registration



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ABOUT ME

18 years broad professional experience in Biodiversity, Ecological and Vegetation Assessments on over 250 projects in southern, western and central Africa. Environmental Assessment Practitioner on over 50 projects in the mining, infrastructure, housing and agricultural sectors. Environmental monitoring and auditing on over 50 civil infrastructure and construction projects. Have managed all aspects of projects from inception through to implementation. Advanced GIS mapping tools and Analysis.

EDUCATION

Bachelor of Science
Rhodes University
2002 (Botany & Environmental Science)

Bachelor of Science (Honours)
Rhodes University
2003 (Botany)

Professional Natural Scientist
SACNASP: 2016 (Ecological Science)

SERVICES

Terrestrial Biodiversity Specialist Assessments
IFC PS6 Biodiversity & Critical Habitat Assessments
Terrestrial Biodiversity Compliance Statements
Geographic Information Systems
Environmental Management Plans & Programmes
Environmental Compliance & Monitoring
Independent Environmental & Ecological reviews
Bioremediation, Restoration & Rehabilitation Plans
Permit and License applications (Flora & Fauna)
Flora Search & Rescue Plans & Relocations
Invasive Alien Plant Control & Management Plans
Environmental & Mining Applications

EXPERIENCE AND CLIENTS

Key Sectors

- *Wind, Solar Energy Facilities*
- *Infrastructure and Housing*
- *Agriculture and Forestry*
- *Mining and Industrial*

Key Projects

- *Over 250 independent Biodiversity/Ecological Assessments throughout southern, western and central Africa.*
- *Basic Assessments, Mining applications and compliance monitoring on over 50 projects for various clients including the Eastern Cape Department of Roads and Public Works, Department of Transport and the South African National Roads Agency (SANRAL) throughout the Eastern Cape, including over 300 individual borrow pits.*
- *South-End Precinct Mixed Use Development for Mandela Bay Development Agency - Environmental application, Ecological assessments and Pre-Construction compliance.*
- *Coega Development Corporation IDZ projects – Ecological assessments, Flora search & rescue and Construction monitoring.*
- *Environmental applications, construction monitoring and auditing for a wide range of projects, including infrastructure and housing clients.*
- *Various agricultural expansion and infrastructure projects.*
- *Various wind and solar energy and associated infrastructure projects.*
- *Numerous infrastructure projects including electrical, water and roads.*
- *Various Environmental Management and Rehabilitation Plans.*

24/06/2021

SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Jamie Robert Claude Pote

Registration Number: 115233

is a registered scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following fields(s) of practice (Schedule 1 of the Act)

Ecological Science (Professional Natural Scientist)

Effective **20 July 2016** Expires **31 March 2023**

Chairperson

Chief Executive Officer

To verify this certificate scan this code

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Genesis Enertrag Koup 1 (Pty) Ltd

COMPARATIVE ENVIRONMENTAL NOISE IMPACT ASSESSMENT

of the proposed

Koup 1 Wind Energy Facility and associated Infrastructure

south of Beaufort-west, Western Cape Province

Study done for:

ARCUS

Prepared by:

EARES
Enviro Acoustic Research

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EXECUTIVE SUMMARY

INTRODUCTION

Enviro-Acoustic Research cc was commissioned by the ARCUS Consulting South Africa SA (Pty) Ltd ("ARCUS") to reassess the potential noise impact from the construction and operation of the proposed Koup 1 Wind Energy Facility ("WEF") and associated infrastructure on the surrounding area.

The developer is proposing a number of changes to the WEF and it was requested to review the potential change in the noise impact and whether it would result in a change in the findings and recommendations of the previous ENIA. Potential changes would include:

- A change in the Wind Turbine Generator ("WTG") layout; and
- A change in the potential WTG.

This is a comprehensive, stand-alone report which describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the WF may have on the surrounding environment, highlighting the methods used, potential issues identified, findings and recommendations.

PROJECT DESCRIPTION

The authorized Koup 1 WEF is located approximately 55 km south of Beaufort West in the Western Cape Province.

The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line. The project propose a Battery Energy Storage System ("BESS"), located next to the onsite substation. The WEF will include the following infrastructure:

- Up to twenty-eight (28) WTG, each with a hub height of up to 200m, a rotor diameter of up to approximately 200m with a maximum generating capacity of 10MW;
- Permanent compacted hardstand areas / platforms (also known as crane pads) per turbine during construction and for on-going maintenance purposes;
- Electrical transformers (690V/33kV) adjacent to each wind turbine (typical footprint of up to approximately 2m x 2m) to step up the voltage to 11-33kV;
- Associated infrastructure of approximately 25ha which includes:
  - One (1) Independent Power Producer on-site substation including associated equipment and infrastructure.

- A Battery Energy Storage System ("BESS"), to be located next to the onsite substation. The storage capacity and type of technology would be determined at a later stage during the development phase, but most likely comprise an array of containers, outdoor cabinets and/or storage tanks.
- One (1) construction laydown / staging area.
- Operation and Maintenance ("O&M") buildings, including offices, a guard house, operational control centre, O&M area / warehouse / workshop and ablution facilities (to be located on the site identified for the substation).
- The wind turbines will be connected to the proposed substation via medium voltage (11-33kV) underground cabling and overhead power lines.
- Internal roads to access the wind turbines. Existing site roads will be used wherever possible, although new site roads will be constructed where necessary.

DESCRIPTION OF THE SURROUNDING LAND USE

Land use is mostly agricultural activities (game and sheep farming) and wilderness areas (including eco-tourism). 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.

DESCRIPTION OF THE CLOSEST POTENTIAL NOISE SENSITIVE RECEPTORS

Residential areas and potential noise-sensitive developments/receptors/communities ("NSR") were identified using aerial images as well as a physical site visit, with a number of locations identified that is used on a temporary or permanent basis for residential purposes.

BASELINE SOUND LEVELS

Ambient sound levels (residual noise levels) were measured at six locations over 35 hours from the afternoon of the 10th until the morning of the 12 June 2021 in the vicinity of the project focus area. The data indicate an area where ambient sound levels were low (typical of winter periods), though it should be noted that the period coincided with very low wind speeds.

Based on the sound measurements:

- More than 1,000 10-minute measurements were collected during the day, with the highest fast-weighted sound level (during the various 10-minute measurements) measured being 55.4 dBA, with the lowest sound level being 16.6 dBA;

- More than 650 10-minute measurements were collected during the night-time period, with the highest fast-weighted sound level (during the numerous 10-minute measurements) measured being 65.7 dBA, with the lowest sound level being 22.6 dBA;
- The average of the 10-minute sound levels at the seven measurement locations were 29.8 dBA for the daytime period and 23.3 dBA for the night-time period (fast-weighted sound levels).

ACCEPTABLE NOISE LIMITS

Based on the developmental character and ambient sound level measurements:

- The daytime rating level (zone sound level) would be typical of a rural noise district (45 dBA), setting a maximum noise limit of 52 dBA during the day; and
- The night-time rating level (zone sound limit) is typical of a rural noise district (35 dBA), setting a recommended noise limit of 42 dBA at night (for the construction phase).

Because the National and provincial Noise Control Regulations (NCR) and SANS 10103 does not cater for instances when background noise levels change due to the impact of external forces (such as noises induced by higher wind speeds), this assessment used international guidelines and local regulations to recommend more appropriate noise limits for this project.

This is important, as the wind turbines will only operate during periods of higher wind speeds, a period that may coincide with higher ambient sound levels. This assessment therefore recommends a night-time noise limit of 42 dBA (periods with low or no winds – with this limit relevant for the construction phase) and an upper limit of 45 dBA (periods that wind turbines may operate – the operational phase).

FINDINGS

This review assessment considers the potential noise impact on the surrounding environment due to the construction, operational and future decommissioning activities associated with the Project. It makes use of conceptual scenarios to develop noise propagation models to estimate potential noise levels. Considering the ambient sound levels measured onsite, the proposed noise limits as well as the calculated noise levels, it was determined that the significance of the potential noise impacts would be:

- of a **medium significance** for the construction of access roads (or upgrading of existing roads). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment.

Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;

- of a **medium significance** relating to noises from construction traffic. This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the assembly of the WTG and other infrastructure). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a potential **medium significance** for the night-time construction activities (the potential pouring of concrete, erection of WTG). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for daytime operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level; and
- of a **high significance** for night-time operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available and included in this assessment that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level.

There is a slight potential for a cumulative noise impact to occur during the operational phase. NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs and there is a slight cumulative impact at these NSR. Total cumulative noise levels are higher than 45 dBA at these NSR, but this noise impact mainly relates to noises from operating WTG of the Koup 1 WEF (potential noise levels due to the WTG of the Koup 2 WEF will be less than 40 dBA). Due to the **high significance** of the noise impact for the operational phase, the significance will remain high for the cumulative scenario.

MANAGEMENT & MITIGATION OF NOISE IMPACT

The significance of the noise impact will be of a **medium** significance for both day- and night-time activities and additional mitigation measures are required or recommended.

Night-time activities especially may generate noises at sufficient level to be annoying to some NSR and the following measures could reduce annoyance with construction activities. Potential measures could include:

- The applicant can relocate the access road further than 100m from structures used for residential purposes during the construction period;
- Applicant to minimize simultaneous construction activities when working within 2,000m from NSR (such as limiting construction activities at one WTG location);
- Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life;
- The Applicant to minimize night-time activities when working within 2,000m from any structure used for residential purposes where possible. Work should only take place at one WTG location to minimize potential night-time cumulative noises (when working at night within 2,000m from NSR used for residential purposes);
- The applicant must notify the NSR when night-time activities will be taking place within 2,000m from the NSR (including construction traffic passing NSR); and
- The applicant must plan the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period (even though it is expected that it is highly unlikely that this may take place at night).

The significance of the noise impact during the operation phase could be **medium** for daytime activities, but of a **high** significance for night -time operations. Operating WTG however will be clearly audible at closest NSR, especially at night. Potential measures could include:

- The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA re 1 pw) – the scenario illustrated in **Figure 9-5**; **<u>or</u>**
- The applicant can relocate one or NSR located within the 45dBA noise rating level contours;
- The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR[1].

- For the currently layout, noise levels less than 45dBA would be possible when relocating:
  - WTG 1 and 14 further than 2,500m from NSR01; **and**
  - WTG 17, 18 and 28 further than 2,500m from NSR02; **and**

- The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.

RECOMMENDATIONS

Active noise monitoring is recommended because the projected noise levels are more than 38.7 dBA (the level defined by the WHO where noise levels from WTG may become annoying) for the layout and WTG as assessed in this report. Noise levels is projected to be higher than 45 dBA at NSR for a WTG with an SPL of 107.5 dBA (re 1 pW).

From an acoustic perspective the WTG layout is considered acceptable should the applicant select to use a WTG with a SPL less than 107.5 dBA (re 1 pW). Should the applicant select to use a WTG with an SPL exceeding 107.5 dBA (re 1 pW), additional mitigation measures must be implemented to ensure that total noise levels are less than 45 dBA at verified NSR (locations where residential activities would be taking place during the operational phase), with the potential mitigation measures highlighted in this review assessment.

Subject to the condition that the applicant limit total noise levels to less than 45 dBA at the NSR, it is recommended that the Koup 1 WEF be authorized (from an acoustic perspective).

It is also highlighted that the applicant re-evaluates the noise impact:

1. should the layout be revised where:
    a. any WTG, located within 1,500 m from any NSR are moved closer;
    b. the number of WTG within 2,500 m from any NSR are increased; and
2. should the applicant make use of a wind turbine with a maximum SPL exceeding 112.2 dBA re 1 pW.

If the project is to be developed in the future, the final layout and sound power emission levels of the selected WTG **must** be re-accessed to ensure the noise levels are less than 45 dBA at verified NSR (if the applicant changed the layout or the WTG as assessed in this report).

- WTG 2 further than 2,500m from NSR04.

To ensure that noise does not become an issue for future residents, landowners or the local communities, it is recommended that the applicant get written agreement from current landowners/community leaders that no new residential dwellings will be developed within areas enveloped by the 42dBA noise level contour (of the Koup 1 WEF). Dwellings and structures located within the 45dBA noise rating level contour should not be used for permanent residential activities.

Signature
Morné de Jager
2023 – 06 – 26

Report should be sited as:

De Jager, M (2023). "*Comparative Environmental Noise Impact Assessment for the proposed Koup 1 Wind Energy Facility and associated Infrastructure south of Beaufort-west, Western Cape Province*", Enviro-Acoustic Research cc, Pretoria

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Date:

June 2023

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GLOSSARY OF ABBREVIATIONS

AESAG	Acciona Energy South Africa Global
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BA	Basic Assessment
BESS	Battery Energy Storage System
DEM	Digital Elevation Model
DFFE	Department of Forestry, Fisheries and the Environment
EAP	Environmental Assessment Practitioner
EARES	Enviro Acoustic Research cc
ECA	Environment Conservation Act
ECO	Environmental Control Officer
EGI	Electrical Grid Infrastructure
EHS	Environmental Health and Safety
EMPr	Environmental Management Programme
ENIA	Environmental Noise Impact Assessment

ENM	Environmental Noise Monitoring
ENPAT	Environmental Potential Atlas for South Africa
ETSU	Energy Technology Support Unit
EPs	Equator Principles
EPFIs	Equator Principles Financial Institutions
FEL	Front-end Loader
GN	Government Notice
GNR	Government Notice Regulation
HNI	House Not Inhabited
I&APs	Interested and Affected Parties
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Organization for Standardization
LAN	Local Authority Notice
METI	Ministry of Economy, Trade, and Industry
MTS	Main Transmission Substation
NA	No Access
NASA	National Aeronautical and Space Administration
NEMA	National Environmental Management Act
NCR	Noise Control Regulations
NSR	Noise-sensitive Receptor
PFA	Project Focus Area
PPP	Public Participation Process
SABS	South African Bureau of Standards
SANS	South African National Standards
SPL	Sound Power Emission Level (or Sound Power Level)
SR	Significance Rating
TLB	Tractor-Loader-Backhoe (also referred to as a backhoe)
UTM	Universal Transverse Mercator
WHO	World Health Organization
WEF	Wind Energy Facility
WF	Wind Farm
WIN	Wind Induced Noises
WTG	Wind Turbine Generator
WTN	Wind Turbine Noise

GLOSSARY OF UNITS

^oC	Degrees Celsius (measurement of temperature)
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)
pW	pico Watt (10^{-12}) (measurement of power – sound power in air)
µPa	Micro pascal (measurement of pressure – in air in this document)

1 CHECKLIST: GG43110 MINIMUM REQUIREMENTS

The National Web based Environmental Screening Tool[2] was used to screen the proposed site for the noise environmental sensitivity as per the requirements of GNR320 (20 March 2020), considering the site location illustrated in **Figure 2-1**.

The site report generated by the Screening Tool highlighted that a Noise Impact Assessment must be completed and appended to the Environmental Authorization (EA) documentation.

The screening report was developed for *Utilities Infrastructure => Electricity => Generation => Renewable => Wind* category, with the noise sensitive areas illustrated on **Figure 2-3**. The areas defined to have a potential "**very high**" sensitivity to noise were downloaded as a layer from the online screening tool.

In terms of GNR320 (20 March 2020), a Noise Study must contain, as a minimum, the following information:

Clause	Requirement	Comment / Reference
2.3.1	Current ambient sound levels recorded at relevant locations over a minimum of two nights and that provide a representative measurement of the ambient noise climate, with each sample being a minimum of ten minutes and taken at two different times of the night on each night, in order to record typical ambient sound levels at these different times of night	Sections 4.1 and 4.3
2.3.2	Records of the approximate wind speed at the time of the measurement	Section 4.3, Figure 4-33
2.3.3	Mapped distance of the receiver from the proposed development that is the noise source	Section 2.4.6 and 9
2.3.4	Discussion on temporal aspects of baseline ambient conditions	Section 4.1
2.4.1	Characterization and determination of noise emissions from the noise source, where characterization could include types of noise, frequency, content, vibration and temporal aspects	Table 5-2, Table 5-3 and Table 5-1
2.4.2	Projected total noise levels and changes in noise levels as a result of the construction, commissioning and operation of the proposed	Section 9

[2] https://screening.environment.gov.za/screeningtool/#/pages/welcome

	development for the nearest receptors using industry accepted models and forecasts	
2.5.1	Contact details of the environmental assessment practitioner or noise specialist, their relevant qualifications and expertise in preparing the statement, and a curriculum vitae	Appendix A
2.5.2	a signed statement of independence by the environmental assessment practitioner or noise specialist.	Appendix C
2.5.3	The duration and date of the site inspection and the relevance of the season and weather condition to the outcome of the assessment	See section 4
2.5.4	A description of the methodology used to undertake the on-site assessment, inclusive of the equipment and models used, as relevant, together with the results of the noise assessment	See section 4.1
2.5.5	a map showing the proposed development footprint (including supporting infrastructure) overlaid on the noise sensitivity map generated by the screening tool	See Figure 2-1
2.5.6	confirmation that all reasonable measures have been taken through micro- siting to minimize disturbance to receptors	Site development limited to wind resource
2.5.7	a substantiated statement from the specialist on the acceptability, or not, of the proposed development and a recommendation on the approval, or not, of the proposed development	See section 13
2.5.8	any conditions to which this statement is subjected	See section 8.6
2.5.9	the assessment must identify alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered	Site development limited to the location of the wind resource
2.5.10	A motivation must be provided if there were development footprints identified as per paragraph 2.5.9 above that were identified as having a "low" noise sensitivity and that were not considered appropriate	Site development limited to the location of the wind resource
2.5.11	where required, proposed impact management outcomes, mitigation measures for noise emissions during the construction and commissioning phases that may be of relative short duration, or any monitoring requirements for inclusion in the Environmental Management Programme (EMPr), and	See section 11
2.5.12	a description of the assumptions made and any uncertainties or gaps in knowledge or data as well as a statement of the timing and intensity of site inspection observations	See section 8

2 INTRODUCTION

2.1 INTRODUCTION AND PURPOSE

Enviro-Acoustic Research cc was commissioned by the ARCUS Consulting South Africa SA (Pty) Ltd ("ARCUS") to reassess the potential noise impact from the construction and operation of the proposed Koup 1 Wind Energy Facility ("WEF") and associated infrastructure on the surrounding area.

The developer is proposing a number of changes to the WEF and it was requested to review the potential change in the noise impact and whether it would result in a change in the findings and recommendations of the previous ENIA. Potential changes would include:

- A change in the Wind Turbine Generator ("WTG") layout; and
- A change in the potential WTG.

This is a comprehensive, stand-alone report which describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the WF may have on the surrounding environment, highlighting the methods used, potential issues identified, findings and recommendations.

This study considered local regulations and both local and international guidelines, using the terms of reference ("ToR") as proposed by SANS 10328:2008 for a comprehensive Environmental Noise Impact Assessment ("ENIA") and as proposed by the requirements specified in the Assessment Protocol for Noise that were published on 20 March 2020, in Government Gazette 43110, GN 320. The study also considers the noise limits as proposed by the International Finance Corporation ("IFC") which is based on studies completed by the World Health Organization ("WHO").

2.2 BRIEF PROJECT DESCRIPTION

The authorized Koup 1 WEF is located approximately 55 km south of Beaufort West in the Western Cape Province. The regional location of the project focus area ("PFA") is presented in **Figure 2-1**.

The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line. The project propose a Battery Energy Storage System ("BESS"), located next to the onsite substation. The WEF will include the following infrastructure:

- Up to twenty-eight (28) WTG, each with a hub height of up to 200m, a rotor diameter of up to approximately 200m with a maximum generating capacity of 10MW;
- Permanent compacted hardstand areas / platforms (also known as crane pads) per turbine during construction and for on-going maintenance purposes;
- Electrical transformers (690V/33kV) adjacent to each wind turbine (typical footprint of up to approximately 2m x 2m) to step up the voltage to 11-33kV;
- Associated infrastructure of approximately 25ha which includes:
    - One (1) Independent Power Producer on-site substation including associated equipment and infrastructure.
    - A Battery Energy Storage System ("BESS"), to be located next to the onsite substation. The storage capacity and type of technology would be determined at a later stage during the development phase, but most likely comprise an array of containers, outdoor cabinets and/or storage tanks.
    - One (1) construction laydown / staging area.
    - Operation and Maintenance ("O&M") buildings, including offices, a guard house, operational control centre, O&M area / warehouse / workshop and ablution facilities (to be located on the site identified for the substation).
    - The wind turbines will be connected to the proposed substation via medium voltage (11-33kV) underground cabling and overhead power lines.
    - Internal roads to access the wind turbines. Existing site roads will be used wherever possible, although new site roads will be constructed where necessary.

2.3 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 applicant has been evaluating several turbine models, however the selection will only be finalized at a later stage once a most optimal wind turbine is identified (factors such as meteorological data, price and financing options, guarantees and maintenance costs, etc. must be considered).

The applicant indicated that they are considering a number of different wind turbines, however, due to various reasons, a developer does not want to reveal the actual WTG that they may consider, whether for commercial/economic reasons, possible Non-Disclosure Agreements etc. As the noise propagation modelling requires the details of a wind turbine, the applicant requested that the assessment considers a potential worst-case scenario, using a WTG with a maximum sound power emission level ("SPL") of 112.2 dBA (re 1 pW), as well as the SPL of a quieter WTG with an SPL of 107.1 dBA (re 1 pW).

It is important to note that the exact details of the actual WTG are irrelevant to noise analysis, as the major factors that determine the noise levels are:

- The layout of the WEF (which would include the number of WTG as well as the distance from various receptors); and
- The sound power emission levels ("SPL") of the WTG (or noise source) selected/that the developer is considering.

Minor factors in the noise levels are:

- The spectral characteristics of the WTG;
- Temperature and Humidity;
- Noise abatement technologies implemented by the manufacturer;
- Topography and wind shear effects;
- The hub height of the WTG nacelle (the declared SPL level already include this factor, modelling using different hub height than the level specified by the manufacturer does have a slight influence on the calculated noise levels at a receptor location);
- Ground surface characteristics.

Factors that do influence SPL are:

- The rotor diameter of the WTG (the declared SPL level already include this factor);
- The manufacture of the WTG, the model name or number (the declared SPL level already include this factor).

The sound power emission levels are provided by the manufacturer either as the apparent SPL, maximum warranted SPL, a calculated SPL (for new WTG where the noise levels were not previously measured) or measured sound power levels as reported in terms of IEC 61400-11 or IEC 61400-14. It is unique for each make and model and the sound power levels already include the effect of the hub height, rotor diameter and abatement technologies.

There are smaller WTG with higher SPL, with larger WTG with a lower SPL. Therefore, the generating capacity, hub height or rotor diameter of the potential WTG should not be used to assume the noise levels.

Therefore, due to these factors, the total generating capacity of the WEF project may be less or more, when considering the individual generating capacity of the WTG (used for this noise specialist study) as well as the number of WTG in the layout. This however will not influence the findings of this noise specialist study.

2.4 STUDY AREA

The proposed Koup 1 WEF and associated infrastructure will be located within the Beaufort West Local Municipality, in the Central Karoo District Municipality, Western Cape Province. A project focus area ("PFA") was defined up to 2,000m from the WTG of the WEF, with the PFA further described in terms of environmental components that may contribute to or change the sound character in the area.

2.4.1 Topography

The Environmental Potential Atlas of South Africa (van Riet, 1998) [**141**] describes the topography as mainly *"extremely irregular plains"* within the PFA. The proposed WTG will be situated at approximately 950 – 1,050 meters above sea level ("mamsl"). There are little natural features that could act as noise barriers considering practical distances at which sound from a WTG may propagate.

2.4.2 Surrounding Land Use

Land use is mostly agricultural activities (game and sheep farming) and wilderness areas (including eco-tourism). 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.

2.4.3 Transportation Networks

The N12 pass the proposed WEF on the east (see **Figure 2-2**), though traffic on this road is low and will not influence ambient sound levels within the PFA. There are a number of small access roads leading from the N12, mainly to serve the farmers in the area. Traffic volumes on the small access roads are low and will be of no acoustical significance.

2.4.4 Other industries and mines

Based on a desktop assessment as well as information gained during the site visits, there are no industries and mines located within the PFA that would impact on the ambient sound levels in the area.

2.4.5 Ground conditions and vegetation

The area falls within the Nama Karoo biome (van Riet, 1998) [**141**] with most of the area well vegetated.

Taking into consideration available information it is the opinion of the author that the ground conditions (when considering acoustic propagation on a ground surface) can be classified as medium. 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. For modelling purposes, a ground surface factor of:

- 50% medium-hard ground (ground surface slightly acoustically absorbent) for modelling purposes for the construction phase.
- 75% hard ground (which implies that it is not very acoustically absorbent) used for the operational phase for modelling purposes (as recommended by the Institute of Acoustics ("IOA"), 2013) [**65**] for wind projects.

2.4.6 Potential Noise-sensitive Receptors

Potential noise-sensitive developments, receptors and communities ("NSR") were identified using tools such as Google Earth® up to a distance of 2,000m (recommendation SANS 10328:2008) from WTG locations. The statuses of these structures (see also **Figure 2-2**) were verified during the site visit in June 2021, with a list of the closest NSR presented in **Appendix F, Table 1**.

Also indicated on **Figure 2-2** are generalized 500, 1 000 and 2 000 m buffer zones. Generally, noises from wind turbines:

- could be significant within 500 m, with receptors[3] staying within 500 m from operational WTG subject to noises at a potentially sufficient level to be considered disturbing;
- are normally limited to a distance of approximately 1,000m from operational wind turbines (subject to WTG layout, as the WTG cumulatively contribute to noise levels with 2,000m from WTG). Night-time ambient sound levels could be elevated and the potential noise impact measurable; and
- likely to be audible up to a distance of 2,000m at night. Noises from the WTG are of a low concern at distances greater than 2,000m, although the sound of the WTGs may be audible at greater distances during certain metrological phenomena (sound levels are generally very low at distances greater than 2,000m).

[3] Depending on the layout as well as the specific sound power emission levels of the selected wind turbine.

2.5 ENVIRONMENTAL SENSITIVITY – NOISE THEME

The project site was assessed in terms of the Noise Sensitivity Theme using the online Environmental Screening Tool[4].

Potential noise-sensitive areas with a "very high" sensitivity were obtained from the online screening tool using the *Utilities Infrastructure => Electricity => Generation => Renewable => Wind* category, with the potential noise-sensitive areas illustrated on **Figure 2-3**. The screening report generated for the category *Utilities Infrastructure => Electricity => Generation => Renewable => Wind* does stipulate:

- that a Noise Specialist Study should be appended to the EIA, and
- that the GNR320 Assessment Protocol be followed when doing the noise impact assessment.

2.6 COMMENTS RECEIVED DURING THE EIA

The author is not aware of any comments raised by the authorities or interested and affected parties at the date this report was compiled.

2.7 TERMS OF REFERENCE

This assessment considers the requirements of GNR320 of 2020 (see **sub-section 2.7.1**) as well as SANS 10328:2008 (see **sub-section 2.7.2**).

2.7.1 Requirements as per Government Gazette 43110 of March 2020

The Department of Forestry, Fisheries and Environment ("DFFE") also promulgated Regulation 320, dated 20 March 2020 as published in Government Gazette No. 43110. The Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation would be applicable to this project.

This regulation defines the requirements for undertaking a site sensitivity verification, specialist assessment and the minimum report content requirements for environmental impact where a specialist assessment is required but no protocol has been prescribed. It requires that the current land use be considered using the national web based environmental

[4] https://screening.environment.gov.za/screeningtool/#/pages/welcome

screening tool to confirm the site sensitivity available at: https://screening.environment.gov.za.

If an applicant intending to undertake an activity identified in the scope of this protocol for which a specialist assessment has been identified on the screening tool on a site identified as being of:

- "very high" sensitivity for noise, must submit a Noise Specialist Assessment; or
- "low" sensitivity for noise, must submit a Noise Compliance Statement.

On a site where the information gathered from the site sensitivity verification differs from the designation of "very high" sensitivity on the screening tool and it is found to be of a "low" sensitivity, a Noise Compliance Statement must be submitted.

On a site where the information gathered from the initial site sensitivity verification differs from the designation of "low" sensitivity on the screening tool and it is found to be of a "very high" sensitivity, a Noise Specialist Assessment must be submitted.

If any part of the proposed development footprint falls within an area of "very high" sensitivity, the assessment and reporting requirements prescribed for the "very high" sensitivity apply to the entire footprint excluding linear activities for which noise impacts are associated with construction activities only and the noise levels return to the current levels after the completion of construction activities, in which case a compliance statement applies. In the context of this protocol, development footprint means the area on which the proposed development will take place and includes any area that will be disturbed.

The minimum requirements for a Noise Specialist Study (i.t.o. GNR 320 of 2020) are also covered in **Section 1** in the form of a checklist.

This assessment will be comprehensive and a Noise Specialist Assessment will be submitted because there may be a number of potential noise-sensitive receptors living within 2 000 m from the proposed Project.

2.7.2 Requirements as per South African National Standards ("SANS")

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

In addition, SANS 10328:2008 (Edition 3) [**116**] 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 EIA purposes. These minimum requirements are:

a) the purpose of the investigation (see **section 2.1**);
b) a brief description of the planned development or the changes that are being considered (see **section 2.2**);
c) a brief description of the existing environment including, where relevant, the topography, surface conditions and meteorological conditions during measurements (see **section 2.4 and 4**);
d) the identified noise sources together with their respective sound pressure levels or sound power levels (or both) and, where applicable, the operating cycles, the nature of sound emission, the spectral composition and the directional characteristics (see **sections 5** and **7**);
e) the identified noise sources that were not taken into account and the reasons as to why they were not investigated (see **sections 5, 7 and 8**);
f) the identified noise-sensitive developments and the noise impact on them (see **section 2.4.6, 9 and 10**);
g) where applicable, any assumptions, made with regard to any calculations or determination of source and propagation characteristics (see **section 8**);
h) an explanation, either by a brief description or by reference, of all measuring and calculation procedures that were followed, as well as any possible adjustments to existing measuring methods that had to be made, together with the results of calculations (see **section 7 and 8**);
i) an explanation, either by description or by reference, of all measuring or calculation methods (or both) that were used to determine existing and predicted rating levels, as well as other relevant information, including a statement of how the data were obtained and applied to determine the rating level for the area in question (see **section 4, 7 and 9**);
j) the location of measuring or calculating points in a sketch or on a map (see **Figure 9-4**);
k) quantification of the noise impact with, where relevant, reference to the literature consulted and the assumptions made (see **section 9**);
l) alternatives that were considered and the results of those that were investigated (see **section 10.4**);
m) a list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation (see **section 2.6**);

n) 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 (see **section 2.6**);
o) conclusions that were reached (see **section 13**);
p) proposed recommendations (see **section 13**);
q) 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 (see **section 11 and 13**); and
r) any follow-up investigation which should be conducted at completion of the project as well as at regular intervals after the commissioning of the project so as to ensure that the recommendations of this report will be maintained in the future (see **section 13**).

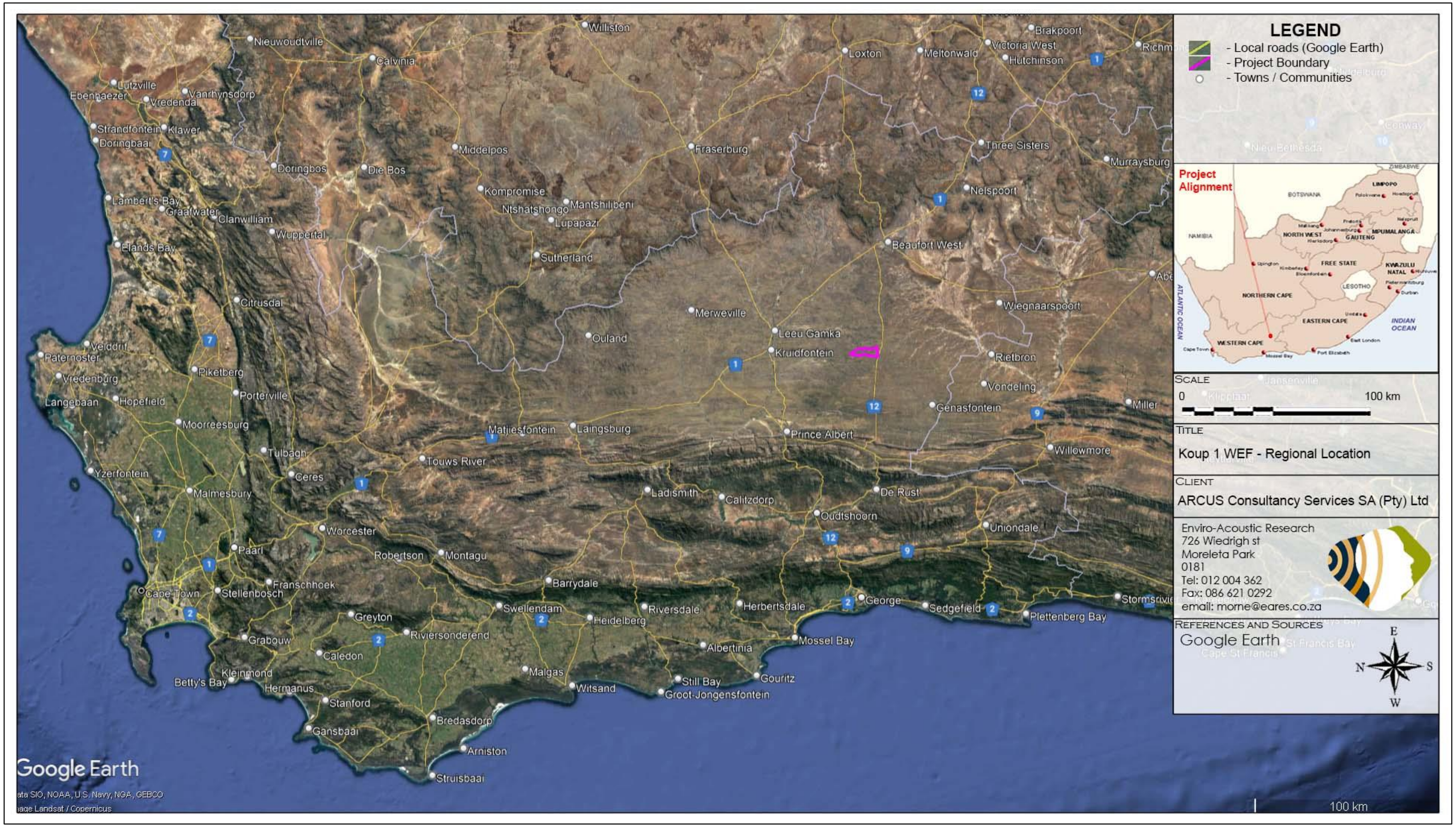

Figure 2-1: Regional Location of the proposed Koup 1 WEF

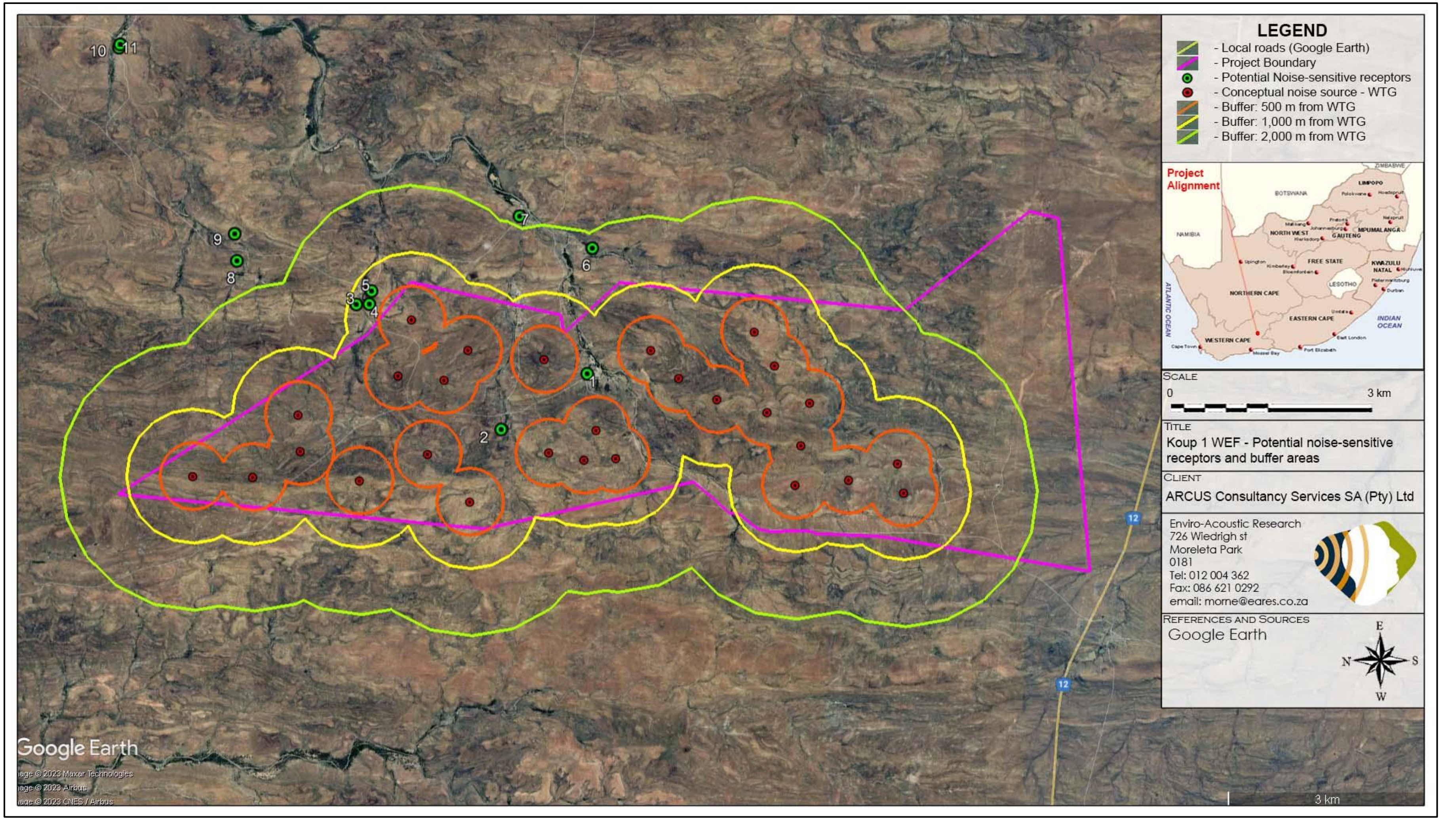

Figure 2-2: Study area and potential noise-sensitive receptors within the PFA of the Koup 1 WEF

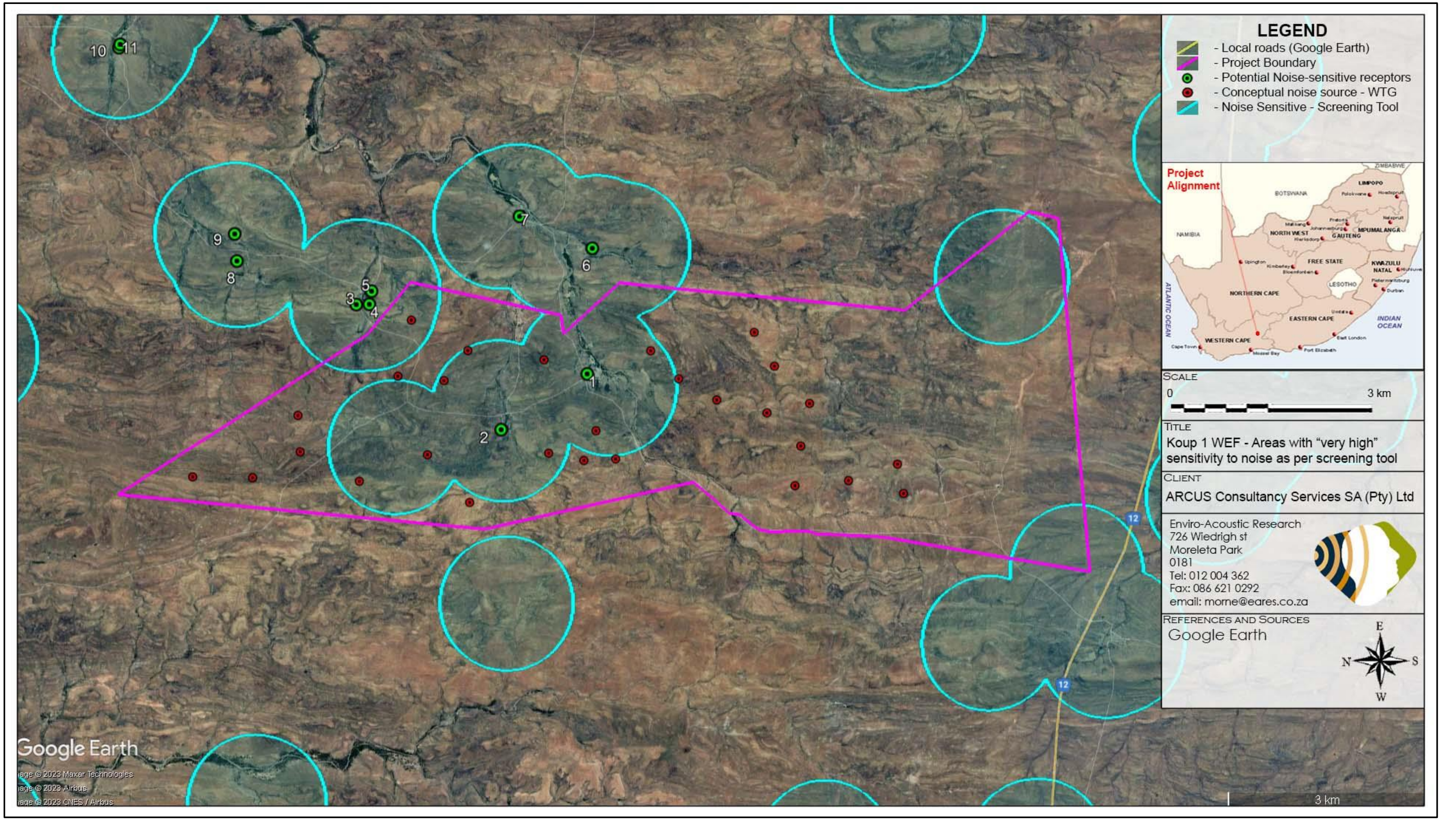

Figure 2-3: Study area and potential noise-sensitive areas identified by the online screening tool

3 LEGAL CONTEXT, POLICIES AND GUIDELINES

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

The environmental rights contained in section 24 of the Constitution provide that everyone is entitled to an environment that is not harmful to his or her well-being. In the context of noise, this requires a determination of what level of noise is harmful to well-being. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic, which has led to the development of noise standards (see **Section 3.4**).

"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.

3.2 THE ENVIRONMENT CONSERVATION ACT (ACT 73 OF 1989)

The Environment Conservation Act ("ECA") allows the Minister of Environment, Forestry and Fisheries to make regulations regarding noise, among other concerns. See also **section 3.2.1**.

3.2.1 National Noise Control Regulations (GN R154 of 1992)

The Noise Control Regulations ("NCR") were promulgated in terms of section 25 of the ECA. The NCRs were revised under Government Notice Number R. 55 of 14 January 1994 to make it obligatory for all authorities to apply the regulations.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996 legislative responsibility for administering the noise control regulations was devolved to provincial and local authorities. Provincial noise control regulations exist in the Free State, Gauteng and Western Cape provinces.

3.2.2 Western Cape Provincial Noise Control Regulations (PN 200 of 2013)

The control of noise in the Western Cape is legislated in the form of the Noise Control Regulations in terms of Section 25 of the Environment Conservation Act No. 73 of 1989, applicable to the Province of the Western Cape as Provincial Notice 200 of 20 June 2013.

The regulations define:

- "**ambient noise**" means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes".

- "**disturbing noise**" means a noise, excluding the unamplified human voice, which—
- *(a)* exceeds the rating level by 7 dBA;
- *(b)* exceeds the residual noise level where the residual noise level is higher than the rating level;
- *(c)* exceeds the residual noise level by 3 dBA where the residual noise level is lower than the rating level; or
- *(d)* in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103;

- **''noise sensitive activity''** means any activity that could be negatively impacted by noise, including residential, healthcare, educational or religious activities;

- **''low-frequency noise''** means sound which contains sound energy at frequencies predominantly below 100 Hz;

- **''rating level''** means the applicable outdoor equivalent continuous rating level indicated in Table 2 of SANS 10103;

- **''residual noise''** means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise. In this report the term ambient sound level (instead of Residual Noise) will be used, as defined in the National Noise Control Regulations;

- **"sound level''** means the equivalent continuous rating level as defined in SANS 10103, taking into account impulse, tone and night-time corrections;

- These Regulations prohibits anyone from causing a disturbing noise (Clause 2) and uses the $L_{Aeq,impulse}$ descriptor to define ambient sound and noise levels.

Also, in terms of regulation 4:

(1) The local authority, or any other authority responsible for considering an application for a building plan approval, business license approval, planning approval or environmental authorisation, may instruct the applicant to conduct and submit, as part of the application—

(a) a noise impact assessment in accordance with SANS 10328 to establish whether the noise impact rating of the proposed land use or activity exceeds the appropriate rating level for a particular district as indicated in SANS 10103; or

(b) where the noise level measurements cannot be determined, an assessment, to the satisfaction of the local authority, of the noise level of the proposed land use or activity.

(2) *(a)* A person may not construct, erect, upgrade, change the use of or expand any building that will house a noise-sensitive activity in a predominantly commercial or industrial area, unless he or she insulates the building sufficiently against external noise so that the sound levels inside the building will not exceed the appropriate maximum rating levels for indoor ambient noise specified in SANS 10103.

(b) The owner of a building referred to in paragraph *(a)* must inform prospective tenants or buyers in writing of the extent to which the insulation measures contemplated in that paragraph will mitigate noise impact during the normal use of the building.

(c) Paragraph *(a)* does not apply when the use of the building is not changed.

(3) Where the results of an assessment undertaken in terms of sub regulation (1) indicate that the applicable noise rating levels referred to in that sub regulation will likely be exceeded, or will not be exceeded but will likely exceed the existing residual noise levels by 5 dBA or more—

(a) the applicant must provide a noise management plan, clearly specifying appropriate mitigation measures to the satisfaction of the local authority, before the application is decided; and

(b) implementation of those mitigation measures may be imposed as a condition of approval of the application.

(4) Where an applicant has not implemented the noise management plan as contemplated in sub regulation (3), the local authority may instruct the applicant in writing to—

(a) cease any activity that does not comply with that plan; or

(b) reduce the noise levels to an acceptable level to the satisfaction of the local authority.

3.3 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 any facility to prevent noise pollution occurring. NEMA sets out measures, which may be regarded as reasonable. They include the following 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 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 the pollution or degradation
5. to eliminate any source of the pollution or degradation
6. to remedy the effects of the pollution or degradation

In addition, a number of regulations have been promulgated as Regulation 982 of December 2014 (Government Notice 38282) in terms of this Act. It defines minimum information requirements for specialist reports, with Government Gazette ("GG") 43110 (20 March 2020) updating the minimum requirements for reporting, with this protocol referred as GNR320 of 2020.

GNR320 prescribe general requirements for undertaking site sensitivity verification and for protocols for the assessment and minimum report content requirements of environmental impacts for environmental themes for activities requiring environmental authorisation. These protocols were promulgated in terms of sections 24(5)(a), (h) and 44 of the NEMA.

When the requirements of a protocol apply, the requirements of Appendix 6 of the Environmental Impact Assessment Regulations, as amended, (EIA Regulations), promulgated under sections 24(5) and 44 of the NEMA are replaced by these requirements.

3.4 NOISE STANDARDS

There are a few South African scientific standards ("SABS") relevant to noise from developments, industry and roads. They are:

- SANS 10103:2008. 'The measurement and rating of environmental noise with respect to annoyance and to speech communication' [**113**].
- SANS 10210:2004. 'Calculating and predicting road traffic noise' [**115**].
- SANS 10328:2008. 'Methods for environmental noise impact assessments' [**116**].
- SANS 10357:2004. 'The calculation of sound propagation by the Concave method' [**117**].

- SANS 10181:2003. 'The Measurement of Noise Emitted by Road Vehicles when Stationary' [**114**].

The relevant standards use the equivalent continuous rating level (calculated from the sound pressure levels over the reference time, see **Appendix A**) 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. With regards to SANS 10103:2008, the recommendations are likely to inform decisions by authorities, but non-compliance with the standard will not necessarily render an activity unlawful *per se.*

3.5 INTERNATIONAL GUIDELINES

While a number of international guidelines and standards exists, those selected below are used by numerous countries for environmental noise management.

3.5.1 Guidelines for Community Noise (WHO, 1999) [146]

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 [**146**]. It is based on the document entitled "Community Noise" that was prepared for the WHO and published in 1995 by the Stockholm University and Karolinska Institute.

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

- Interference with communication, noise-induced hearing impairment, sleep disturbance effects, cardiovascular and psychophysiological effects, mental health effects, effects on performance, annoyance responses and effects on social behavior.

It further discusses how noise can affect (and propose guideline noise levels) specific environments such as residential dwellings, schools, preschools, hospitals, ceremonies, festivals and entertainment events, sounds through headphones, impulsive sounds from toys, fireworks and firearms, and parklands and conservation areas.

To protect the majority of people from being affected by noise during the daytime, it proposes that sound levels at outdoor living areas should not exceed 55 dB L_{Aeq} for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the day, the outdoor sound pressure level should not exceed 50 dB L_{Aeq}. At night, equivalent sound levels at the outside façades of the living spaces should not exceed 45 dBA and 60 dBA L_{Amax} so that people may sleep with bedroom windows open. It is critical to note that this guideline requires the sound level measuring instrument to be set on the "fast" detection setting.

3.5.2 Night Noise Guidelines for Europe (WHO, 2009) [147]

Refining previous Community Noise Guidelines issued in 1999, and incorporating more recent research, the WHO has released a comprehensive report on the health effects of night time noise, along with new (non-mandatory) guidelines for use in Europe (WHO, 2009) [**147**]. Rather than a maximum of 30 dB inside at night (which equals 45-50 dB max outside), the WHO now recommends a maximum year-round outside night-time noise average of 40 db to avoid sleep disturbance and its related health effects. The report notes that only below 30 dB (outside annual average) are "*no significant biological effects observed*," and that between 30 and 40 dB, several effects are observed, with the chronically ill and children being more susceptible; however, "*even in the worst cases the effects seem modest*." Elsewhere, the report states more definitively, "*There is no sufficient evidence that the biological effects observed at the level below 40 dB (night, outside) are harmful to health*." At levels over 40 dB "*Adverse health effects are observed*" and "*many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected*."

The 184-page report offers a comprehensive overview of research into the various effects of noise on sleep quality and health (including the health effects of non-waking sleep arousal), and is recommended reading for anyone working with noise issues. The use of an outdoor noise standard is in part designed to acknowledge that people do prefer to leave windows open when sleeping, though the year-long average may be difficult to obtain (it would require longer-term sound monitoring than is usually budgeted for by either industry or neighbourhood groups).

While recommending the use of the average level, the report notes that some instantaneous effects occur in relation to specific maximum noise levels, but that the health effects of these "cannot be easily established."

3.5.3 The Assessment and Rating of Noise from Wind Farms (Energy Technology Support Unit, 1997)

This report describes the findings of a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry (ETSU, 1997) [**42**]. It was developed as an Energy Technology Support Unit[5] ("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 are more appropriate;
2. $L_{A90,10mins}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels;
3. The effects of other wind turbines in a given area[6] should be added to the effect of any proposed Wind Farm ("WF"), to calculate the cumulative effect;
4. Noise from a WF should be restricted to no more than 5 dBA above the current ambient noise level at a Noise Sensitive Receptor(s) ("NSR"). Ambient noise levels are 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 35 dBA to 40 dBA (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 NSR has financial investments in the WF; and
6. A penalty system should be implemented for wind turbine/s that operates with a tonal characteristic.

While this guideline may be 25 years old, planning policy in England, Scotland, Wales and Northern Ireland still refer to the ETSU-R97 for guidance on the assessment of wind turbine noise (Cooper, 2020) [**22**], (EPA, 2011) [**41**], (IOA, 2013) [**65**], (The Scottish Government, 2011) [**131**], (UK Department for Communities and Local Government, 2013) [**134**]. In Australia and New Zealand, ETSU-R-97 has been adopted as the base assessment method of assessment (Cooper, 2020) [**22**], (EPA, 2009) [**40**]. The ETSU-R97 is referenced in

[5] 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.

[6] Though the area has not been defined, it is the opinion of the author that this would be withing the potential area of effect, defined as 2,000m in SANS 10328:2008. Considering that WTG from two adjacent WEFs may have a slight influence at 2,000m, this area typically would be a maximum of 4,000m from two or more WEFs

NARUC (2011) [**89**] as well as the recommended method in IFC (2015) [**64**]. Because of its international importance, the methodologies used in the ETSU R97 document will be considered in this report for implementation should projected noise levels (from the proposed WFs at NSR) exceed the zone sound levels as recommended by SANS 10103:2008.

3.5.4 Noise Guidelines for Wind Farms (MoE, 2008) [87]

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 ECA 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 3-1**[7]
- 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;
    - Prediction methods to be used (ISO 9613-2);
    - Cumulative impact assessment requirements;
    - It also defines specific model input parameters;
    - Methods on how the results must be presented; and
    - Assessment of Compliance (defining magnitude of noise levels).

Table 3-1: 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 a WF), this criterion will be considered during the determination of the significance of the noise impact.

[7]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

3.5.5 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 Equator Principles were developed by private sector banks and were launched in June 2003. Revision III of the EPs has been in place since June 2013. As of March 2021, 116 financial institutions in 37 countries have officially adopted the Equator Principles, covering the majority of international project finance debt in emerging and developed markets.

The participating banks chose to model the Equator Principles on the environmental standards of the World Bank (1999) and the social policies of the International Finance Corporation ("IFC"). As of beginning 2022:

- More than 90 banks and financial institutions have voluntarily adopted the Equator Principles, which are based on IFC's Performance Standards[8].
- 32 export credit agencies of the Organization of Economic Co-operation and Development countries benchmark private sector projects against IFC's Performance Standards.
- The Multilateral Investment Guarantee Agency applies IFC's Performance Standards in its operations.
- The World Bank applies IFC's Performance Standards (known as World Bank Performance Standards) to projects supported by International Bank for Reconstruction and Development ("IBRD") and the International Development Association ("IDA") that are owned, constructed and/or operated by the private sector.

3.5.6 IFC: General EHS Guidelines – Environmental Noise Management [63]

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

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8 https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/performance-standards

Document 1.7[9] of the IFC: General EHS Guidelines states that noise prevention and mitigation measures should be applied where predicted or measured noise impacts from project facilities/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 source. It goes as far as to proposed 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 minimize 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 3-2**) and highlights certain monitoring requirements pre- and post-development. It adds another criterion in that the existing background ambient noise level should not rise by more than 3 dBA. This criterion will effectively sterilize large areas of any development. Therefore, it is EARE's considered opinion that this criterion was introduced to address cases where the existing ambient noise level is already at, or in excess of the recommended limits.

9 https://www.ifc.org/wps/wcm/connect/4a4db1c5-ee97-43ba-99dd-8b120b22ea32/1-7%2BNoise.pdf?MOD=AJPERES&CVID=nPtgwZY

Table 3-2: 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 $L_{Aeq,1hr}$ noise descriptors to define noise levels. It does not determine the detection period, but refers to the IEC standards, which requires the fast detector setting on the Sound Level Meter during measurements in Europe.

3.5.7 European Parliament Directive 2000/14/EC [36]

Directive 2000/14/EC relating to the noise emission in the environment by equipment for use outdoors was adopted by the European Parliament and the Council and first published in May 2000 and applied from 3 January 2002. The directive placed sound power limits on equipment to be used outdoors in a suburban or urban setting. Failure to comply with these regulations may result in products being prohibited from being placed on the EU market. Equipment list is vast and includes machinery such as compaction machineries, dozers, dumpers, excavators, etc. Manufacturers as a result started to consider noise emission levels from their products to ensure that their equipment will continue to have a market in most countries.

3.5.8 Environmental, Health, and Safety Guidelines for Wind Energy [64]

The EHS Guidelines for wind energy include information relevant to environmental, health, and safety aspects of onshore and offshore wind energy facilities. It should be applied to wind energy facilities from the earliest feasibility assessments, as well as from the time of the environmental impact assessment, and continue to be applied throughout the construction and operational phases.

It provides a brief overview of construction and operational noises, potential operational mitigation measures and a number of principles on the assessment of noise impacts, including:

- Receptors should be chosen according to their environmental sensitivity (human, livestock, or wildlife);
- Preliminary modeling should be carried out to determine whether more detailed investigation is warranted. The preliminary modeling can be as simple as assuming hemispherical propagation (i.e., the radiation of sound, in all directions, from a source point). Preliminary modeling should focus on sensitive receptors within 2,000 meters (m) of any of the turbines in a wind energy facility;

- If the preliminary model suggests that turbine noise at all sensitive receptors is likely to be below an L_{A90} of 35 dBA at a wind speed of 10 meters/second (m/s) at 10 m height during day and night times, then this preliminary modeling is likely to be sufficient to assess noise impact; otherwise it is recommended that more detailed modeling be carried out, which may include background ambient noise measurements;
- All modeling should take account of the cumulative noise from all wind energy facilities in the vicinity having the potential to increase noise levels;
- If noise criteria based on ambient noise are to be used, it is necessary to measure the background noise in the absence of any wind turbines. This should be done at one or more noise-sensitive receptors. Often the critical receptors will be those closest to the wind energy facility, but if the nearest receptor is also close to other significant noise sources, an alternative receptor may need to be chosen; and
- The background noise should be measured over a series of 10-minute intervals, using appropriate wind screens. At least five of these 10-minute measurements should be taken for each integer wind speed from cut-in speed to 12 m/s.

3.5.9 Environmental Noise Guidelines for the European Region (2018) [148]

This document identifies levels at which noise has “adverse health effects” and recommends actions to reduce exposure. Compared to previous WHO guidelines on noise, this version contains five significant developments:

- Stronger evidence of the cardiovascular and metabolic effects of environmental noise;
- Inclusion of new noise sources, namely wind turbine noise and leisure noise, in addition to noise from transportation (aircraft, rail, and road traffic);
- Use of a standardized approach to assess the evidence;
- A systematic review of evidence, defining the relationship between noise exposure and risk of adverse health outcomes;
- Use of long-term average noise exposure indicators to better predict adverse health outcomes.

The WHO (2018) considers adverse health effects in **section 2.4.3.2** of the report, dividing these effects into the following health outcomes:

- Cardiovascular disease – Ischaemic heart disease and hypertension;
- Cognitive impairment – Reading and oral comprehension;
- Permanent hearing impairment; and
- Self-reported sleep disturbance and annoyance.

While the WHO (2018) highlights that there is insufficient evidence of adverse health effects at noise levels below 40 dBA L_{night}, adverse health effects were reported at levels starting from 40 dB L_{night}. At 40 dB, about 3–4% of the population still reported being highly sleep-disturbed due to noise, which was considered relevant to health. It recommends that the guideline level should minimise adverse health effects to less than:

- 3% of the population experiencing sleep disturbances; and
- 10% of the population being highly annoyed.

This report recommends, that, for average noise exposure, the WHO Guideline Development Group conditionally recommends reducing noise levels produced by wind turbines below 45 dB L_{den}[10], as wind turbine noise above this level is associated with adverse health effects.

3.5.10 Concluding remarks on the use of International Guidelines in this Assessment

As highlighted in **section 6.4**, South African guidelines (such as SANS 10103:2008) or regulations (such as GNR.154 of 1992 or PN.200 of 213), does not cater for instances when background noise levels change due to the impact of external forces (such as the influence of increased winds). As such this report considers both local legislation, regulations and guidelines as well as international guidelines. Of the more than 340,000 WTG operation in the rest of the world (more than 2,000 wind farms[11]), less than 500 WTG are currently operational in South Africa (less than 40 wind farms[12]). The rest of the world have had experience with the effects and impacts of wind farms since 1980, South Africa since 2002.

As such, almost all the scientific articles, papers, publications and presentations available are based on the research and experiences gained from these international wind farms. Therefore, discarding the knowledge and experiences gained by the rest of the world would be irresponsible and unwise. In summary:

- The WHO Guidelines for Community Noise recommends that night-time equivalent sound levels (at the outside façades of the living spaces) not exceed 45 dBA with L_{Amax} less than 60 dBA so that people may sleep with bedroom windows open **(Section 3.5.1)**;

[10] *Day–evening–night noise level is a European standard to express noise level over an entire day. It imposes a penalty on sound levels during evening and night and it is primarily used for noise assessments of airports, busy main roads, main railway lines and in cities over 100,000 residents. This equates to a night-time equivalent noise level of approximately 38.7 dBA.*
[11] *https://gwec.net/there-are-over-341000-wind-turbines-on-the-planet-heres-how-much-of-a-difference-theyre-actually-making/*
[12] *https://sawea.org.za/wind-map/wind-ipp-table/*

- The Night Noise Guidelines for Europe revised noise levels, recommending a maximum year-round outside night-time noise average of 40 dB to avoid sleep disturbance and its related health effects **(Section 3.5.2)**;
- The ETSU-R97 guideline recommends an upper noise limit of 45 dBA for project participants, and a noise limit of 40 dBA for external parties **(Section 3.5.3)**;
- The MoE guideline propose a changing noise limit at different wind speeds for wind farm developments, varying from 40 dBA (at a wind speed of 4 m/s) to a maximum of 51 dBA (at a wind speed of 10 m's or more) **(Section 3.5.4)**;
- The environmental standards of the World Bank have been integrated into the social policies of the IFC since April 2007, with the guidelines recommending a night-time noise limit of 45 dBA **(Section 3.5.6)**;
- The European Directives does not set noise limits, but it obligate equipment manufacturers to define and indicate the sound power emission levels of their equipment. When presented with a number of equipment options, applicants can use this data to select the quietest piece of equipment, in such to minimize noise levels **(Section 3.5.7)**;
- While the IFC EHS Guidelines for Wind Energy does not stipulate specific noise limits, it does recommend the measurement of ambient sound levels at different speeds (referring to the ETSU-R97 guidelines discussed in **Section 3.5.3** should noise criteria based on ambient sound levels be used **(Section 3.5.8)**; and
- The Environmental Noise Guidelines for the European Region report recommends that, for average noise exposure, noise levels produced by wind turbines should remain below 45 dBA L_{den} (an L_{Aeq} of ± 38.7 dBA at night) **(Section 3.5.9)**.

As WTGs only operate during a period with wind speeds are elevated, a period that generally coincide with increased noise levels (due to wind-induced noises – "WIN") this report recommends an upper noise limit of 45 dBA (focusing on the night-time period), at the same time considering the international recommended levels (as further motivated in **sections 6.4.1** and **6.4.3**) and summarized in **Table 6-2**.

4 CURRENT ENVIRONMENTAL SOUND CHARACTER

4.1 INFLUENCE OF SEASON 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) [**45**] 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.

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 higher wind speeds may have an insignificant 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 is more significant during the warmer spring and summer months as various species communicate in an effort to find mates. Faunal communication is normally less during the colder months, with ambient sound levels measured during the winter period frequently being very low.
- The occurrence of temperature inversions, see **Sub Section 4.1.1**, and
- Seasonal changes in weather patterns, mainly due to increased wind speeds (also see **Sub Section 4.1.2 4.1.1**below) and potential gustiness of the wind.

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 the sub-sections below.

Ambient sound levels are generally less during the colder months (due to less faunal communication) and higher during the warmer months.

4.1.1 Effect of Temperature inversions

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, but, during certain meteorological conditions, the normal vertical temperature gradient could be inverted so that the air is colder near the surface, with a warmer layer blanketing the lower layer. This is illustrated in **Figure 4-1** below.

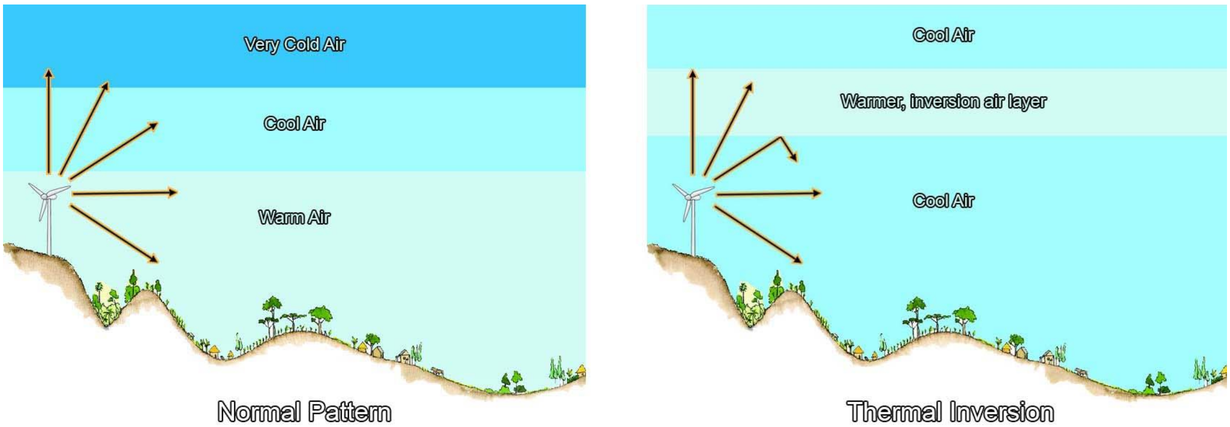

Figure 4-1: Influence of temperature inversions on the propagation of sound

When such an inversion layer is present, some of the sound waves will be refracted[13] by the temperature gradient, with the refracted sound waves returned to the ground. This effect has been noticed near airports and roads, where noises can be heard over greater distances at night than other times of day (Parnell, 2015, [**98**]; Saurenman, 2005, [**118**]), and reported by Van der Berg (2003) [**136**] for WEF noises.

Like wind gradients, temperature gradients can influence sound propagation over long distances, complicate sound level measurements as well as propagation modelling.

4.1.2 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

[13] Redirecting the wave propagation direction due to a change in the density of the air which influence the speed of sound.

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 conifers), 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).

4.1.3 Effect of Humidity and Temperature

Generally, sound propagate better at lower temperatures (down to 10^{o}C), and with everything being equal, a decrease in temperature from 32^{o}C to 10^{o}C could increase the sound level at a listener 600 m away by ±2.5 dB (at 1,000 Hz).

The effect of humidity on sound propagation is quite complex, but effectively relates to how increased humidity 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^{o}C).

Together, the impact of temperature and humidity (together with air pressure - to a minor extent) are complex and highly dependent on the frequency composition of the noise. This is illustrated in **Figure 4-2**.

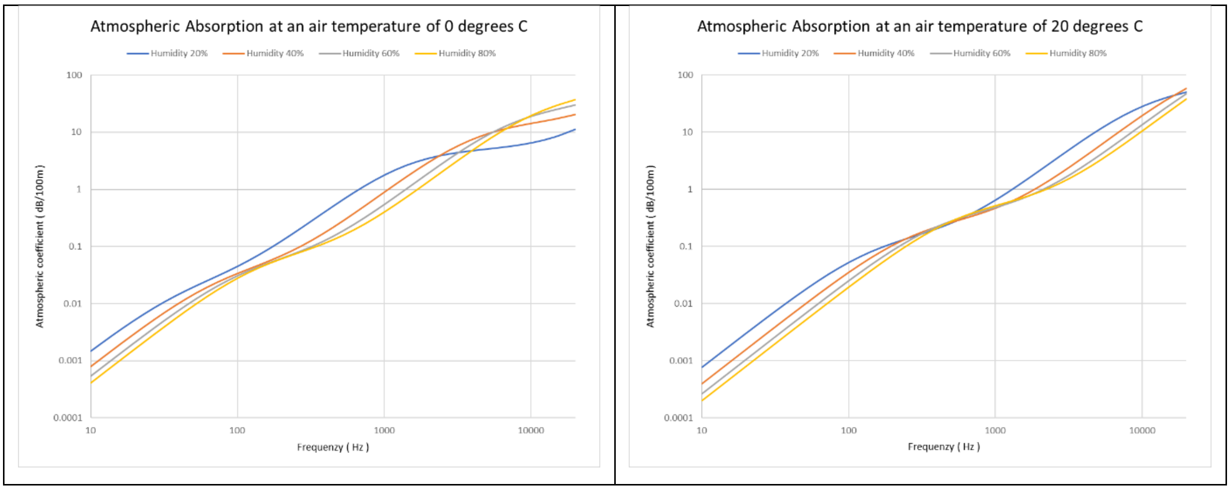

Figure 4-2: Effect of Temperature and Humidity on propagation of Sound

4.2 TEMPERATURE AND HUMIDITY MEASUREMENTS

Temperature and humidity were measured during the site visit from 10 to 12 June 2021, with the average, maximum and minimum readings defined in **Table 4-1** with the various readings illustrated in **Figure 4-3**.

For the purpose of modelling, average humidity of 70% and temperatures of 10 ^{o}C at an air pressure of 950 kPA will be used (parameters ideal for the propagation of noise, the worst-case scenario).

Table 4-1: Temperature and Humidity measured onsite

	Humidity	Temperature
Day average	38.3	16.5
Night average	44.7	11.8
Day minimum	25.0	9.2
Day maximum	59.0	26.7
Night minimum	34.0	9.5
Night maximum	57.0	13.5

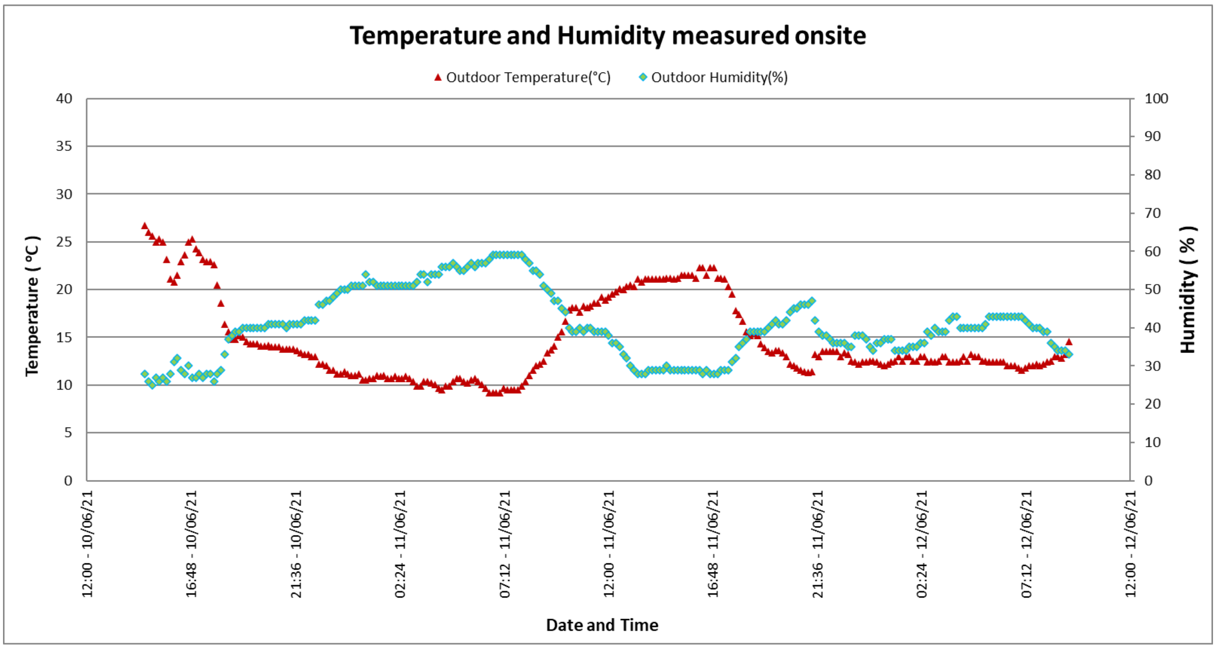

Figure 4-3: Temperature and Humidity readings measured onsite

4.3 SOUND MEASUREMENTS – PROCEDURE AND DATA

Ambient sound levels (residual noise levels) were measured at six locations over 35 hours from the afternoon of the 10th until the morning of the 12 June 2021 in the vicinity of the project focus area. The data indicate an area where ambient sound levels were low (typical of winter periods), though it should be noted that the period coincided with very low wind speeds.

Ambient sound levels (residual noise levels) were measured in accordance with the South African National Standard ("SANS") 10103:2008 "***The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication***". Long-term measurements were done over a period of 2 nights as per the protocols defined in GG 43110.

The guidelines and protocol define the procedures, minimum equipment accuracy and time periods (in which measurements must be collected) such as:

- type of equipment (Class 1) to be used;
- minimum duration of measurement as well as time periods when measurements must take place;
- microphone positions and height above ground level;
- calibration procedures and instrument checks; and
- supplementary weather measurements and observations.

The sound levels were measured using class-1 Sound Level Meters ("SLMs") with the measurement localities presented in **Figure 4-4**. The SLMs would measure "average" sound levels over 10-minute periods, save the data and start with a new 10-minute measurement till the instrument was stopped. The SLMs were referenced at 1,000 Hz directly before and after the measurements were taken. In all cases drift was less than 1.0 dBA.

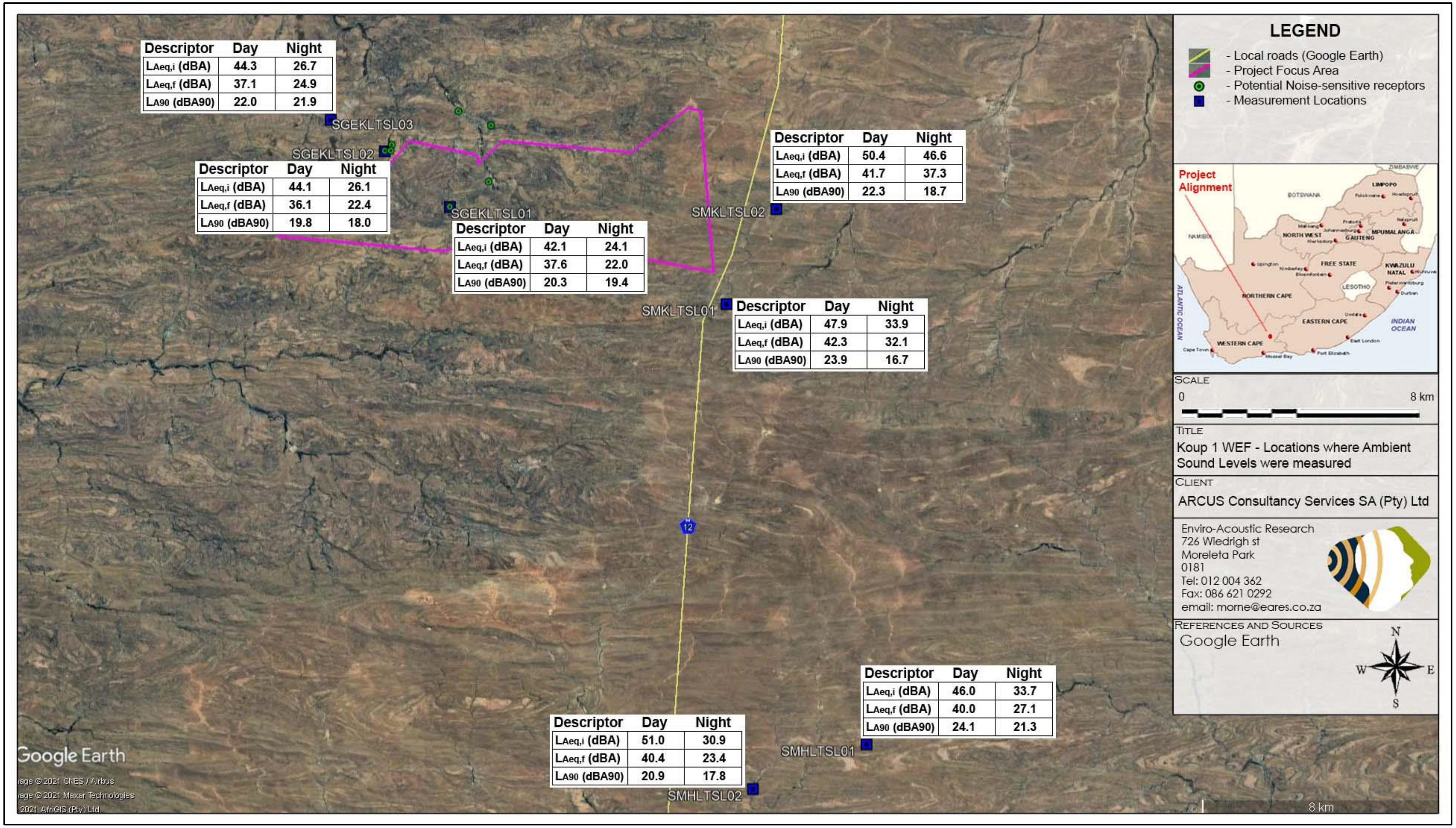

Figure 4-4: Localities where ambient sound levels were measured

4.3.1 Long-term Measurement Location SGEKLTSL01

The microphone was deployed in front of the residential dwelling, with some vegetation within 10 m of the microphone. This vegetation may increase Wind-induced Noises ("WIN") during periods of increased winds. The equipment defined in **Table 4-2** was used for gathering data with **Table 4-3** highlighting sounds heard during equipment deployment and collection. **Appendix E.1** presents photos of the measurement location.

Table 4-2: Equipment used to gather data at SGEKLTSL01

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34160	March 2021
Microphone	ACO 7052E & SV 12L	54645	March 2021
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-3: Noises/sounds heard during site visits at SGEKLTSL01

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • Barely Audible • Audible • Dominating	During equipment deployment and collection of instrument	
	Faunal and Natural	Bird calls dominant.
	Sounds associated with the household/ farm	-
	Industrial & transportation	-

Fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-5** and summarized in **Table 4-4** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-6**.

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.

The L_{A90} level is presented in this report to define the "background residual noise level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[14].

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-7** (night) and **Figure 4-8** (day).

Table 4-4: Sound levels considering various sound level descriptors at SGEKLTSL01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	30.4	26.1	20.3	-
Night arithmetic average	-	22.1	20.8	19.4	-
Day Equivalent Levels	-	42.1	37.6	-	-
Night Equivalent Levels	-	24.1	22.0	-	-
Day minimum	-	19.3	19.1	-	18.5
Day maximum	85.1	59.9	55.2	-	-
Night minimum	-	19.2	19.0	-	18.4
Night maximum	58.9	38.5	33.1	-	-
Day 1 equivalent	-	43.3	32.3	-	-
Night 1 Equivalent	-	24.0	22.8	-	-
Day 2 equivalent	-	36.1	29.3	-	-
Night 2 Equivalent	-	24.2	21.0	-	-
Day 3 equivalent	-	40.8	36.9	-	-

(14) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

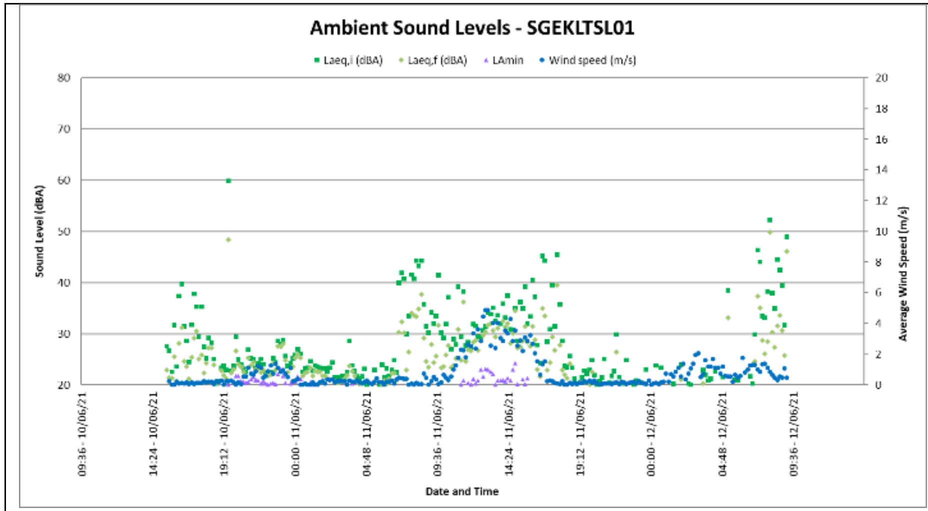

Figure 4-5: Ambient Sound Levels at SGEKLTSL01

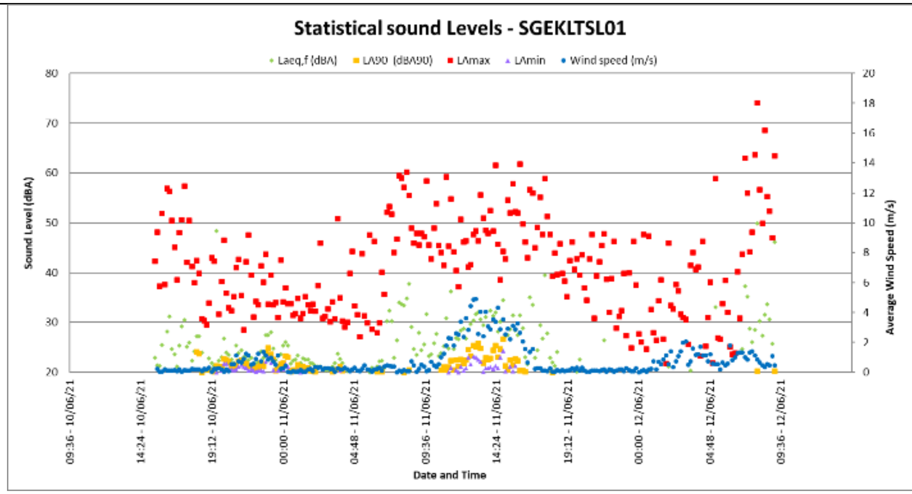

Figure 4-6: Maximum, minimum and Statistical sound levels at SGEKLTSL01

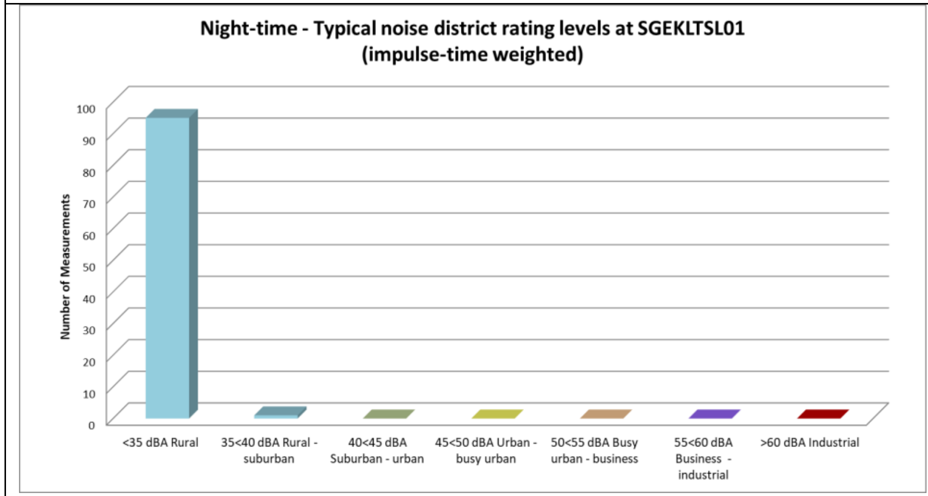

Figure 4-7: Classification of night-time measurements in typical noise districts at SGEKLTSL01

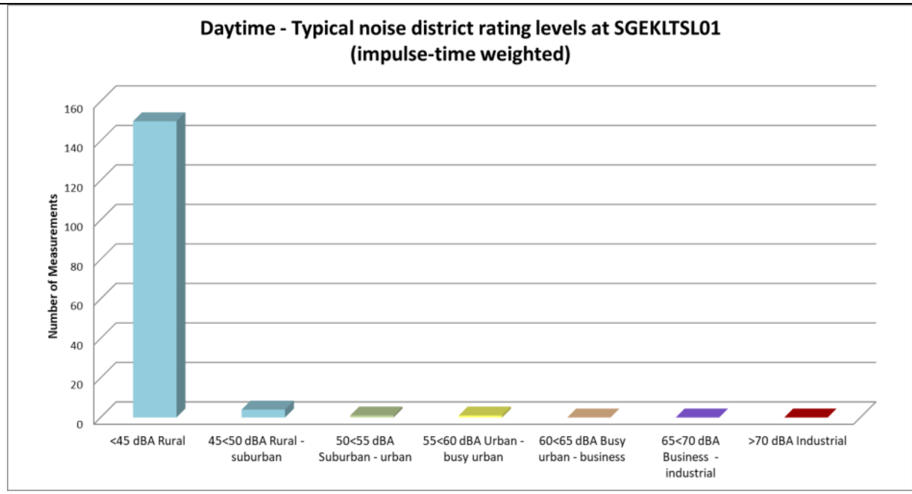

Figure 4-8: Classification of daytime measurements in typical noise districts at SGEKLTSL01

4.3.2 Long-Term Measurement Location - SGEKLTSL02

This measurement location was deployed close to a dwelling, reported to be renovated in the future for residential use. There were a significant number of large trees close to the microphone which may significantly influence WIN. The equipment defined in **Table 4-5** was used for gathering data with **Table 4-6** highlighting sounds heard during equipment deployment and collection. **Appendix E.2** presents photos of the measurement location.

Table 4-5: Equipment used to gather data at SGEKLTSL02

Equipment	Model	Serial no	Calibration Date
SLM	BSWA 308	589036	March 2020
Microphone and Pre-amplifier	MP231	570172	March 2020
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-6: Noises/sounds heard during site visits at SGEKLTSL02

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • Barely Audible • Audible • Dominating	During equipment deployment and collection of instrument	
	Faunal and Natural	Birds dominant.
	Sounds associated with the household/ farm	Sheep audible.
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-9** and summarized in **Table 4-7** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-10**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little

noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[15].

Table 4-7: Sound level descriptors as measured at SGEKLTSL02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	33.0	27.5	19.8	-
Night arithmetic average	-	21.8	19.5	18.0	-
Day Equivalent Levels	-	44.1	36.1	-	-
Night Equivalent Levels	-	26.1	22.4	-	-
Day minimum	-	18.5	17.4	-	16.7
Day maximum	72.1	54.4	55.2	-	-
Night minimum	-	18.1	17.1	-	16.6
Night maximum	61.7	41.6	37.3	-	-
Day 1 equivalent	-	38.8	29.3	-	-
Night 1 Equivalent	-	24.7	22.2	-	-
Day 2 equivalent	-	41.9	34.1	-	-
Night 2 Equivalent	-	27.1	22.5	-	-
Day 3 equivalent	-	40.0	31.7	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-11** (night) and **Figure 4-12** (day).

(15) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

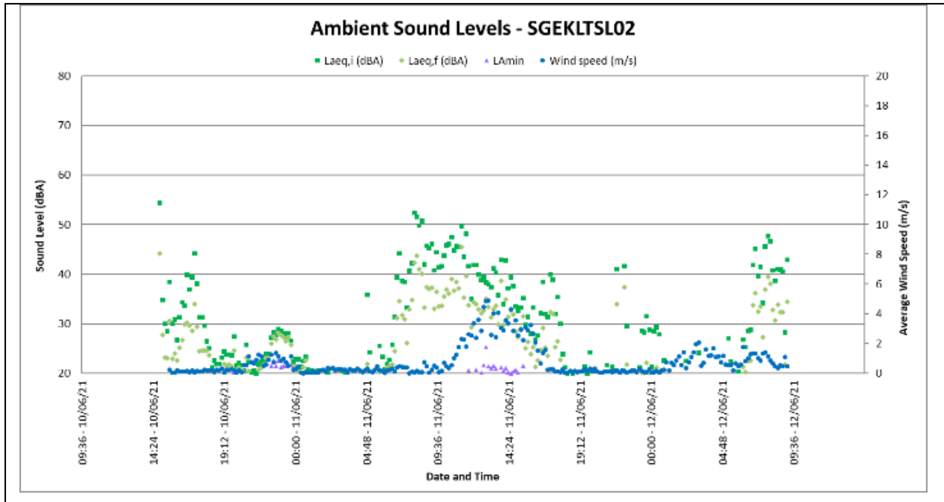

Figure 4-9: Ambient sound levels at SGEKLTSL02

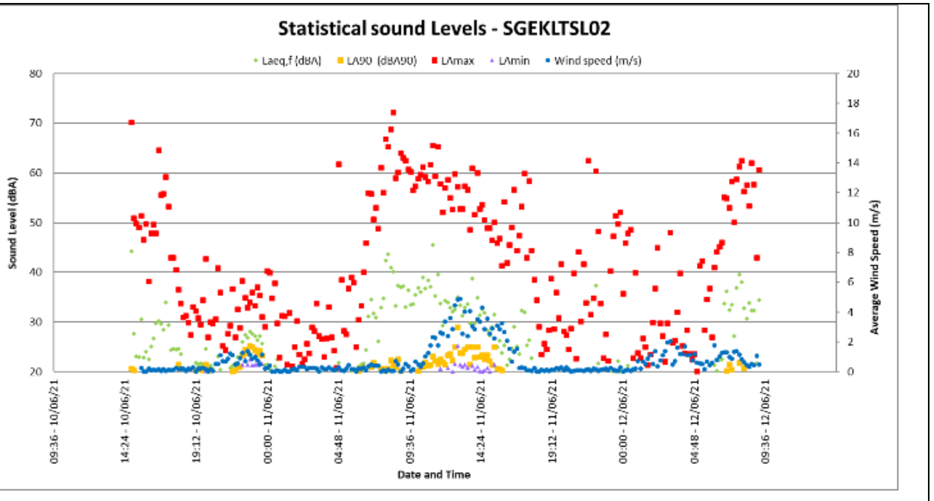

Figure 4-10: Maximum, minimum and statistical values at SGEKLTSL02

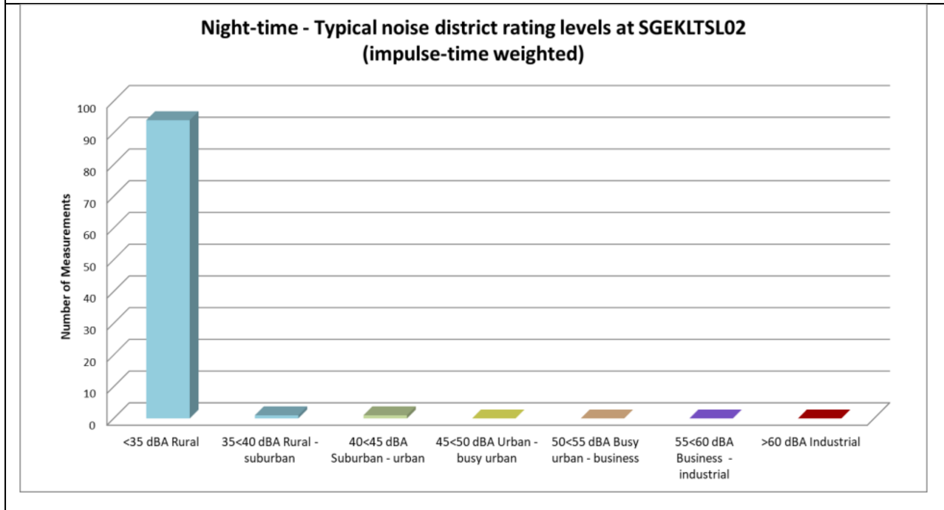

Figure 4-11: Classification of night-time measurements in typical noise districts at SGEKLTSL02

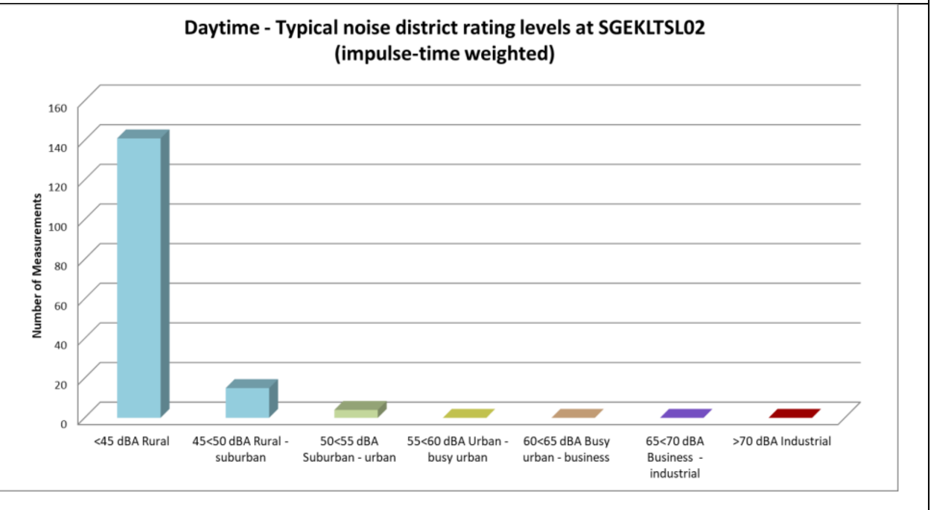

Figure 4-12: Classification of daytime measurements in typical noise districts at SGEKLTSL02

4.3.3 Long-term Measurement Location - SGEKLTSL03

The measurement location was located in an open area in front of the residential house, with some vegetation in the area. The owner confirmed that the house is mainly used over weekends. The equipment defined in **Table 4-8** was used for gathering data with **Table 4-9** highlighting sounds heard during equipment deployment and collection, with photos of this measurement location presented in **Appendix E.3**.

Table 4-8: Equipment used to gather data at SGEKLTSL03

Equipment	Model	Serial no	Calibration Date
SLM	SVAN 977	36176	January 2020
Microphone	ACO 7052E & SV 12L	49596	January 2020
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-9: Noises/sounds heard during site visits at SGEKLTSL03

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • Barely Audible • Audible • Dominating	**During equipment deployment and collection of instrument**	
	Faunal and Natural	Bird communication dominant.
	Sounds associated with the household/ farm	-
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-13** and summarized in **Table 4-10** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-14**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background residual noise level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little

noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[16].

Table 4-10: Sound levels considering various sound level descriptors at SGEKLTSL03

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	33.4	28.5	22.0	-
Night arithmetic average	-	25.2	23.5	21.9	-
Day Equivalent Levels	-	44.3	37.1	-	-
Night Equivalent Levels	-	26.7	24.9	-	-
Day minimum	-	22.6	21.3	-	20.4
Day maximum	76.8	53.2	55.2	-	-
Night minimum	-	21.4	21.0	-	20.3
Night maximum	52.4	35.3	33.4	-	-
Day 1 equivalent	-	37.1	28.9	-	-
Night 1 Equivalent	-	28.1	26.5	-	-
Day 2 equivalent	-	41.9	34.2	-	-
Night 2 Equivalent	-	24.6	22.4	-	-
Day 3 equivalent	-	40.5	34.0	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-15** (night) and **Figure 4-16** (day).

(16) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

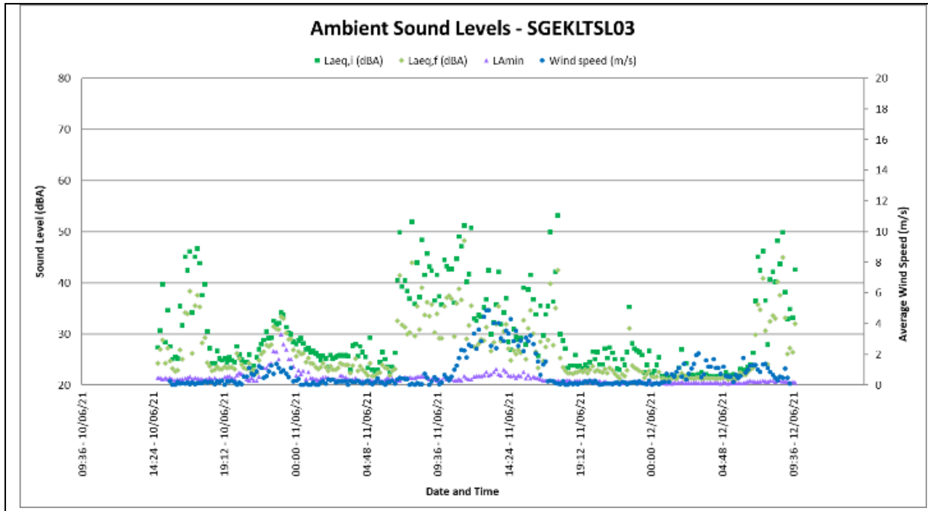

Figure 4-13: Ambient Sound Levels at SGEKLTSL03

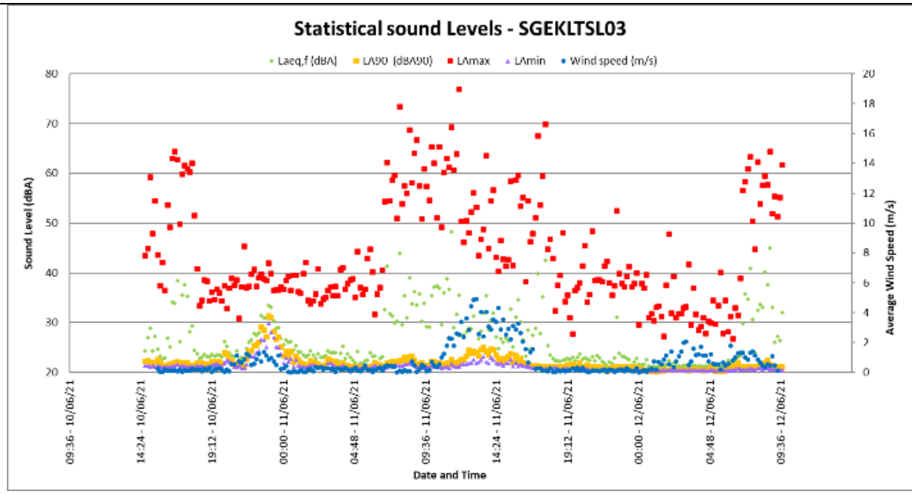

Figure 4-14: Maximum, minimum and Statistical sound levels at SGEKLTSL03

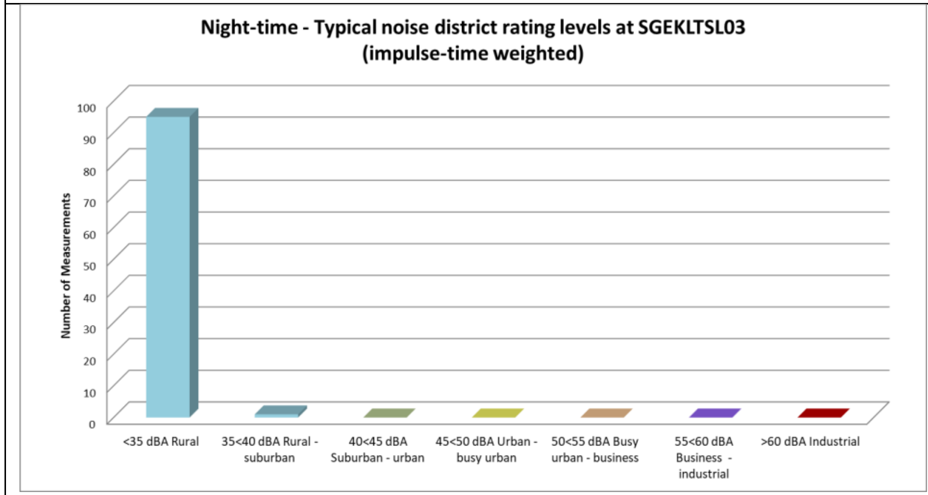

Figure 4-15: Classification of night-time measurements in typical noise districts at SGEKLTSL03

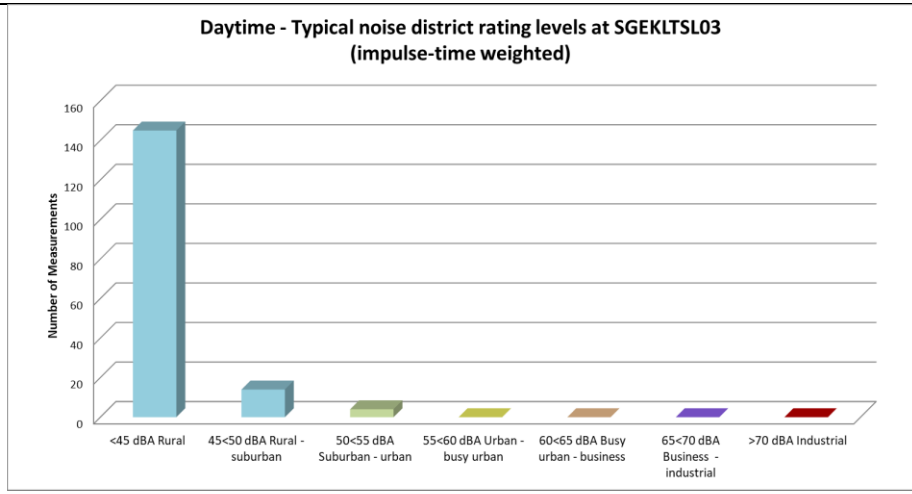

Figure 4-16: Classification of daytime measurements in typical noise districts at SGEKLTSL03

4.3.4 Long-term Measurement Location - SMKLTSL01

The instrument was deployed close to the residential dwelling of a farm worker. The ambient sound level measurements are representative of the area surrounding the small residence. The equipment defined in **Table 4-11** was used for gathering data with

Equipment	Model	Serial no	Calibration Date
SLM	NL-32	01182945	October 2020
Microphone	NH-21	28879	October 2020
Calibrator	Quest CA-22	J 2080094	June 2020

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

Table 4-12 highlighting sounds heard during equipment deployment and collection. **Appendix E.4** presents photos of the measurement location.

Table 4-11: Equipment used to gather data at SMKLTSL01

Equipment	Model	Serial no	Calibration Date
SLM	NL-32	01182945	October 2020
Microphone	NH-21	28879	October 2020
Calibrator	Quest CA-22	J 2080094	June 2020

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

Table 4-12: Noises/sounds heard during site visits at SMKLTSL01

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • **Barely Audible** • **Audible** • **Dominating**	**During equipment deployment and collection of instruments**	
	Faunal and Natural	Birds audible.
	Sounds associated with the household	Geese clearly audible and dominant at times. Voices of people at guest house just audible, with voices not influencing measurements.
	Industrial & transportation	Road traffic noises audible and dominant during passing. Road traffic noises did influence the measurements.

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-17** and summarized in **Table 4-13** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-18**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background residual noise level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[17].

Table 4-13: Sound levels considering various sound level descriptors at SMKLTSL01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	40.9	37.1	23.9	-
Night arithmetic average	-	28.8	27.0	16.7	-
Day Equivalent Levels	-	47.9	42.3	-	-
Night Equivalent Levels	-	33.9	32.1	-	-
Day minimum	-	21.0	20.0	-	14.4
Day maximum	66.5	55.4	55.2	-	-
Night minimum	-	14.9	14.7	-	14.0
Night maximum	58.6	41.3	39.3	-	-
Day 1 equivalent	-	36.0	31.9	-	-
Night 1 Equivalent	-	31.4	29.7	-	-
Day 2 equivalent	-	45.7	39.9	-	-
Night 2 Equivalent	-	35.5	33.6	-	-
Day 3 equivalent	-	43.9	38.6	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-19** (night) and **Figure 4-20** (day).

(17) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

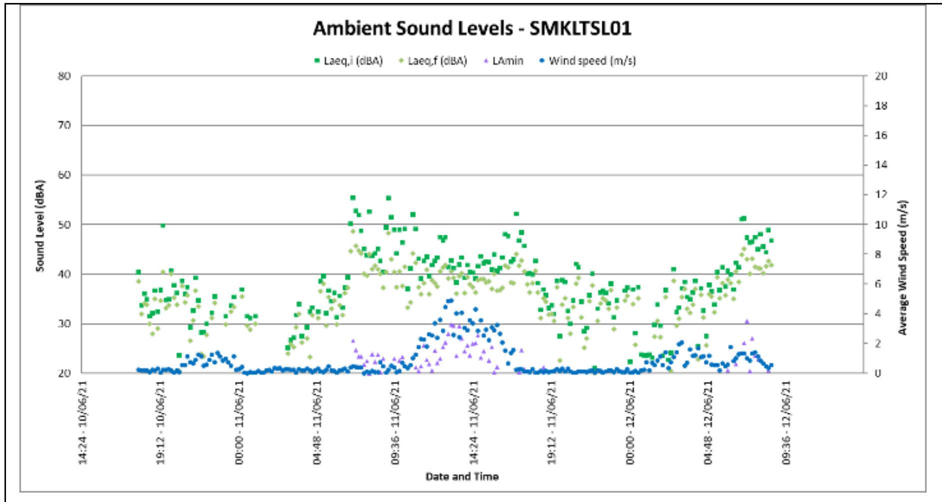

Figure 4-17: Ambient Sound Levels at SMKLTSL01

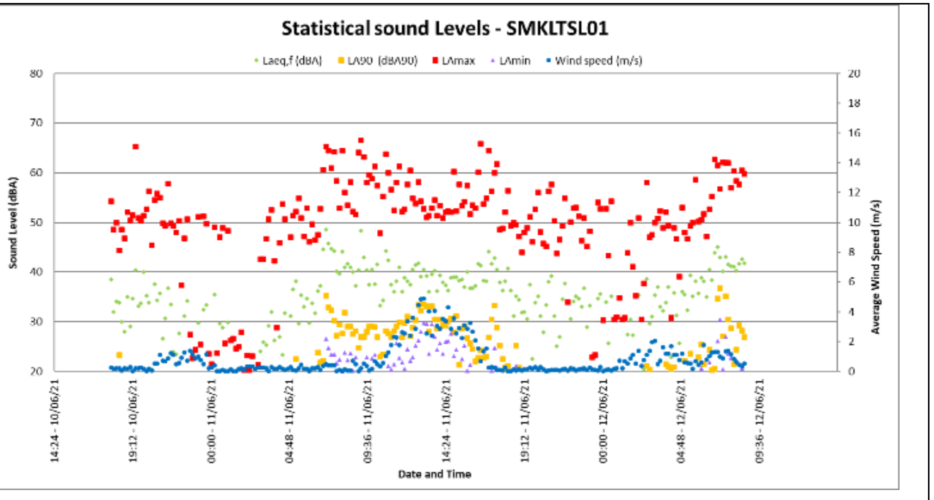

Figure 4-18: Maximum, minimum and Statistical sound levels at SMKLTSL01

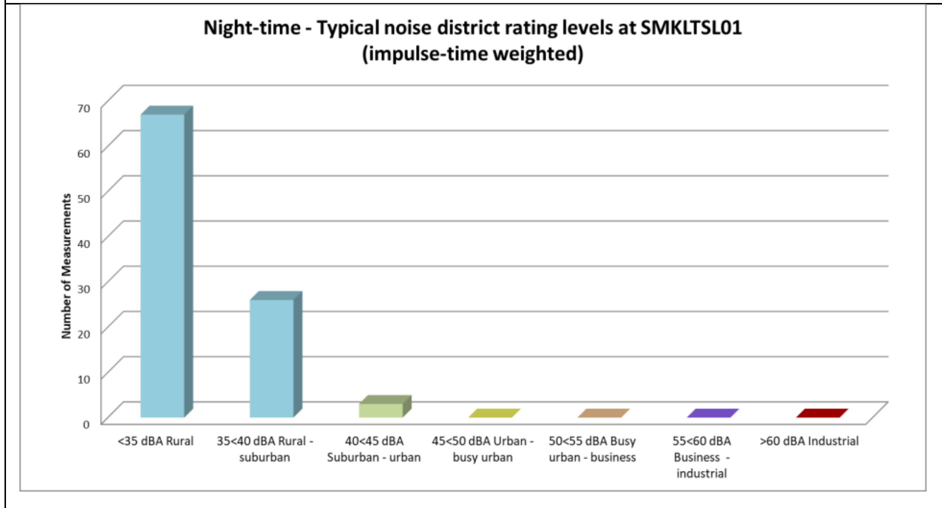

Figure 4-19: Classification of night-time measurements in typical noise districts at SMKLTSL01

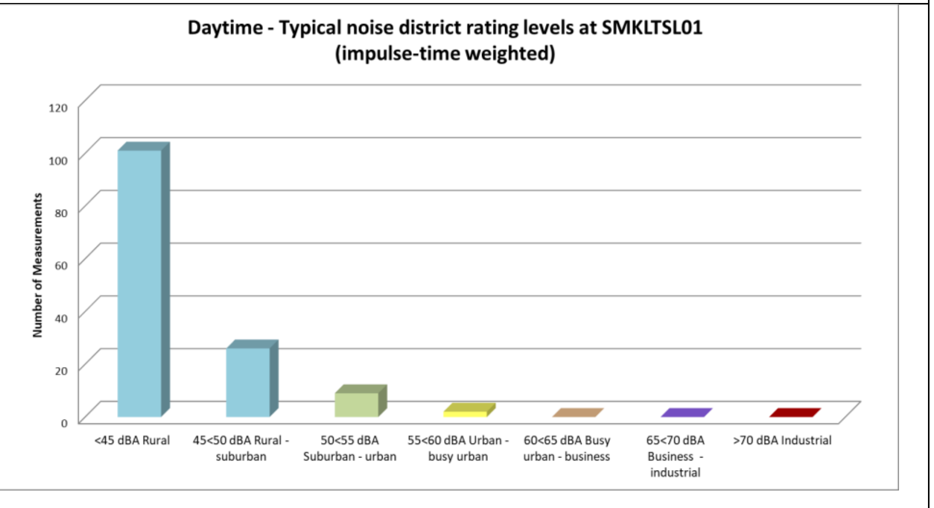

Figure 4-20: Classification of daytime measurements in typical noise districts at SMKLTSL01

4.3.5 Long-term Measurement Location - SMKLTSL02

The measurement location was deployed in an open area near the residence of a farm worker. There is very little vegetation near the microphone. The equipment defined in **Table 4-14** was used for gathering data with **Table 4-15** highlighting sounds heard during equipment deployment and collection, with photos of this measurement location presented in **Appendix E.5**.

Table 4-14: Equipment used to gather data at SMKLTSL02

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34849	October 2018
Microphone and Pre-amplifier	ACO 7052E & SV 12L	33077	October 2018
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-15: Noises/sounds heard during site visits at SMKLTSL02

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • Barely Audible • Audible • Dominating	**During equipment deployment and collection of instruments**	
	Faunal and Natural	Birds dominant noise.
	Sounds associated with the household	Dog barking in area (audible to significant).
	Industrial & transportation	Road noises audible during passing.

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-21** and summarized in **Table 4-16** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-22**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little

noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

Maximum noise level exceeded 65 dBA at least 1 time the second night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[18].

Table 4-16: Sound levels considering various sound level descriptors at SMKLTSL02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	37.2	33.8	22.3	-
Night arithmetic average	-	28.2	26.3	18.7	-
Day Equivalent Levels	-	50.5	41.7	-	-
Night Equivalent Levels	-	46.6	37.3	-	-
Day minimum	-	19.1	18.8	-	18.2
Day maximum	86.9	64.3	55.2	-	-
Night minimum	-	18.9	18.7	-	18.2
Night maximum	86.5	66.3	56.4	-	-
Day 1 equivalent	-	47.2	38.5	-	-
Night 1 Equivalent	-	30.0	28.2	-	-
Day 2 equivalent	-	49.7	40.6	-	-
Night 2 Equivalent	-	49.6	40.1	-	-
Day 3 equivalent	-	43.0	35.3	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-23** (night) and **Figure 4-24** (day).

(18) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

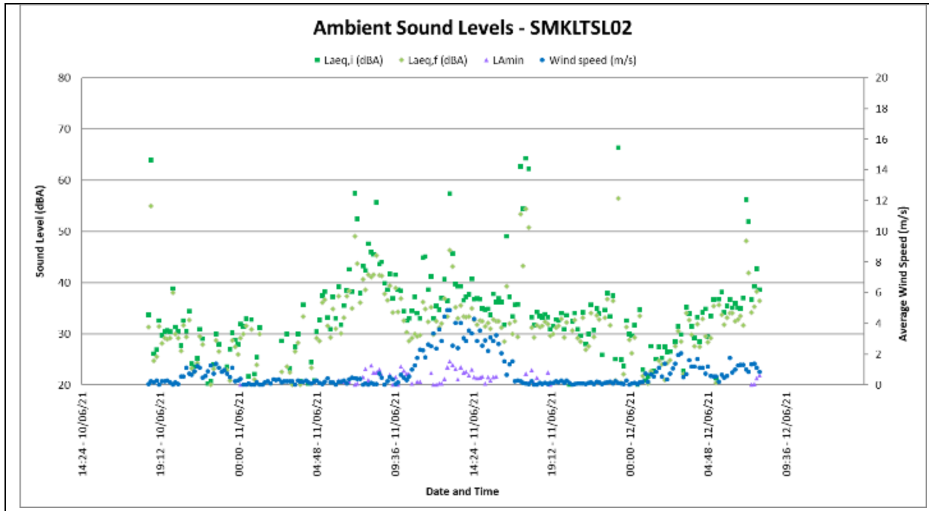

Figure 4-21: Ambient Sound Levels at SMKLTSL02

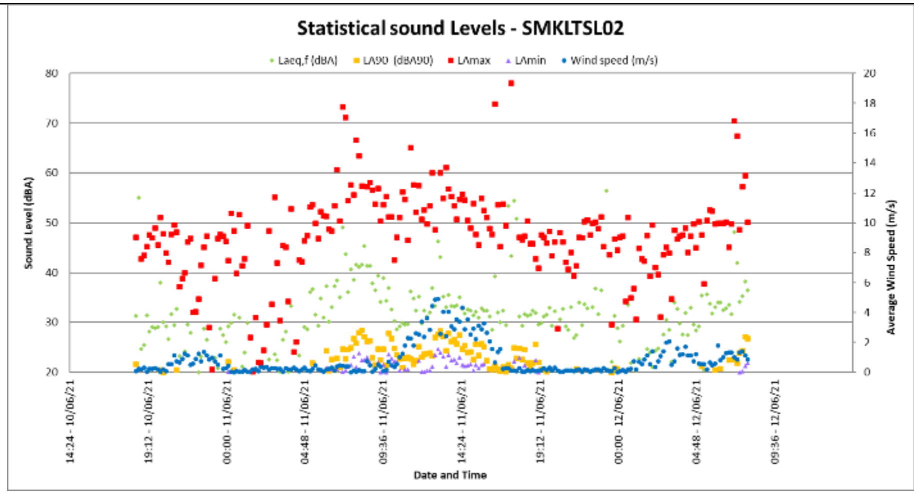

Figure 4-22: Maximum, minimum and Statistical sound levels at SMKLTSL02

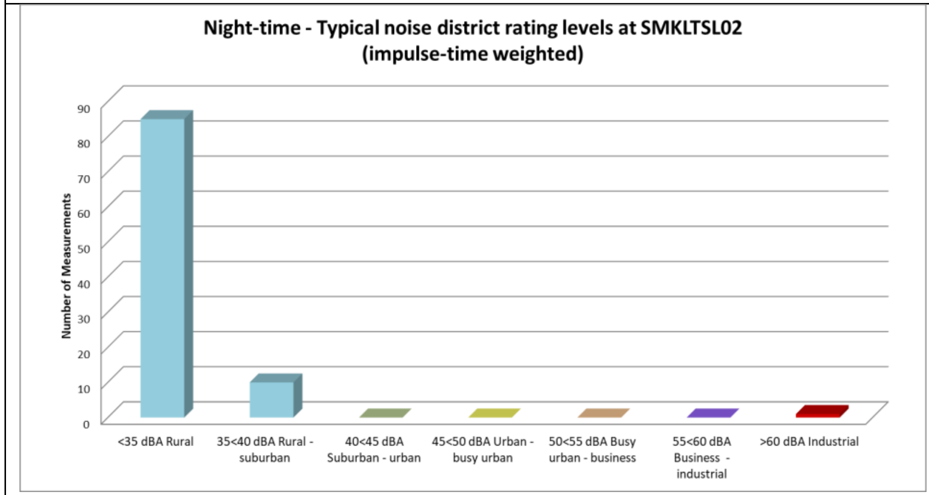

Figure 4-23: Classification of night-time measurements in typical noise districts at SMKLTSL02

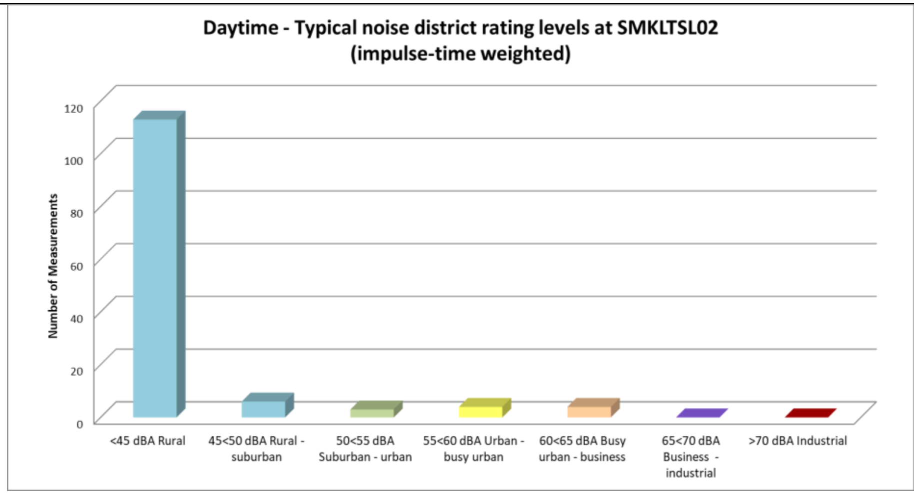

Figure 4-24: Classification of daytime measurements in typical noise districts at SMKLTSL02

4.3.6 Long-term Measurement Location - SMHLTSL01

The measurement location was located in front of the house, with significant vegetation close to the microphone. There were peacocks in the area, which would at times result in high noise levels. The equipment defined in **Table 4-17** was used for gathering data with **Table 4-18** highlighting sounds heard during equipment deployment and collection. **Appendix E.6** presents photos of the measurement location.

Table 4-17: Equipment used to gather data at SMHLTSL01

SLM	Svan 955	27637	October 2020
Microphone and Pre-amplifier	ACO 7052E & SV 12L	52437	October 2020
Calibrator	Quest CA-22	J 2080094	June 2020
SLM	Svan 955	27637	October 2020

Table 4-18: Noises/sounds heard during site visits at SMHLTSL01

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • Barely Audible • Audible • Dominating	**During equipment deployment and collection of instruments**	
	Faunal and Natural	Birds audible and dominant.
	Sounds associated with the household	Dogs barking in area.
	Industrial & transportation	-

Fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-25** and summarized in **Table 4-19** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-26**.

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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

Maximum noise level exceeded 65 dBA at least 1 time the first night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[19].

Table 4-19: Sound levels considering various sound level descriptors at SMHLTSL01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	34.4	29.1	24.1	-
Night arithmetic average	-	19.4	16.2	21.3	-
Day Equivalent Levels	-	46.0	40.0	-	-
Night Equivalent Levels	-	33.7	27.1	-	-
Day minimum	-	12.1	8.6	-	3.2
Day maximum	73.6	51.3	55.2	-	-
Night minimum	-	11.3	7.2	-	3.2
Night maximum	77.7	52.3	45.5	-	-
Day 1 equivalent	-	32.4	26.6	-	-
Night 1 Equivalent	-	36.5	29.5	-	-
Day 2 equivalent	-	42.4	37.6	-	-
Night 2 Equivalent	-	23.3	21.3	-	-
Day 3 equivalent	-	43.6	36.2	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-27** (night) and **Figure 4-28** (day).

(19) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

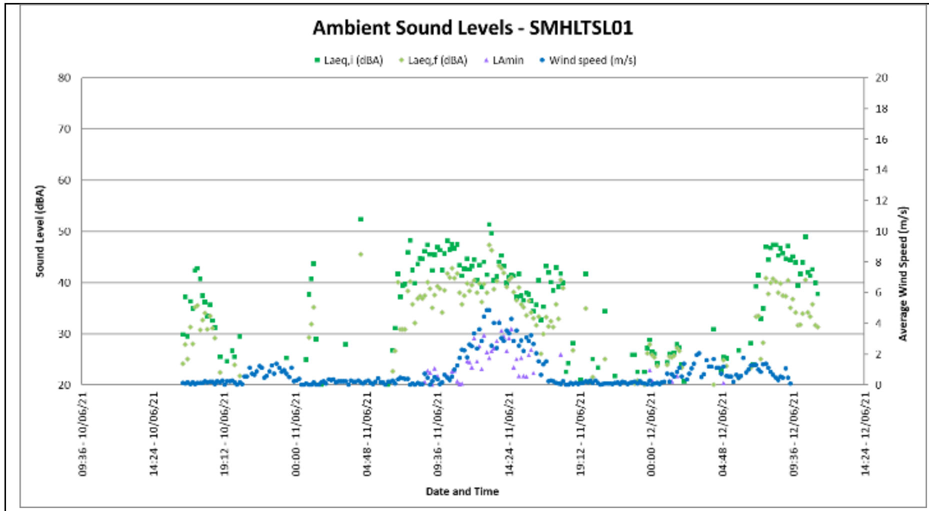

Figure 4-25: Ambient Sound Levels at SMHLTSL01

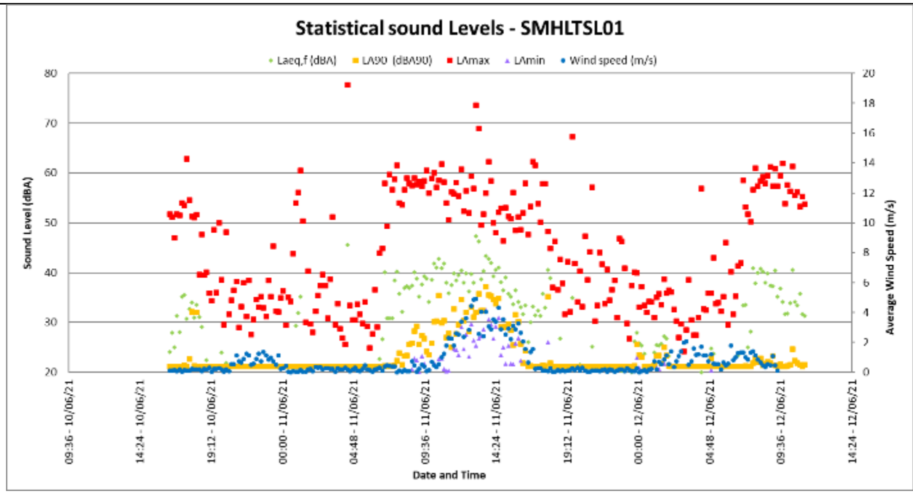

Figure 4-26: Maximum, minimum and Statistical sound levels at SMHLTSL01

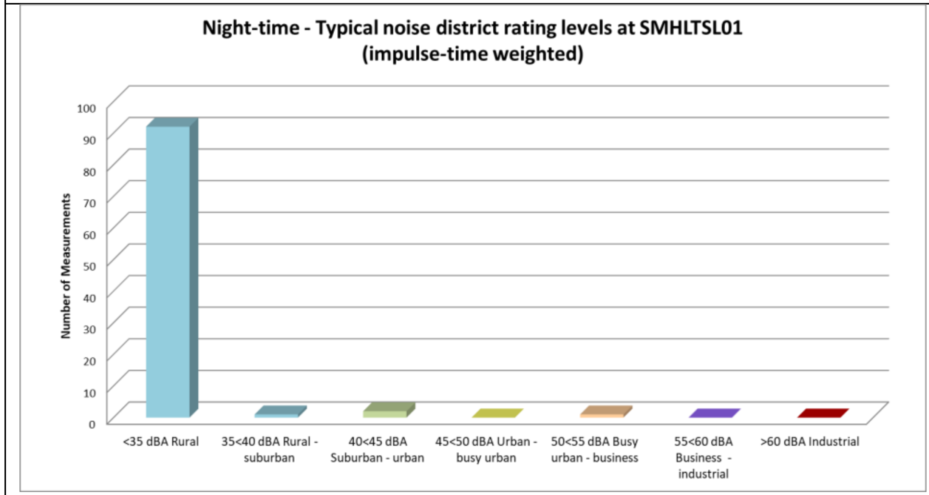

Figure 4-27: Classification of night-time measurements in typical noise districts at SMHLTSL01

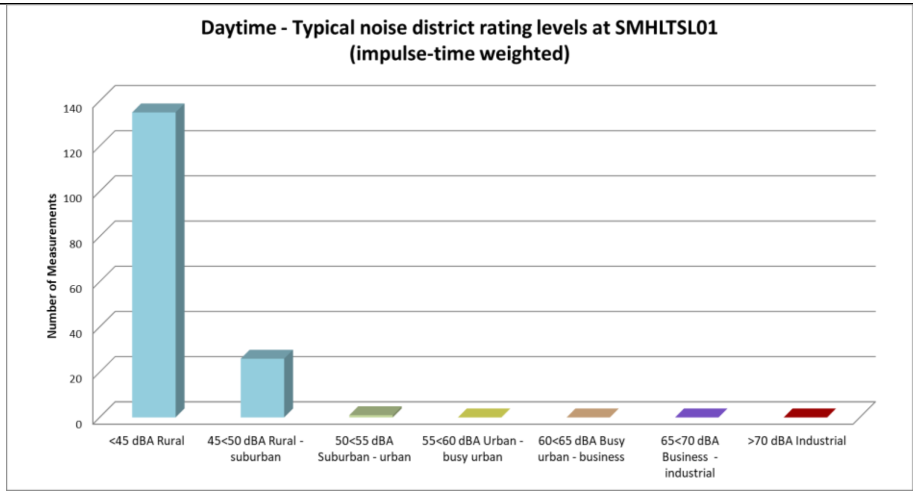

Figure 4-28: Classification of daytime measurements in typical noise districts at SMHLTSL01

4.3.7 Long-term Measurement Location - SMHLTSL02

The measurement location was located in an open area close to residential dwellings. There is significant vegetation in the areas. The equipment defined in **Table 4-20** was used for gathering data with **Table 4-21** highlighting sounds heard during equipment deployment and collection. **Appendix E.7** presents photos of the measurement location.

Table 4-20: Equipment used to gather data at SMHLTSL02

Equipment	Model	Serial no	Calibration
SLM	NA-28	00901489	April 2019
Microphone	NH-23	01533	April 2019
Calibrator	Quest CA-22	J 2080094	June 2020

Table 4-21: Noises/sounds heard during site visits at SMHLTSL02

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: • **Barely Audible** • **Audible** • **Dominating**	**During equipment deployment and collection of instruments**	
	Faunal and Natural	Bird sound constant and the dominant noise source.
	Sounds associated with the household	Dogs chained to tree frequently barking.
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{AIeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-29** and summarized in **Table 4-22** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-30**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. 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.

The L_{A90} level is presented in this report to define the "background sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

Maximum noise level exceeded 65 dBA at least 1 time the first night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep[20].

Table 4-22: Sound levels considering various sound level descriptors at SMHLTSL02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	37.4	30.6	20.9	-
Night arithmetic average	-	20.9	19.8	17.8	-
Day Equivalent Levels	-	51.0	40.4	-	-
Night Equivalent Levels	-	30.9	23.4	-	-
Day minimum	-	14.6	16.6	-	15.3
Day maximum	84.0	66.6	55.4	-	-
Night minimum	-	14.4	16.6	-	15.3
Night maximum	65.3	47.2	38.1	-	-
Day 1 equivalent	-	36.0	27.3	-	-
Night 1 Equivalent	-	30.9	23.3	-	-
Day 2 equivalent	-	51.0	40.4	-	-
Night 2 Equivalent	-	20.5	18.4	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 4-31** (night) and **Figure 4-32** (day).

(20) World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

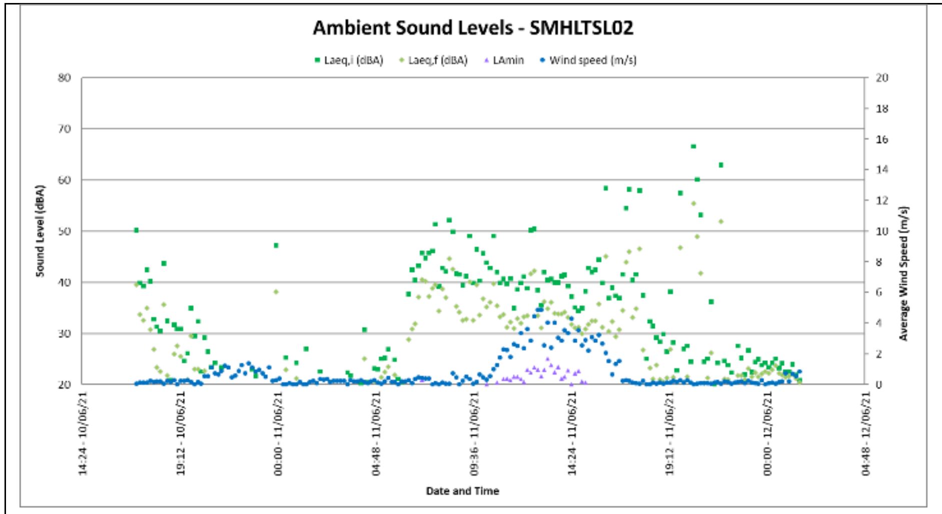

Figure 4-29: Ambient Sound Levels at SMHLTSL02

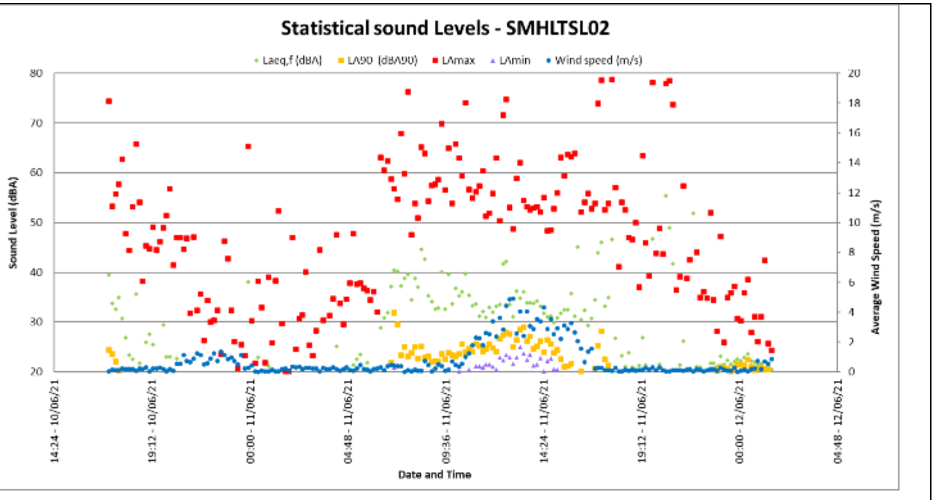

Figure 4-30: Maximum, minimum and Statistical sound levels at SMHLTSL02

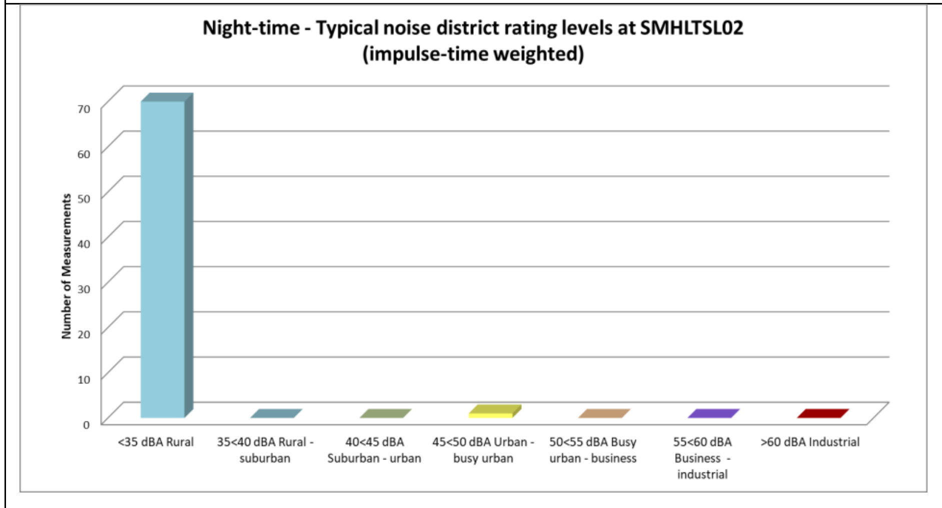

Figure 4-31: Classification of night-time measurements in typical noise districts at SMHLTSL02

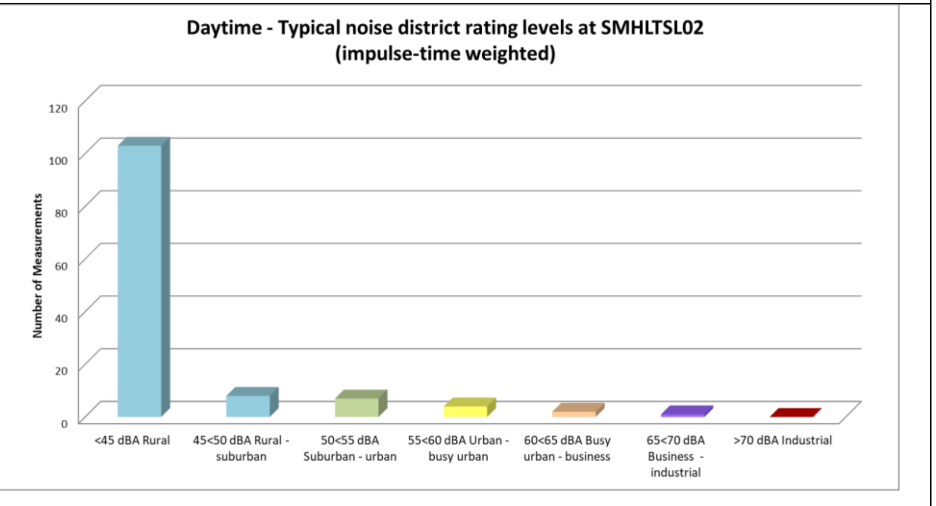

Figure 4-32: Classification of daytime measurements in typical noise districts at SMHLTSL02

4.4 Ambient Sound Levels – Findings and Summary

Based on the sound measurements:

- More than 1,000 10-minute measurements were collected during the day, with the highest fast-weighted sound level (during the various 10-minute measurements) measured being 55.4 dBA, with the lowest sound level being 16.6 dBA;
- More than 650 10-minute measurements were collected during the night-time period, with the highest fast-weighted sound level (during the numerous 10-minute measurements) measured being 65.7 dBA, with the lowest sound level being 22.6 dBA;
- The average of the 10-minute sound levels at the seven measurement locations were 29.8 dBA for the daytime period and 23.3 dBA for the night-time period (fast-weighted sound levels).

Considering the developmental character, the acceptable zone sound level (noise rating level) during low and no-wind conditions would be expected to be that of a rural noise district for both the daytime and night-time period:

- **45 dBA for the daytime period;** and,
- **35 dBA for the night-time period**.

To assess the noise impact occurring during the construction phase, this assessment will use the following noise limits:

- **52 dBA for the daytime period**; and,
- **42 dBA for the night-time period**.

Considering measurements collected over the past decade at numerous locations during different seasons, ambient sound levels will likely increase as wind speeds increase, as illustrated in **Figure 4-33**. The sound level data collected for this project is also illustrated on these figures. This figure also illustrates a trend of increased ambient sound levels as wind speed increase. The same trend will also be assumed for the project site as illustrated on **Figure 4-33**. This increasing ambient sound level, as wind speeds increase, will be considered for the operational phase (as the wind turbines will only operate during a period with increased wind speeds).

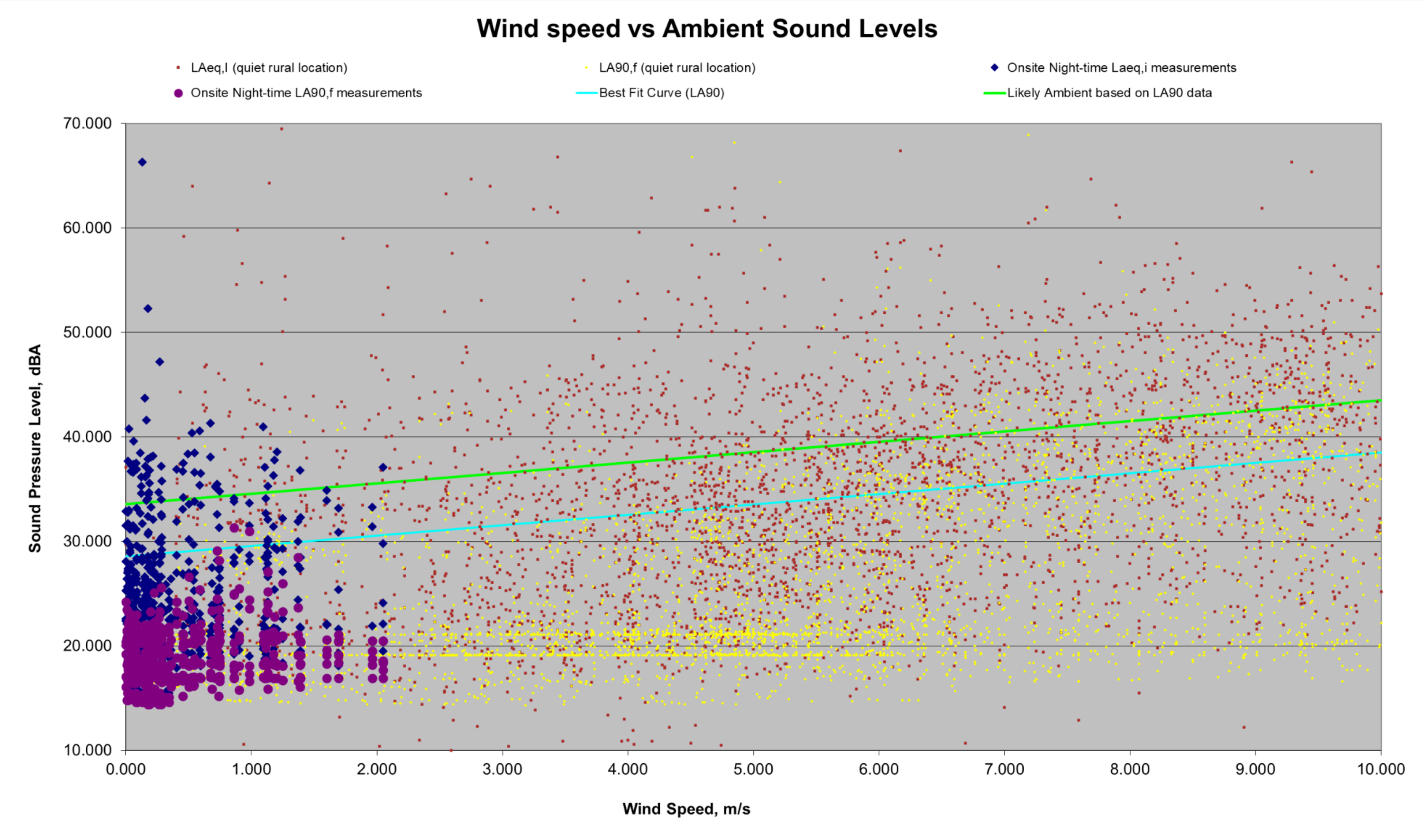

Figure 4-33: Night-time residual noise levels measured in vicinity of project

5 POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the proposed Koup 1 WEF 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.

5.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

5.1.1 Construction equipment

It is estimated that construction will take approximately 24 - 30 months subject to the final design of the WEF, 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 with WTG component 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.
- Transport of components & equipment to site – all components will be brought to site in sections by means of flatbed trucks. Additionally, components of various specialized 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 may require up to 100 concrete trucks, and is undertaken as a continuous pour);
- Establishment of laydown & 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 are removed; 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 5-2**.

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 5-3**.

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.

Noise from the contractor's camp will be minimal and will not influence the ambient sound levels in the surrounding area. The noise levels and the octave sound power emission levels used for modelling for the construction phase are highlighted in **Table 5-1**.

Table 5-1: Equipment list and Sound power emission levels used for modelling

Equipment	Sound power level, dB re1 pW, in octave band, Hz							SPL
Centre frequency	63	125	250	500	1000	2000	4000	(dBA)
Construction and WTG equipment and activities								
Bulldozer CAT D5	107.4	105.9	104.8	104.5	104.4	97.5	90.2	107.4
Diesel Generator (Large - mobile)	107.2	104.0	102.4	102.7	100.2	99.5	97.4	106.1
Excavator and truck	111.0	112.2	109.3	106.4	105.4	101.6	98.4	112.0
General noise (Construction)	95.0	100.0	103.0	105.0	105.0	100.0	100.0	113.6
Goldwind GW155-4.5	109.8	108.9	109.5	107.4	101.0	92.3	77.4	107.5
Goldwind GW182-7.2 (maximum)	Octave SPL not available, use octave SPL of the GW155-4.5							112.6
Road Transport Reversing/Idling	108.2	104.6	101.2	99.7	105.4	100.7	98.7	108.2
Vestas V162-7.2MW	114.2	113.3	110.0	105.4	100.8	95.1	86.8	107.1
Area noise sources (using the octave sound power characteristics of General Noise)								
General noise (dBA/m^2 re 1 pW)	95.0	100.0	103.0	105.0	105.0	100.0	100.0	65.0

5.1.2 Material supply: Concrete batching plants

There exist mainly two 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 closer to the activities. This would most likely be a movable plant.

This noise study will consider the use of a concrete batching plant, though the infrastructure layout indicate that the batching plants are further than 1,000m from any NSR. Potential noise from this source will be minimal.

5.1.3 Blasting

Though unlikely, blasting may be required as part of the civil works to clear obstacles or to prepare foundations (of either the WEF, power pylons or other infrastructure).

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. The breaking of rocks and obstacles with explosives is also a specialized field, and when correct techniques are used, it causes less noise than using a rock-breaker.
- People are generally more concerned over ground vibration and air blast levels that might cause building damage than the impact of the noise from the blast.
- Blasts are an infrequent occurrence, with a loud but a relative instantaneous character. Potentially affected parties normally receive sufficient notice (siren), and the knowledge that the duration of the siren noise as well as the blast will be over relatively fast, resulting in a higher acceptance of the noise.

5.1.4 Construction Traffic

The last potential significant source of noise during the construction phase is additional traffic to and from the site, as well as traffic on 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). Traffic volumes were estimated using up to 10 trucks and cars each, travelling on a gravel road at 40 km/hr, as well as a surfaced road at 80 km/hr.

Table 5-2: Potential maximum noise levels generated by construction equipment

Equipment Description[21]	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 modeling 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
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
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
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
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
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
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

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

Table 5-3: 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	55.6	47.6	41.5	38.0	35.4	31.9	27.3	23.6	20.9	14.2
Bulldozer CAT D10	111.9	86.9	80.9	74.9	66.9	60.8	57.3	54.7	51.2	46.6	42.9	40.2	33.5
Cement truck (with cement)	111.7	86.7	80.7	74.7	66.7	60.6	57.1	54.5	51.0	46.4	42.7	40.0	33.3
Crane	107.5	82.5	76.5	70.5	62.5	56.4	52.9	50.3	46.8	42.2	38.5	35.8	29.1
Diesel Generator (Large - mobile)	106.1	81.1	75.1	69.1	61.1	55.0	51.5	48.9	45.4	40.8	37.1	34.4	27.7
Dumper/Haul truck - Terex 30 ton	112.2	87.2	81.2	75.2	67.2	61.1	57.6	55.0	51.5	46.9	43.2	40.5	33.8
Excavator - Hitachi EX1200	113.1	88.1	82.1	76.1	68.1	62.0	58.5	55.9	52.4	47.8	44.1	41.4	34.7
FEL (988) (FM)	115.6	90.6	84.6	78.6	70.6	64.5	61.0	58.4	54.9	50.3	46.6	43.9	37.2
General noise	108.8	83.8	77.8	71.8	63.8	57.7	54.2	51.6	48.1	43.5	39.8	37.1	30.4
Grader - Operational Hitachi	108.9	83.9	77.9	71.9	63.9	57.8	54.3	51.7	48.2	43.6	39.9	37.2	30.5
Road Truck average	109.6	84.6	78.6	72.6	64.6	58.5	55.0	52.4	48.9	44.3	40.6	37.9	31.2
Rock Breaker, CAT	120.7	95.7	89.7	83.7	75.7	69.6	66.1	63.5	60.0	55.4	51.7	49.0	42.3
Vibrating roller	106.3	81.3	75.3	69.3	61.3	55.2	51.7	49.1	45.6	41.0	37.3	34.6	27.9
Substation (one transformer)	85.2	60.2	54.2	48.2	40.2	34.1	30.6	28.0	24.5	19.9	16.2	13.5	6.8
Water Dozer, CAT	113.8	88.8	82.8	76.8	68.8	62.7	59.2	56.6	53.1	48.5	44.8	42.1	35.4
Wind Turbine: Acciona AW125/3000	108.5	83.5	77.5	71.5	63.5	57.4	53.9	51.3	47.8	43.2	39.5	36.8	30.1
Wind Turbine: Goldwind GW165 6.0	112.6	87.6	81.6	75.6	67.6	61.5	58.0	55.4	51.9	47.3	43.6	40.9	34.2
Wind Turbine: Goldwind GW182 7.2	112.2	87.2	81.2	75.2	67.2	61.1	57.6	55.0	51.5	46.9	43.2	40.5	33.8
Wind Turbine: Nordex N163 / 5.X	109.2	84.2	78.2	72.2	64.2	58.1	54.6	52.0	48.5	43.9	40.2	37.5	30.8
Wind Turbine: Vesta V66, ave	110.4	85.4	79.4	73.4	65.4	59.3	55.8	53.2	49.7	45.1	41.4	38.7	32.0
Wind Turbine: Vestas V162-7.2MW	107.1	82.1	76.1	70.1	62.1	56.0	52.5	49.9	46.4	41.8	38.1	35.4	28.7

5.2 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 Project. 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 noise sources of lower levels, such as the substations and traffic (maintenance).

The noise levels and the octave sound power emission levels of the selected WTG used for the operational noise model are highlighted in **Table 5-1**.

5.2.1 Wind Turbine Noise: Aerodynamic sources [7, 17, 29, 39, 108]

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

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

Therefore, as the wind speed increases, noises created by the wind turbine also increase. 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 5-1**.

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. As the noise propagation modelling requires the details of a wind turbine, the applicant requested that the assessment considers a potential worst-case scenario, using a WTG with a sound power emission level ("SPL") of 112.2 dBA (re 1 pW), using the SPL characteristics of the Goldwind GW182-7.2 WTG (Goldwind, 2023 **[52]**) for the worst-case scenario, as well as the SPL characteristics of the Vestas V162-7.2 WTG (Vestas, 2023 [**142**]).

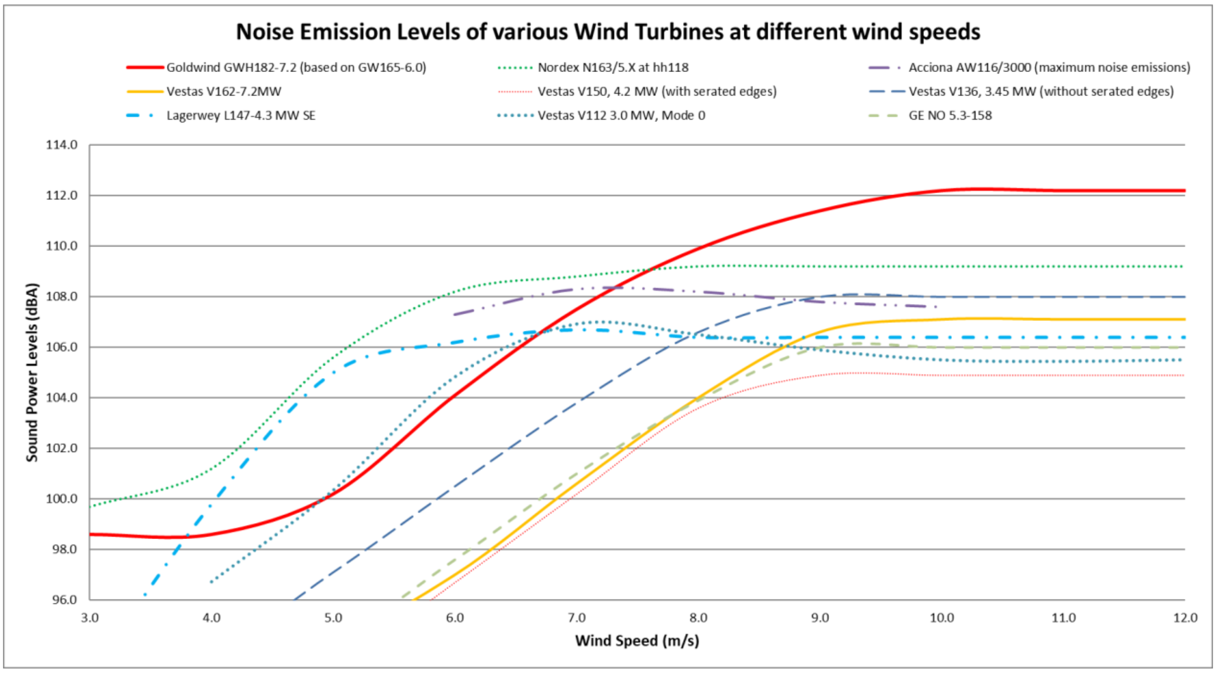

Figure 5-1: Noise Emissions Curve of a number of different wind turbines (figure for illustration purposes only)

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 emission levels for various wind turbines are presented on **Figure 5-2**.

5.2.1.1 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 from the different manufacturers); 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.

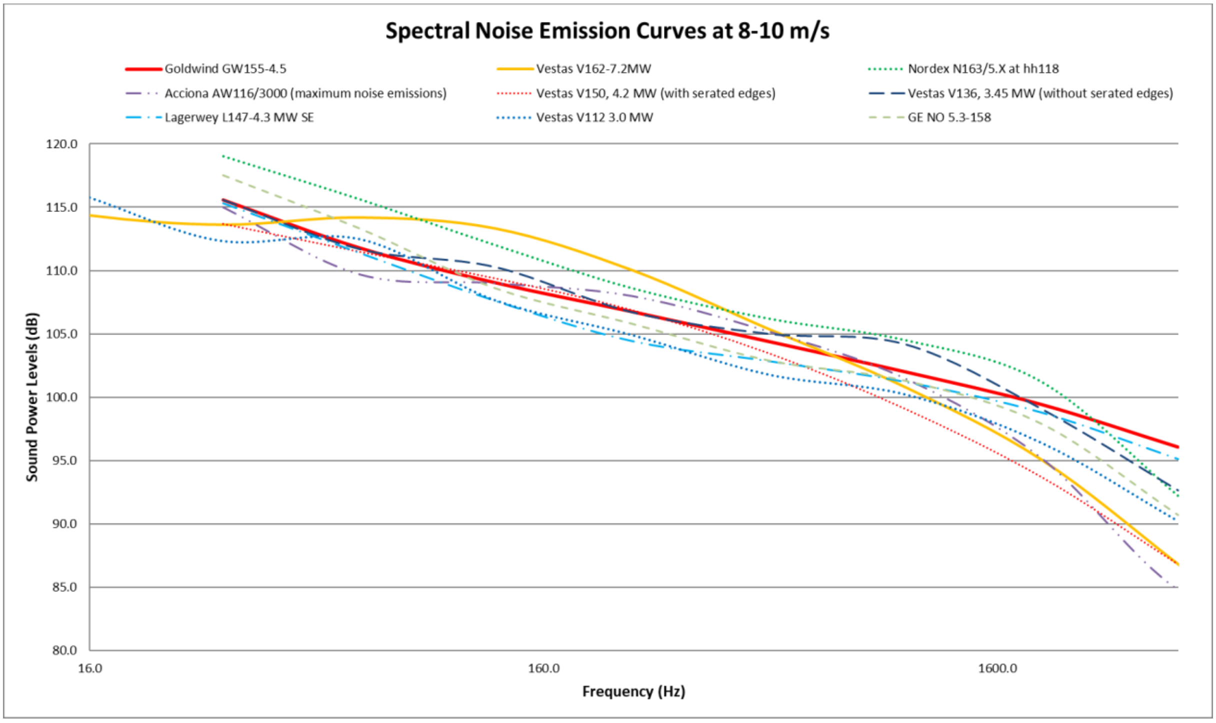

Figure 5-2: Octave sound power emissions of various wind turbines

5.2.2 Wind Turbine: Mechanical sources [42, 61, 108, 111]

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 minimize 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***.

5.2.3 Low Frequency Noise

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 (DELTA, 2008) [**32**], (HGC Engineering, 2006 [**60**], (O'Neal *et al*., 2011) [**95**], (Van den Berg, 2004) [**137**].

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 5-3**, 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 (Bolin *et al*, 2011) [**10**], (DELTA, 2008) [**32**], (Kamperman and James, 2008) [**72**].

Ambrose (2011) [**1**] and other authors have confirmed modulations consistent with the frequency that the blade pass the tower. 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 (BWEA, 2005) [**16**], (Cummings, 2012) [**28**], (HGC Engineering, 2006) [**60**].

The British Wind Energy Association (BWEA) [**16**] highlighted that these sounds are below the threshold of perception, 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 (DEFRA, 2003) [**30**], (Evans, Cooper and Lenchine, 2012) [**44**], (HGC Engineering, 2011) [**62**], (Oud, 2012) [**97**].

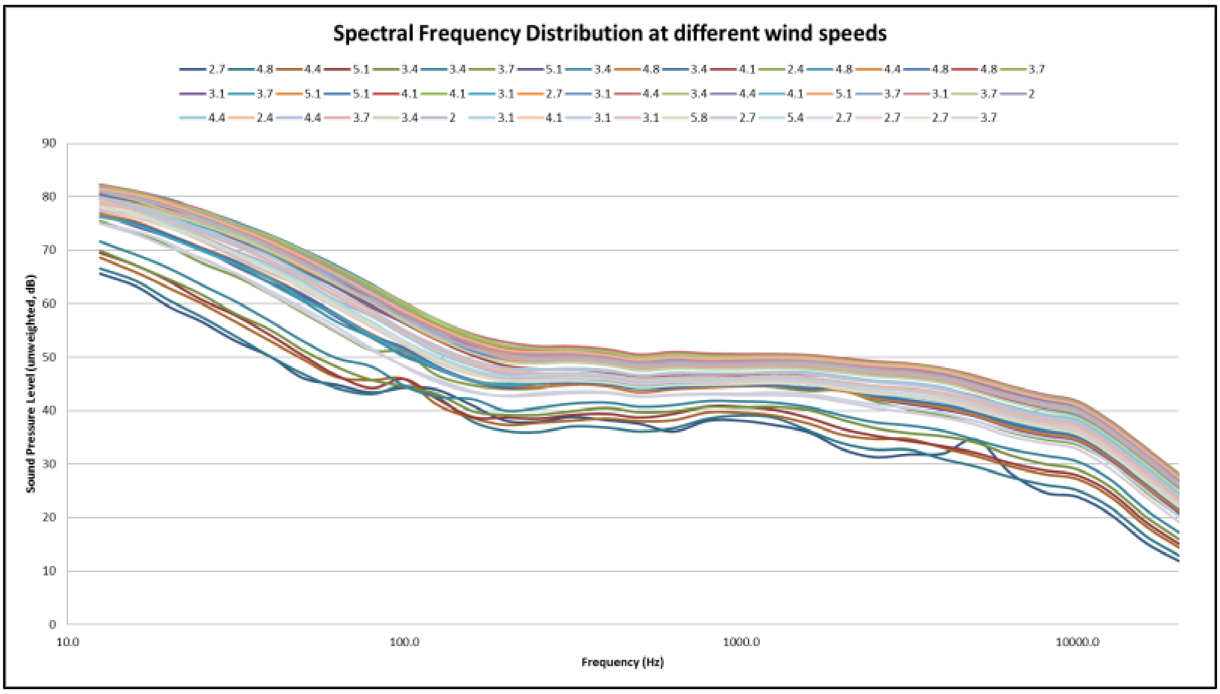

Figure 5-3: Third octave band sound power levels at various wind speeds at a location where wind induced noises dominate

In February 2013, the Environmental Protection Authority of South Australia published the results of a study into low-frequency noise near wind farms (Evans and Cooper, 2012) [**43**, **44**]. This study measured infrasound levels at urban locations, rural locations with wind turbines close by, and rural locations with no wind turbines in the vicinity. It found that infrasound levels near wind farms are comparable to levels away from wind farms in both urban and rural locations. Infrasound levels were also measured during organized shut-downs of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.

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.

5.2.4 Amplitude modulation

Wind Turbine Noise (WTN) includes a steady component (see also the preceding section **5.2.1** and **5.2.2**) as well as, in some circumstances, a periodically fluctuating or Amplitude Modulated (AM) component or character (RenewableUK, 2013) [**112**]. Although generally considered rare, it is a characteristic of WTN that increases the annoyance with a project above that of other long-term noise sources (Bowdler, 2008) [**12**], (Conrady et al., 2019) [**20**], (DEFRA, 2007) [**31**], (Noise-con, 2008) [**91**], (Smith *et al.*, 2012) [**126**].

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 rotational speed, sometimes referred to as a "swish" or "thump".

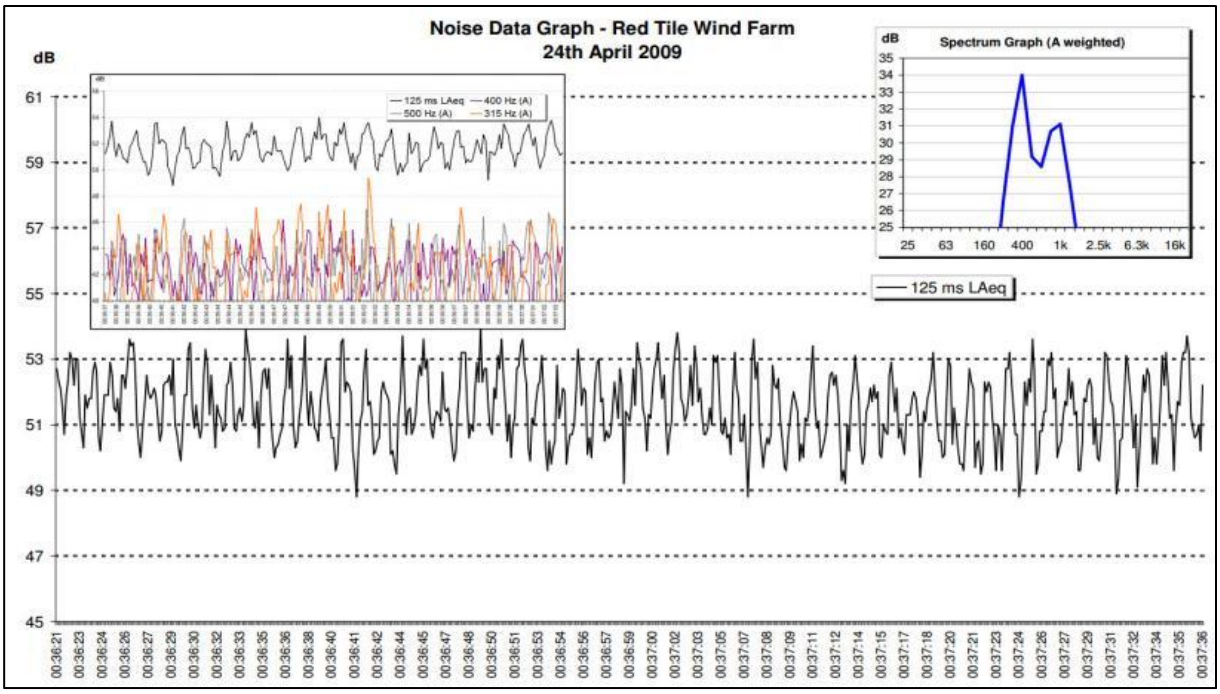

Figure 5-4: Example time-sound series graph illustrating AM as measured by Stigwood (2013) [127]

Pedersen (2003) [**103**] 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, with people able to distinguish between background ambient sounds and the sounds that the blades made. The noise produced by the blades lead to most complaints. Most of the annoyance was experienced between 16:00 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.

That AM can be a risk and significantly increase the annoyance with WEFs that cannot be disputed. It has been reported with a number of recent studies confirming this significant noise characteristic (Pedersen, Halmstad and Högskolan, 2003) [**103**]. However, even though there are thousands of wind turbine generators in the world, amplitude modulation is still one subject receiving the least complaints and due to these very few complaints, less research went into this subject. It is also a complex source of wind turbine noise, with studies highlighting that time of year, atmospheric conditions, wind direction and atmospheric conditions all play a role in the generation of AM (CanWEA, 2007) [**17**]**,** (Cummings , 2012) **[28**], (Cummings, 2009) **[29**], (RenewableUK, 2013) [**112**].

How people may respond to AM is also complex. WSP (2016) [**149**], in a study done for the Department of Energy and Climate Change summarized that:

- Within both laboratory and field test environments there is a strong association between increasing overall time-average levels of AM WTN-like sounds with increasing ratings of annoyance.
- Within a laboratory test environment:
    - subjects rated noticeable modulating WTN-like sounds as more annoying than similar noise without significant modulation;
    - the onset of fluctuation sensation for a modulating WTN-like sound appeared to be in the region of around 2 dB modulation depth;
    - increasing modulation depth above the onset of fluctuation sensation showed a broadly increasing trend in mean ratings of annoyance, but changes in mean annoyance rating tended to be relatively small and, in some cases, inconsistent;
    - equivalent annoyance ratings of AM and steady WTN-like sounds derived by level adjustment did not show a strong increasing trend with increasing depth of modulation; and
    - equivalent 'noisiness perception' of WTN-like AM sounds compared with a steady sound showed a gradually increasing trend with modulation depth.

WSP (2016) also concluded that the results from both the laboratory and field studies should be approached with caution, since they may not readily translate to how people respond to WTN exposure in their homes (WSP, 2016) [**149**].

This assessment notes the various findings from these studies, and recommend a more precautious approach, raising the probability of a noise impact occurring with one point for all night-time operational activities where (whichever is the lowest):

- the projected noise levels exceed the long-term fast-weighted ambient sound levels with more than 3 dB, or
- the projected noise levels exceed the typical rating levels for the area with more than 5 dBA.

5.2.5 Battery Energy Storage Systems

The developer proposes to include a BESS at their WEF to store energy for use at a later time or date using electro-chemical solutions. The typical components of a BESS are:

- The battery system which could consist of:
  - Multiple cells,
  - The battery management system; and,
  - The battery thermal management system.
- Components required for the reliable operation of the overall system, including:
  - Energy management system; and,
  - System thermal management.
- Power electronics that can be grouped into the conversion unit (such as an invertor), which manage the power flow between the grid and battery, including the required control and monitoring components, voltage sensing units and thermal management of power electronic components (fans or climate control system).

There could be numerous such BESS modules running in parallel to increase the total storage capacity of the system up to the desired or needed capacity. The typical components are illustrated in **Figure 5-5**.

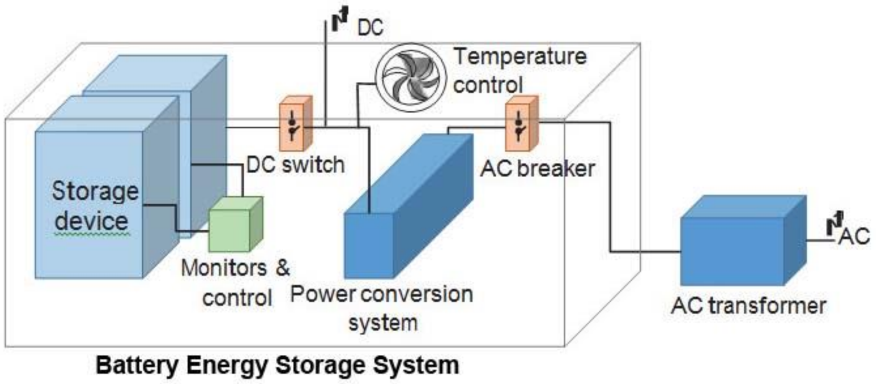

Figure 5-5: Conceptual BESS components[22]

While certain components may generate a slight hum under load, the dominant source of noise is from the fans or climate control system used to manage heat in the system and/or

[22] Source: http://www.amdcenergy.com/battery-energy-storage-system.html

to maintain the BESS within its optimal operating temperature range. These BESSs however generate low noise levels, with any potential noise impact generally limited to areas within 200m of the BESS. This is an insignificant noise level and the significance of this noise will be low.

5.2.6 Transformer noises (Substations)

Also known as magnetostriction[23], is when the sheet steel used in the core of the transformer tries to change shape when being magnetised. When the magnetism is taken away, the shape returns, only to try and deform in a different manner when the polarity is changed.

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

However, this is a relatively easy noise to mitigate with the use of acoustic shielding and/or placement of the transformer and will not be considered further in this ENIA study. Substations in addition generate low noise levels, with the hum from the transformers inaudible further than 200 m from the transformers.

5.2.7 Transmission Line Noise (Corona noise)

Corona noise[24] 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

[23] https://en.wikipedia.org/wiki/Magnetostriction
[24] https://en.wikipedia.org/wiki/Corona_discharge

'crackling' or 'buzzing', but ***fortunately it is generally only a feature that occurs 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 METHODS: NOISE IMPACT ASSESSMENT

6.1 NOISE IMPACT ON ANIMALS

A significant amount of research was undertaken during the 1960's and 70's on the effects of aircraft noise on animals (Autumn, 2007) [**2**], (Noise quest, 2010) [**92**]. While aircraft noise has a specific characteristic that might not be comparable with industrial noise, the findings should be relevant to most noise sources. A general animal behavioural reaction to aircraft noise is the startle response with the strength and length of the startle response to be dependent on the following:

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

Overall, the research suggests that species differ in their response to noise depending on the duration, magnitude, characteristic and source of the noise, as well as how accustomed the animals are to the noise (previous exposure).

Extraneous noises impact on animals as it can increase stress levels and even impact on their hearing. Masking sounds may affect their ability to react to threats, compete and seek mates and reproduce, hunt and forage, communicate and generally to survive.

Unfortunately, there are numerous other factors in the faunal environment 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.

The only animal species studied in detail are humans, and studies are still continuing in this regard. These studies also indicate that there is considerable variation between individuals, highlighting the loss of sensitivity to higher frequencies as humans age. Sensitivity also varies with frequency with humans. Considering the variation in the sensitivity to frequencies and between individuals, this is likely similar with all faunal species. Some of these studies are repeated on animals, with behavioural hearing tests being able to define the hearing threshold range for some animals as indicated on **Figure 6-1**.

Only a few faunal (animal) species have been studied in a bit more detail so far, with the potential noise impact on marine animals most likely the most researched subject, with a few studies that discuss behavioural changes in other faunal species due to increased noises. Few studies indicate definitive levels where noises start to impact on animals, with most based on laboratory level research (USEPA, 1971) [**135**] that subject animals to noise levels that are significantly higher than the noise levels these animals may experience in their environment (excluding the rare case where bats and avifauna fly extremely close to an anthropogenic noise, such as from a moving car or the blades of a wind turbine).

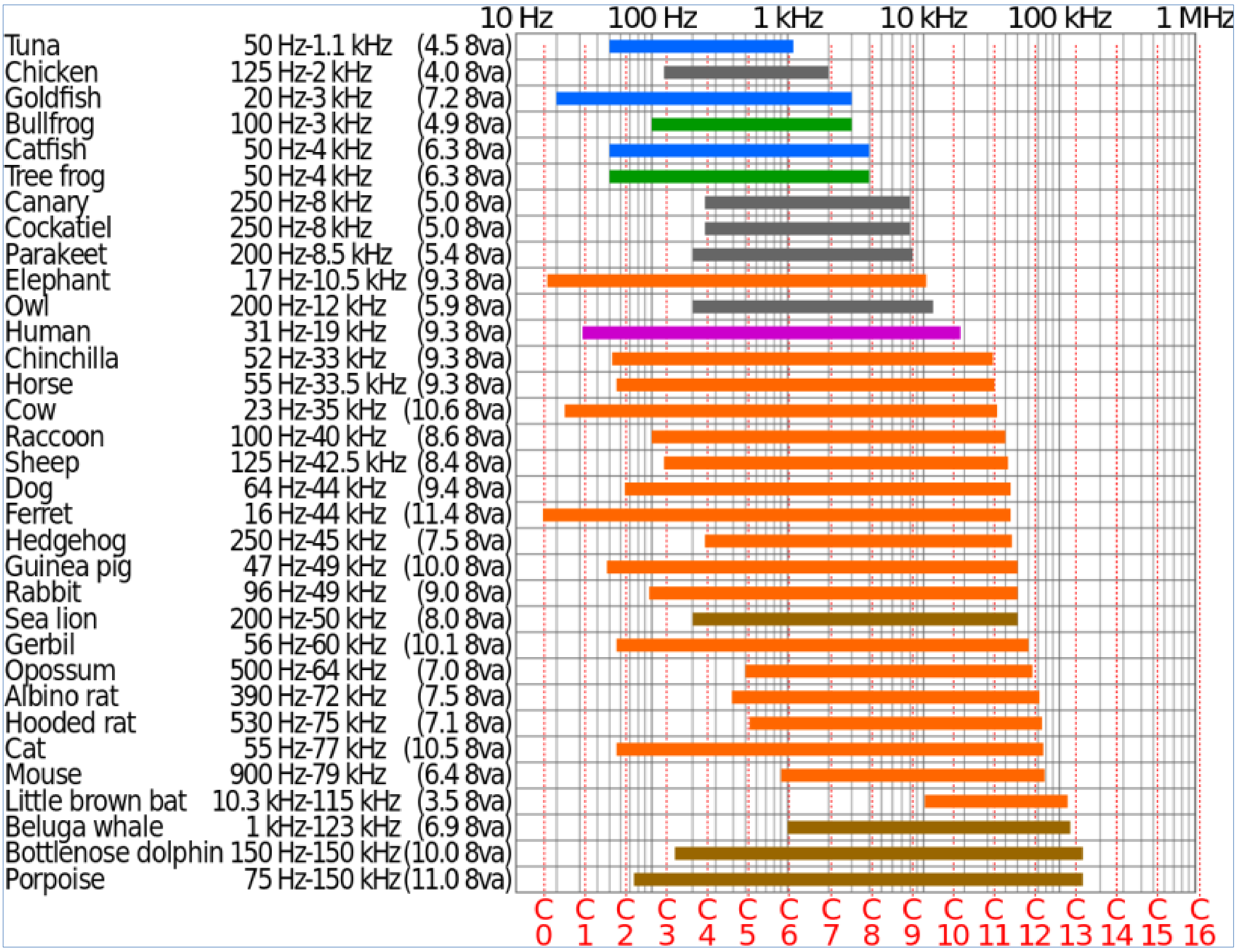

Figure 6-1: Logarithmic Chart of the Hearing Ranges of Some Animals[25]

6.1.1 Domesticated Animals

Excluding loud impulsive noises, considering the environmental noise levels (the noise levels were not defined, but levels of up to 100 dB were reported), it has been observed that most domesticated animals are generally not bothered by noise and generally can acclimatize relatively quickly to loud noises (Šottník, 2011) [**122**]. Considering the expected wind turbine noise (WTN) levels (well less than 60 dBA at all locations), WTN will not impact on domestic animals (Noise quest, 2010) [**92**].

[25] https://en.wikipedia.org/wiki/Hearing_range

6.1.2 Wildlife

Studies indicated that most animals adapt to noises, and would even return to a site after an initial disturbance, even if the noise is continuous. The more sensitive animals that might be impacted by noise would most likely relocate to a quieter area. Helldin (2012) [**58**] however highlights that the network of access road could be a significant factor impacting on animals. Noise impacts are therefore very highly species-dependent (Blickley and Patricelli, 2010) [**9**], (Cummings, 2012) [**28**], (Cummings, 2009) [**29**], (Łopucki, Klich and Gielarek, 2017) [**78**], (Noise quest, 2010) [**92**], (Rabin, Coss and Owings, 2006) [**110**], but there are also other factors that could impact on animals (such as visibility and increased movement of people and vehicles).

6.1.3 Avifauna

As with other terrestrial faunal species, noise (character of sound or change in level) will impact on avifauna (birds of a particular region and/or habitat). Anthropogenic noises result in physical damage to ears, increased stress, flight or flushing, changes in foraging and other behavioural reactions. Ortega (2012) [**96**] summarized that additional responses (with ecological similar controls) include the avoidance of noisy areas, changes in reproductive success and changes in vocal communication. However, as with other faunal species, there are no guidelines to assess at which sound pressure level avifaunal will start to exhibit any response (Autumn, 2007) [**2**], (Cummings, 2009) [**29**], (Dooling and Popper, 2007) [**35**], (Lohr, Wright and Dooling, 2003) [**76**], (Ortega, 2021) [**96**], (Schaub, Ostwald and Siemers, 2008) [**119**], (Zwart *et al.,* 2014) [**150**].

6.1.4 Concluding Remarks - Noise Impacts on Animals

From these and other studies the following can be concluded:

- To date there are no guidelines or sound limits with regards to noise levels that can be used to estimate the potential significance of noises on animals (Blickley *et al.,* 2010) [**9**].
- Animals respond to impulsive (sudden) noises (higher than 90 dBA) by running away. If the noises continue, animals would try to relocate (Dooling, 2007) [**35**].
- Terrestrial wildlife responses begin at noise levels of approximately 40 dBA, with 20% of papers documenting impacts below 50 dBA (Shannon *et al.* 2015) [**123**].
- Animals start to respond to increased noise levels with elevated stress hormone levels and hypertension. These responses begin to appear at exposure levels of 55 to 60 dBA (Baber, 2010) [**5**], with Helldin *et al.* (2012) [**58**] reporting that levels of 60–75 dBA have been shown to cause stress, e.g., increased respiration and heart rate, increased vigilance, and decreased time for grazing in domestic animals such as sheep and horses.

- Animals of most species exhibit adaptation with noise (Broucek, 2014) [**15**], including impulsive noises, by changing their behaviour.
- There may be a possible impact on the health of animals (Mikolajczak, 2013; Karwowska, 2015) caged very close to an operating WTG (within 500 m) (Karwowska, 2015) [**73**], (Mikolajczak, 2013) [**85**];
- Songbirds may change the spectral character of songs and calls used for communication and defence in areas very close to WTGs. This is similar to the effects of other anthropogenic noise sources such as traffic, which can disrupt bird 'chatter' to the point of being detrimental to reproductive success (Szymański, 2017; Zwart, 2014) [**129** ,**150**];
- More sensitive species would relocate to a quieter 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 (Dooling, 2007; Łopucki, 2017) [**35**, **78**].
- Noises associated with helicopters, motor- and quad bikes significantly impact on animals (startle response). This is due to the sudden and significant increase in noise levels due to these activities [(Autumn, 2007) [**2**, **135**];
- Focusing on small species (rodents and shrews), Łopucki (2016) [**77**] assessed differences between control sites and locations close to wind turbines (the distances from WTG were not defined), concluding no significant differences between the sites;
- Łopucki (2017) [**78**] studied tracks from various species (Roe deer, European hare, Common pheasant and Red fox), from as close as 100m from WTG to 700m away. That study determined that
  - Roe deer and European hare visit the areas closer to WTG less frequently than areas further away,
  - Common pheasant appear to visit the areas closer to WTG more frequently, and
  - Red fox showed the most neutral response to WTG; and
- Helldin *et al*. (2012) [**58**] also report that large terrestrial mammals appear to acclimatise to wind farms during the operational phase, arguing that WF mainly affect large terrestrial mammals through an increase in human activity.

With regard to Low-Frequency Noise (LFN) and Infrasound, it is summarized that:

- There are no scientific papers available in reputable journals highlighting the impact of LFN from WTG on wildlife;
- Animal communication is generally the highest during no and low wind conditions. It has been hypothesised that this is one of the reasons why birds sing so much in the mornings (their voices carry the farthest and there are generally less observable wind);

- Background noise levels (ambient sound levels) in remote areas are not always low in space or time. The site is windy and this generates significant noise itself and also significantly changes the ability of fauna to hear the environmental noises around them;
- Wind is a significant source of natural noise, with a character similar to the noise generated by wind turbines, with a significant portion of the acoustic energy in the low frequency and infrasound range;
- Wind turbines do not emit broad-band sound on a continual basis as the turbines only turn and generate noise when the wind speeds are above the cut-in speed;
- The wind turbines will only operate during periods of higher wind speeds, a period when background noise levels are already elevated due to wind-induced noises; and
- The elevated background noise relating with wind also provide additional masking of the wind turbine noise, with periods of higher winds also correlating with lower faunal activity, particularly with regard to communication.

It should be noted that LFN and Infrasound is present in the environment and is generated by a wide range of natural sources (e.g., wind, waves etc.). In February 2013, the Environmental Protection Authority of South Australia published the results of a study into infrasound levels near wind farms (Evans, 2013). This study measured infrasound levels at urban locations, rural locations with wind turbines close by, and rural locations with no wind turbines in the vicinity. It found that infrasound levels near wind farms are comparable to levels away from wind farms in both urban and rural locations. Infrasound levels were also measured during organized shut-downs of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.

6.2 WHY NOISE CONCERNS COMMUNITIES [3, 14, 19, 24, 29, 49, 74, 91, 108, 124]

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

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

However, it is important to remember that whether a given sound is "noise" depends on the listener or hearer. The driver playing loud rock music on their car radio hears only music, but the person in the traffic behind them hears nothing but noise.

Response to noise is unfortunately not an empirical absolute, as it is seen as a multi-faceted psychological concept, including behavioural and evaluative aspects. For instance, in some cases, annoyance is seen as an outcome of disturbances, and 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 prefer to sleep. Noise impacts are also complex to evaluate as numerous issues could cumulatively contribute to the severity of the impact, as discussed in the following subsections.

How a noise may impact (with this assessment using annoyance about the noise) on a receptor is also very complex to assess for the reasons highlighted in **section 6.2.1** below. Only considering the intensity of a sound (or noise) level, some people may become annoyed without hearing any noise (perceived impacts) where others may not even be reporting noise to be a concern, even when subjected to very high levels.

6.2.1 Noise Annoyance

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 the non-acoustic factors play a major role. Non-acoustic factors that have been identified include age, economic dependence on the noise source, attitude towards the noise source and self-reported noise sensitivity (Bakker *et al.*, 2012) [**4**], (Council of Canadian Academies, 2015) [**23**], (Ellenbogen *et al.*, 2012) [**38**], (Halfwerk *et al.*, 2011) [**54**], (Hanning, 2010) [**55**], (Janssen *et al.*, 2011) [**67**], (Knopper *et al.*, 2014) [**74**], (Merlin *et al.*, 2013) [**82**], (Miedema and Vos, 2003) [**83**], (Minnesota Department of Health, 2009) [**86**], (Nissenbaum, 2012) [**90**], (Pedersen, 2007) [**101**], (Pedersen, 2007) [**102**], (Pedersen, Halmstad and Högskolan, 2003) [**103**], (Pedersen, 2011) [**104**], (Pierpont, 2009) [**106**], (Schmidt and Klokker, 2014) [**120**], (Van den Berg *et al.*, 2008) [**138**], (Van den Berg, Verhagen and Uitenbroek, 2014) [**139**], (World Health Organization, 2009) [**147**].

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 6-2**, are recommended in a European Union position paper published in 2002, stipulating policy regarding the quantification of annoyance. This can be used in 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 levels.

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 and health state of the receptor; and
- The attitude of the receptor about the emitter (noise source).

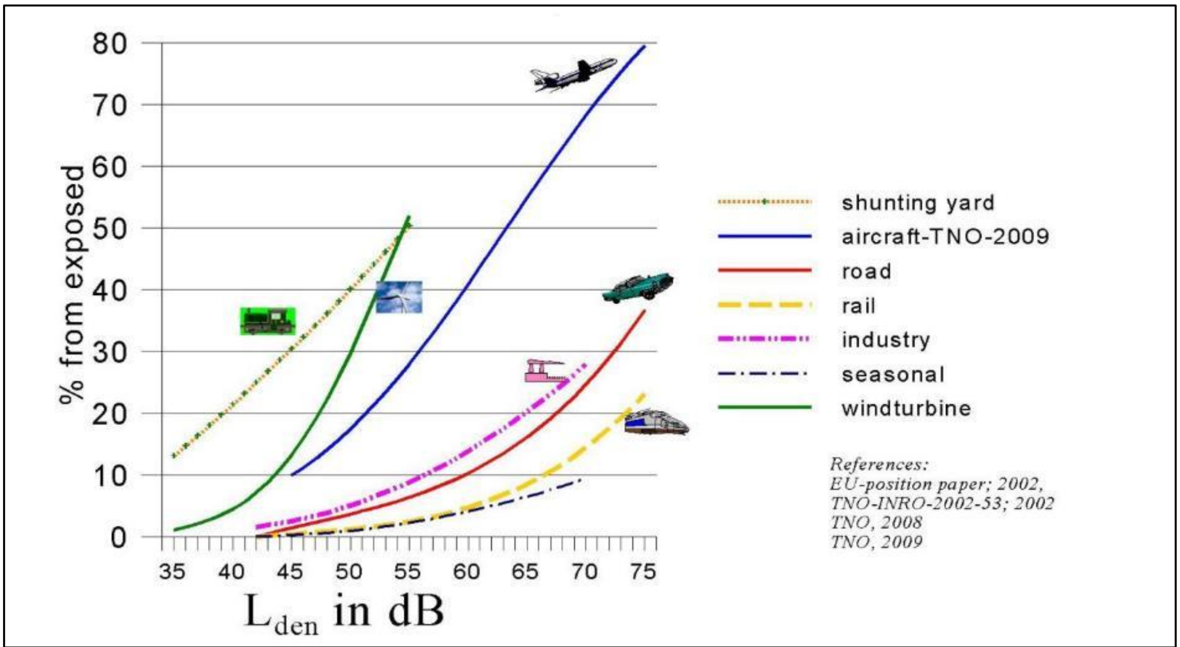

Figure 6-2: Percentage of annoyed persons as a function of the day-evening-night noise exposure at the façade of a dwelling[26]

6.2.1.1 Disturbance to Sleep

Sleep is essential for mental and physical health, and noise is one of the most reported reasons why people may experience sleep interruptions at night. This may be sudden loud

[26] Image from https://rigolett.home.xs4all.nl/ENGELS/topic.htm. Wind Turbine Annoyance curve from Pedersen (2007)

noises, with the WHO (2009) [**147**] reporting that, when maximum noises exceed 60 dBA, with average noise levels exceeding 40 dBA, it may increase the probability of being awakened. People report that quality of life suffer with increased instances of disturbed sleep that may also increase annoyance with a project (Bakker *et al.*, 2012) [**4**], (Van den Berg, Verhagen and Uitenbroek, 2014) [**139**]. It should be noted that Van den Berg (2014) [**138**, **139**] showed an indirect effect between sleep disturbances and annoyance, but not between sleep disturbance and the noise level. It is postulated that this is due to increased annoyance due to the visual impact from WTG.

6.2.1.2 Potential Health Effects from WTN

While there has been a number of complaints about the impact of WTN on the health of people living close to WTG (Halfwerk *et al*., 2011) [**54**], (Hanning, 2010) [**55**], (Janssen *et al.*, 2011) [**67**], (Nissenbaum, 2012) [**90**], (Pierpont, 2009) [**106**], other than annoyance and sleep disturbances, there is no evidence of any direct health effects (Council of Canadian Academies, 2015) [**23**], (Ellenbogen *et al.*, 2012) **38**, (Knopper *et al.*, 2014) [**74**], (Minnesota Department of Health, 2009) [**86**],(MDEP) **81**, (Merlin *et al.*, 2014) [**82**], (Pedersen, Halmstad and Högskolan, 2003) [**103**], (Schmidt and Klokker, 2014) [**120**].

6.2.1.3 Situational and Personal Factors

There are a few other aspects, collectively referred to as non-acoustical factors that may increase annoyance with a project (Miedema, 2003) [**83**], (Pedersen, 2007) [**102**]. These could include:

- Situational factors (visual issues, attractiveness of area) (Merlin *et al.*, 2013) [**82**], (Michaud *et al.*, 2016) [**84**], (Van den Berg *et al.*, 2008) [**138**];
- Socio-economic factors (age, gender, income, level of education) [(Miedema, 2003) **83**, (Michaud *et al.*, 2016) [**84**];
- Social factors (attitude towards the applicant/producer/government, media coverage) [(Pedersen, 2007) **102**, **128**]; and
- Personal factors (fear or worry in relation to noise source, sensitivity to noise, economic benefit from project, existing health condition) [(Miedema, 2003) **83**, **140**].

6.3 IMPACT ASSESSMENT CRITERIA

6.3.1 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; and
- Offensiveness.

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

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

6.3.2 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 of 2014 in terms of the NEMA, SANS 10103:2008, and guidelines from the 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, caused by a new source of noise. With regards to the NCR, an increase of more than 7 dBA is considered a disturbing noise. See also **Figure 6-3**.
- *Zone Sound Levels:* Previously referred to as the acceptable rating levels, sets acceptable noise levels for various areas. See also **Table 6-1**.
- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g. 65 dBA. Anything above this level will be considered unacceptable.

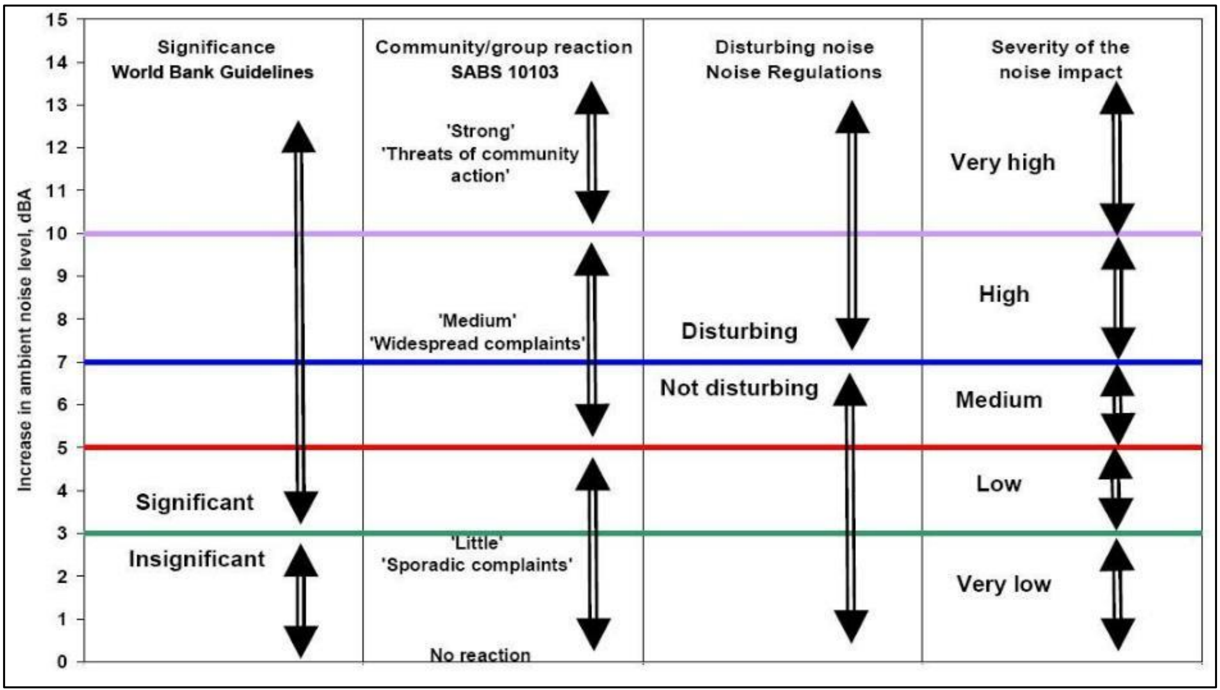

Figure 6-3: Criteria to assess the significance of impacts stemming from noise

In South Africa, the document that addresses the issues concerning environmental noise is SANS 10103:2008 (See also **Table 6-1**). It provides the equivalent ambient noise levels (referred to as Rating Levels), $L_{Req,d}$ and $L_{Req,n}$, during the day and night respectively to which different types of developments may be exposed.

Table 6-1: Acceptable Zone Sound Levels for noise in districts (SANS 10103:2008)

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

6.4 SETTING APPROPRIATE NOISE LIMITS

Onsite ambient sound measurements (**Section 4.3.1**) indicated an area with a potential to be very quiet, with ambient sound levels typical of a rural noise district.

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 considered.

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 ambient sound levels in the environment within which they are heard will probably also be dependent on 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.

6.4.1 Using International Guidelines to set Noise Limits – ETSU-R97

When assessing the overall noise levels emitted by a WEF, 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 most unlikely to cause any greater loss of amenity at higher wind speeds. Turbine noise levels increase only slightly as wind speeds increase; however, background ambient sound levels increase significantly with increasing wind speeds due to the force of the wind.

Available data indicates that wind-induced noises start to increase at wind speeds 3 – 4 m/s, becoming a 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 building, rustling of leaves in trees, rattling noises, etc) could start to drown other noises, including that being generated by wind turbines[27].

Sound level vs. wind speed data is presented in **Figure 4-33**[28]. It is based on approximately 38,000 measurements collected at various quiet locations in South Africa (locations further than 10 km from the ocean). Also indicated are around 1,000 and 500 actual day- and night-time measurements collected within, or close to the PFA, of the proposed WEF. There was a lack of very high wind speeds during the site visit, but as with other sites, ambient sound levels are expected to increase as the surrounding wind speed increase. This has been found at all locations where measurements have been done for a sufficiently long enough period of time (more than 30 locations comprising of more than 38,000 measurements) with the data agreeing with a number of international studies on the subject.

Considering this data as well as the international guidelines (MOE, see **Table 3-1**; IFC, see **Table 3-2**), 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 – does not differentiate between day and night-time periods, although this is assumed to be for the night-time period).

6.4.2 Considering the latest WHO (2018) recommendations

The WHO (2018) [**148**] recommends a guideline night-time noise level of 38.7 dBA (based on the 45 dBA L_{DEN} level) to minimize sleep-disturbance and receptors being highly-annoyed (see **section 3.5.9**).

6.4.3 Using the National and Provincial NCR to set noise limits

Noise limits as set by the National and the Western Cape NCRs (GN R154 of 1992 – **section 3.2.1** and the PN.200 of 2013 – **section 3.2.2**) defines a "**disturbing noise**" as the Noise Level which exceeds the ambient sound level at the same measuring point by 7 dBA or more.

[27] It should be noted that this does not mean that the wind turbines are inaudible.
[28] 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.

Based on the ambient sound level measurements:

- The daytime rating level (zone sound level) would be typical of a rural noise district (45 dBA), setting a maximum noise limit of 52 dBA during the day; and
- The night-time rating level (zone sound limit) is typical of a rural noise district (35 dBA), setting a maximum noise limit of 42 dBA at night (construction phase).

As can be observed from **Figure 4-33**, if ambient sound levels were measured at increased wind speeds, ambient sound levels will be higher as wind-induced noises increase. 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 6-2** will be recommended.

Table 6-2: Proposed ambient sound levels and acceptable rating levels

10 m Height Wind Speed (m/s)	Estimated ambient sound levels (night-time) (dBA)	MoE Sound Level Limits of Class 3 areas (Table 3-1) (dBA)	ETSU-R97 limit for project participants (dBA)	Night-time Zone Sound Level (SANS 10103:2008) (dBA)	Proposed Night Rating Level (dBA)
4	37.6	40	45	35 (at low wind speeds, this will increase as wind speeds increase)	40
5	38.6	40	45		40
6	39.5	40	45		40
7	40.5	43	45		43
8	41.5	45	45		45
9	42.5	49	45		45
10	43.5	49	45		45
11	44.5	49	45		45
12	45.0	49	45		45

6.5 DETERMINING THE SIGNIFICANCE OF THE NOISE IMPACT

6.5.1 Impact Assessment criteria

The level of detail as depicted in the EIA Guidelines (CSIR, 2002) [**26**] was fine-tuned by assigning specific values to each impact, considering the impact rating methodology developed by the EAP. 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. Being a comparative assessment, it should be noted that this review use the same EIA criteria used in the 2022 ENIA (Sivest, 2022 [121]).

This scale takes into consideration the following variables:

- **Nature of Impact**: The type of effect that the activity will have on the environment.
- **Status**: Whether the impact would be positive, negative or neutral.
- **Extent:** the spatial scale defines the physical extent of the impact.
- **Probability:** The likelihood of impacts taking place as a result of project actions arising from the various alternatives.
- **Reversibility:** The extent to which the impacts/risks are reversible at the end of project life.
- **Irreplaceability of resource:** The degree to which the impact may cause a loss of an irreplaceable resource at the end of the life cycle.
- **Duration:** The temporal scale defines the significance of the impact at various time scales, as an indication of the duration of the impact.
- **Consequence (Magnitude):** The severity or intensity of the impact on the surrounding receptors.
- **Significance**: The criteria in **Table 6-8** are used to determine the overall significance of an activity. The impact effect (which includes duration; extent; consequence and probability) and the reversibility/mitigation of the impact are estimated using the criteria as defined before, and after the implementation of the potential mitigation measures.

The impact significance is determined by multiplying the sum of scores of Consequence (**Table 6-7**), Duration (**Table 6-3**) and the Spatial Extent (**Table 6-4**) with the Probability score (**Table 6-5**) to obtain the final Impact Significance as defined in the equation below. It should be noted that while intensity can be calculated to an extent, probability of an impact occurring, or a receptor being annoyed is difficult to determine with this assessment making use an empirical method as defined in **Table 6-5**.

$$Significance\ Rating = (Extent + Probab. + Revers. + Irreplace. + Duration)\ x\ Probability$$

Table 6-3: Impact Assessment Criteria - Duration

The lifetime of the impact that is measured in relation to the lifetime of the proposed development (construction, operational and closure phases). Will the receptors be subjected to increased noise levels for the lifetime duration of the project, or only infrequently.		
Rating	**Description**	**Score**
Short	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of	1

	a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years)	
Medium	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).	2
Long	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).	3
Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).	4

Table 6-4: Impact Assessment Criteria – Spatial extent

Classification of the physical and spatial scale of the impact		
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 / District	The impact could affect the local area or district.	2
Province / Regional	The impact could affect the region or province.	3
National or International	The impact could have an effect that expands throughout the country (South Africa) or more.	4

Table 6-5: Impact Assessment Criteria – Probability

This describes the likelihood of a noise impact (receptors being annoyed) 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**
Unlikely	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
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. In a rural environment, once noise levels exceed 38.7 dBA (see also **section 3.5.9**) at night.	2
Probable	There is a possibility that the impact will occur to the extent that provisions must be made. Noise levels exceeding 45 dBA at night.	3
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. Any noise levels higher than 50 dBA at night.	4

Table 6-6: Impact Assessment Criteria – Irreplaceability of Resource

The degree to which resources will be irreplaceably lost as a result of a proposed activity.		
Rating	**Description**	**Score**
No loss	The impact will not result in the loss of any resources	1
Marginal	The impact will result in marginal loss of resources	2
Significant	The impact will result in significant loss of resources	3

Complete	The impact is result in a complete loss of all resources	4

Table 6-7: Impact Assessment Criteria – Intensity / Magnitude

This defines the impact as experienced by any receptor. In this report, the NSR is defined as any resident in the area but excludes faunal species (because guideline levels are not available for animals).		
Rating	**Description**	**Score**
Low	Increase in average sound pressure levels between 0 and 3 dB from the expected ambient sound levels. Ambient sound levels are defined by average fast-weighted ambient sound levels recorded during measurement dates.	1
Medium / Moderate	Increase in average sound pressure levels between 3 and 5 dB from the expected or measured ambient sound levels.	2
High	Increase in average sound pressure levels between 5 and 7 dB from the expected or measured ambient sound levels. Sporadic complaints expected.	3
Very High	Increase in expected or measured ambient sound pressure levels higher than 10 dBA. Medium to widespread complaints expected.	4

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned probabilities, resulting in a Significance Rating ("SR") value for each impact (prior to the implementation of mitigation measures) as highlighted in **Table 6-8**.

Table 6-8: Impact Assessment Criteria – Significance without Mitigation

SR<24	Low (L)	The anticipated impact will have negligible negative effects and will require little to no mitigation
24<**SR** <43	Medium (M)	The anticipated impact will have moderate negative effects and will require moderate mitigation measures
43<**SR** <62	High (H)	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact
63<**SR** <80	High (H)	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws"

7 METHODS: CALCULATION OF NOISE LEVELS

7.1 POINT[29] AND AREA[30] NOISES – CONSTRUCTION AND OPERATIONAL ACTIVITIES

The noise emissions from various sources were calculated in detail for the conceptual construction and operational activities by using the sound propagation algorithms described by the ISO 9613-2 model. The following were considered:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receivers 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;
- Screening corrections where applicable;
- Topographical layout; and
- Acoustical characteristics of the ground.

Potential operational cycles were not considered and a worst-case scenario was evaluated, assuming that all activities and equipment generate the maximum noise level 100% of the time.

The ISO 9613-2 noise propagation model is used, as it is the noise model most recommended to calculate WTN. The uncertainties and limitations of the ISO 9613 model is well defined; and while there are a number of different noise propagation models that one can use, all of them have uncertainties and limitations.

Therefore, the ISO 9613 noise propagation model is the model most frequently recommended, with this noise propagation model preferred in Australia (EPA, 2009) [**40**], the United Kingdom (IOA, 2013) [**65**], Canada (CanWEA, 2007) [**17**], United States of America (NARUC, 2011) [**89**] and the European Union (Directive 2002/49/EC)[31] [**25**, **36**].

[29] Typically a WTG, or a stationary noise generating activity or piece of equipment.
[30] Such as a large surface vibrating, up to a defined area where equipment is moving around. It can include an industrial project where the locations of noise generating activities or equipment cannot be defined. This is used as a worst-case, as the inclusion of a large area source(s) tend to over model noise levels.
[31] This directive does not recommend but actually stipulate the use of this noise model for industrial noise sources.

7.2 ROAD TRAFFIC NOISE LEVELS

The noise emission into the environment due to project road traffic (mainly construction traffic) will be estimated using a simplified noise propagation model described in SANS 10210:2004. It mainly considers the distance of receptor from the road as well as average speeds of travel. Factors that are not considered include:

- Topography and barrier effects (noise levels could be over-estimated);
- Road construction material (noise levels could be over-estimated);
- Types of vehicles used (noise levels could be under-estimated);
- Road gradient (noise levels could be over- or under-estimated); and
- Ground acoustical conditions (noise levels could be over-estimated).

8 ASSUMPTIONS AND LIMITATIONS

8.1 LIMITATIONS - ACOUSTICAL MEASUREMENTS AND ASSESSMENTS

Ambient sound levels are the cumulative effects of innumerable sounds generated at various instances both far and near. A high measurement may not necessarily mean that the area is always noisy. 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 day, dependant on faunal characteristics (such as mating season or dawn chorus[32]) early hours of the morning, temperature etc.), vegetation in the area and meteorological conditions (especially wind).

Selecting an ideal measurement location could be difficult, with various criteria assessed to identify the viability of a certain location as a point to define ambient sound levels. When selecting a measurement location, the most important criteria would be:

1. Security of the instrument (minimise risk to the technician; prevent theft; sabotage of the equipment);
2. Safety of the equipment (ensure that it does not prevent, interfere or limit typical agricultural or household activities; ensure that the instrument are not in a location where an animal could damage the instrument); and lastly,
3. The suitability of the measurement location to define ambient sound levels (the presence of certain trees or equipment, wetland or other water resources will influence ambient sound level significantly).

As such, after ensuring that the instrument is safe and secure, there are various environmental factors that could influence ambient sound levels measured. These constraints and limitations are discussed below and could include:

- Seasonal changes in the surrounding environment can influence typical ambient sound levels, as many faunal species are more active during warmer periods than the colder periods. As an example, cicada is usually only active during warmer periods. Certain cicada species can generate noise levels up to 120 dB for mating or distress purposes, sometimes singing in synchronisation magnifying noise levels they produce from their tymbals[(33)];
- Defining ambient sound levels using the result of one 10-minute measurement may be very inaccurate (very low confidence level in the results) relating to the reasons mentioned above, and measurements over a longer-term period is critical;

[(32)] Environ. We Int. Sci. Tech. *Ambient noise levels due to dawn chorus at different habitats in Delhi*. 2001. Pg. 134.
[(33)] Clyne, D. *"Cicadas: Sound of the Australian Summer, Australian Geographic"* Oct/Dec Vol 56. 1999.

- Some equipment that could influence measurements may be missed when deploying instruments, or, the equipment may not the audible. This could include equipment such as hidden water pumps and associated pipelines and outflows, ESKOM stepdown transformers, hidden compressors, inverters, condensers or other electrical equipment, etc. While not audible during deployment, such equipment may significantly influence ambient sound levels during quiet periods;
- Type, the number and sizes of trees in the vicinity of the instrument, as well as the distances between the microphone and these trees. Certain trees, especially fruiting trees could attract birds and other animals that will significantly impact on ambient sound levels;
- Type and number of animals in the vicinity of the microphone. Dogs, chickens, geese, etc. generate different noises randomly both night and day, and other livestock (sheep, goats, cattle, horses, etc.) kept in enclosures will also raise noise levels, especially if these animals are penned in large numbers;
- Measurements over wind speeds of 3 m/s could provide data influenced by wind-induced noises. However, when determining the ambient sound levels associated with increased wind speeds, it is desired to measure ambient sound levels at higher wind speeds;
- Ambient sound levels recorded near rivers, streams, wetlands, trees and bushy areas can be high due to faunal activity which can dominate the sound levels around the measurement point (specifically during summertime, rainfall event or during dawn chorus of bird songs). This generally is still considered naturally quiet and accepted as features of the natural environment, and in various cases sought after and pleasing. Ambient sound level data measured in such area however should not be used to develop an opinion in the potential prevailing ambient sound levels in the larger area;
- Exact location of a sound level meter in an area in relation to structures, infrastructure, vegetation, wetlands and external noise sources will influence measurements. It may determine whether you are measuring anthropogenic sounds from a receptors dwelling, or environmental ambient baseline contributors of significance (faunal, roads traffic, railway traffic movement etc.); and

  As a residential area develops the presence of people will result in increased dwelling related 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 an area matures.

8.2 CALCULATING NOISE EMISSIONS – ADEQUACY OF PREDICTIVE METHODS

Limitations due to the calculations of the noise emissions into the environment include the following:

- Many sound propagation models do not consider sound characteristics as calculations are based on an equivalent level (with the appropriate correction implemented e.g. tone or impulse). These other characteristics include intrusive sounds or amplitude modulation;
- Most sound propagation models do not consider refraction through the various temperature layers (specifically relevant during the night-times);
- Most sound propagation models do not consider the low frequency range (third octave 16 Hz – 31.5 Hz). This would be relevant to facilities with a potentially low frequency issue;
- Many environmental models consider sound to propagate in hemi-spherical way. Certain noise sources (e.g., a speaker, exhausts, fans) emit sound power levels in a directional manner;
- 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;
- Many environmental models are not highly suited for close proximity calculations; and
- Acoustical characteristics of the ground are over-simplified, with ground conditions accepted as uniform.

8.3 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 is 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.

8.4 UNCERTAINTIES ASSOCIATED WITH MITIGATION MEASURES

Any noise impact can be mitigated to have a low significance; however, the cost of mitigating this impact may be prohibitive, or the measure may not be socially acceptable (such as the relocation of an NSR). These mitigation measures may be engineered, technological or due to management commitment.

For the purpose of the determination of the significance of the noise impact mitigation measures were selected that are feasible, mainly focussing on management of noise impacts using rules, policy and require a management commitment. This, however, does not mean that noise levels cannot be reduced further, only that to reduce the noise levels further may require significant additional costs (whether engineered, technological or management).

It was assumed the mitigation measures proposed for the construction phase, if any is included and proposed in this report, will be considered during the planning phase, implemented during the construction phase and continued during the operational phase.

8.5 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:

- It is technically difficult and time-consuming to improve the measurement of spectral distribution of large equipment in an industrial setting. This is due to the many correction factors that need to be considered (e.g., other noise sources active in the area, adequacy of average time setting, surrounding field non-uniformity etc.[34] as per SANS 9614-3:2005);
- 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 are 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 worst-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

[34] SANS 9614-3:2005. "Determination of sound power levels of noise sources using sound intensity – Part 3: Precision method for measurement by scanning".

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 likely be over-estimated;
- Modelling cannot capture the potential impulsive character of a noise that can increase the potential nuisance factor, nor the potential effect of the modulation of amplitude of the noise;
- The XYZ topographical information is derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer ("ASTER") Global Digital Elevation Model ("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;
- Receiver height will be assumed at a 4m height above surface level as recommended by the Institute of Acoustics (IOA, 2013) [**65**] for the operational phase;
- Atmospheric conditions relating to an air temperature of 10°C and a 70% air humidity will be used to minimize the effect of air absorption (Bass *et al.*, 1996) [**6**], (IOA, 2013) [**65**], (Kaliski and Duncan, 2008) [**70**]; and
- Acoustical characteristics of the ground are over-simplified with ground conditions accepted as uniform. Seventy-five percent (75%) hard ground conditions will be assumed for the operational modelling, representing a potential worst-case scenario (Bass *et al.*, 1996) [**6**], (IOA, 2013) [**65**], (Kaliski and Duncan, 2008) [**70**].

Due to the uncertainties highlighted in section **8.2** and **8.5**, modelling generally could be out with as much as +10 dBA (the potential noise level is over-modelled), although realistic values ranging from 3 dBA to less than 5 dBA are more common in practice.

8.6 CONDITIONS TO WHICH THIS STUDY IS SUBJECT

This study is subject to the conditions as defined in **section 13**.

9 PROJECTED NOISE RATING LEVELS

9.1 Conceptual Scenarios – Noise due to Future Construction Activities

A noise model was developed considering the conceptual construction activities as discussed in **Section 5.1**. The proposed layout as provided by the applicant for the Koup 1 WEF is presented in **Figure 9-1**. As can be seen from this layout, a number of different activities might take place close to potential NSR, each with a specific potential impact.

As it is unknown where the different activities may take place, it was selected to model:

- the potential impact of road construction (or upgrading) activities, assuming a SPL of 103.5 dBA (re 1 pW), with potential noise levels plotted against distance as illustrated in **Figure 9-3**;
- the potential impact from construction traffic (road traffic noises) passing NSR, with potential noise levels plotted against distance as illustrated in **Figure 9-2**[35]; and
- the impact of the noisiest activity (laying of foundation totalling 113.6 dBA (re 1 pW) cumulative noise impact – various equipment operating simultaneously – see **Table 5-1**) at all locations where wind turbines may be erected, calculating how this may impact on noise levels at NSR[36] (see **Figure 9-3**).

The projected noise levels relating to the various construction activities are defined in

- **Appendix F, Table 2** for the construction of the access roads;
- **Appendix F, Table 3** relating to the noise from construction traffic;
- **Appendix F, Table 4** for daytime construction activities; and,
- **Appendix F, Table 5** for night-time construction activities (even though night-time activities may be unlikely to occur).

[35] Sound level at a receiver set at a certain distance from a road.
[36] The potential cumulative (worst-case) noise level due to construction activities at an NSR are plotted against the distance from the NSR and a potential construction activity.

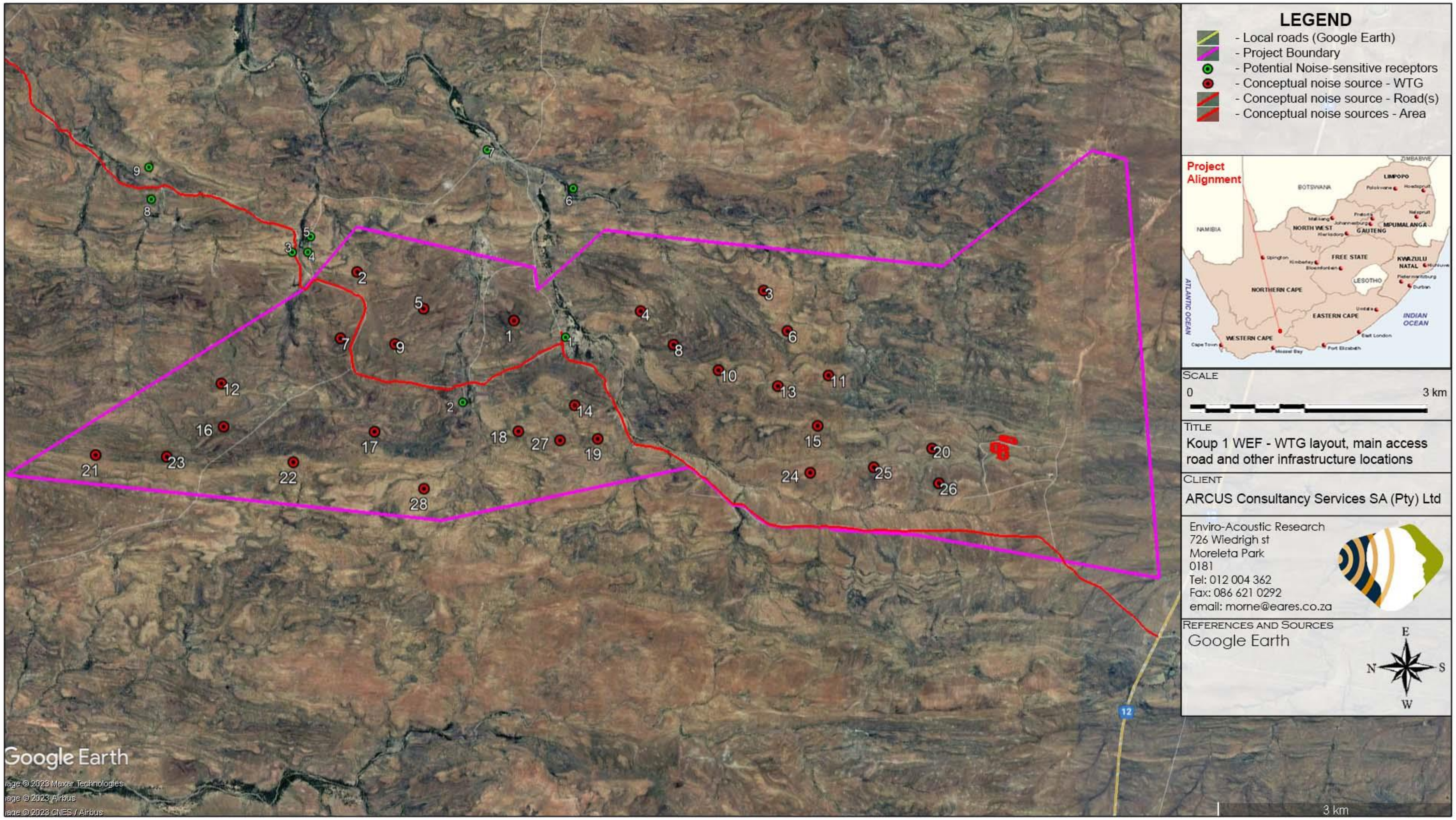

Figure 9-1: WTG locations and associated infrastructure for the proposed Koup 1 WEF

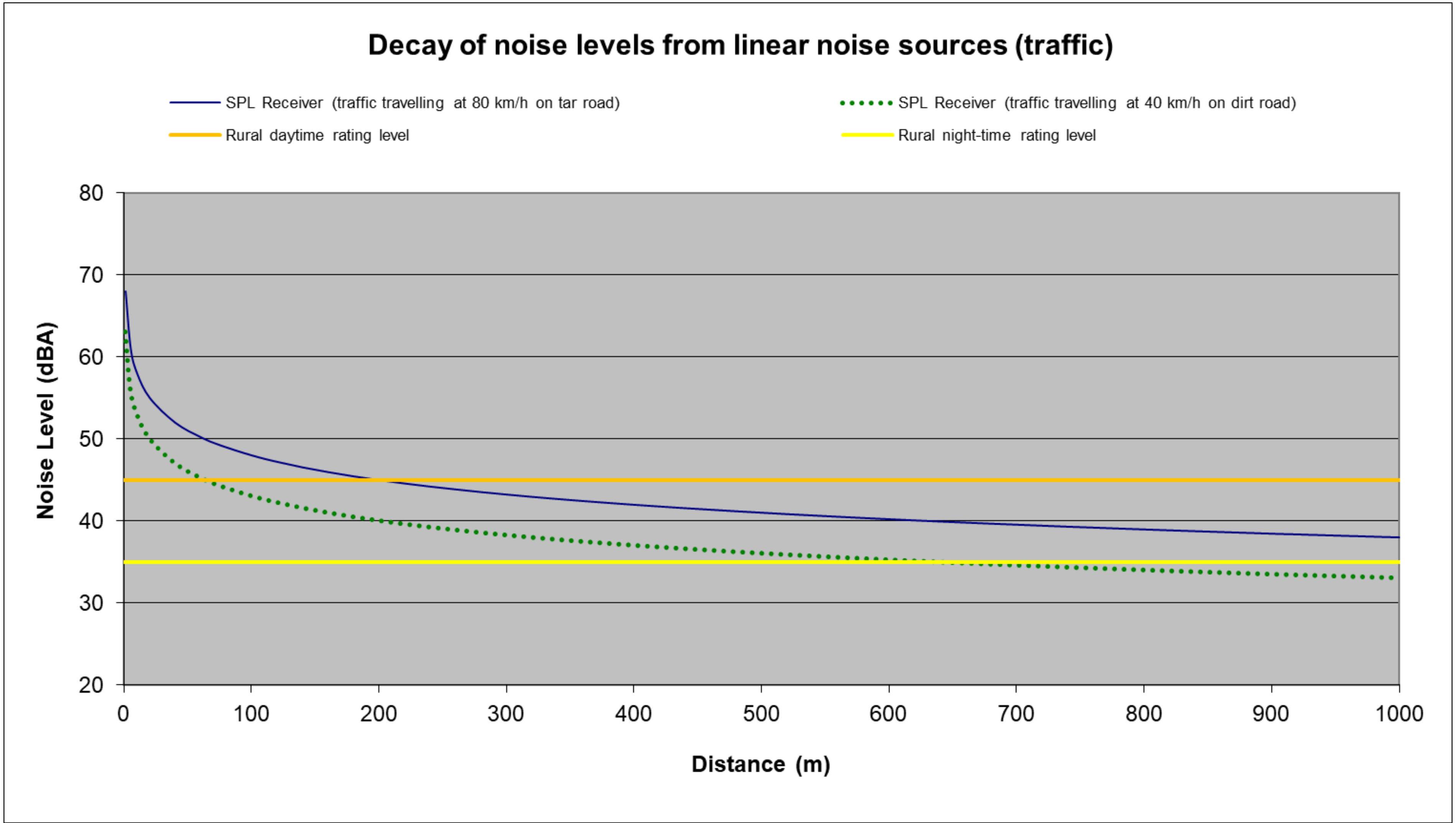

Figure 9-2: Projected conceptual construction noise levels – Decay over distance from linear activities (roads)

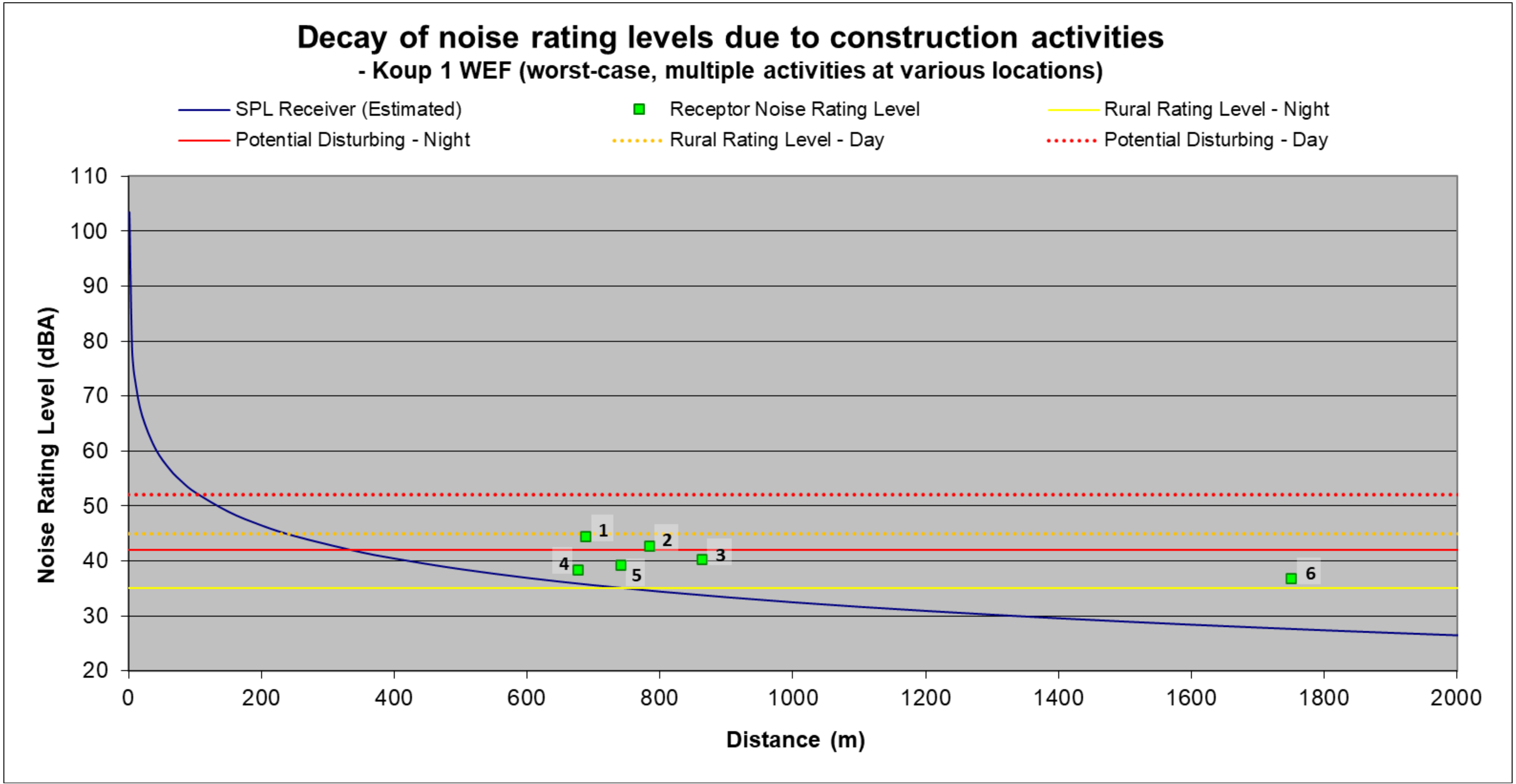

Figure 9-3: Projected conceptual construction noise levels for the proposed Koup 1 WEF

9.2 CONCEPTUAL SCENARIOS – NOISE DUE TO FUTURE OPERATIONAL ACTIVITIES

While the significance of daytime noise impacts was 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 during the night-time period is critical. It should be noted that maintenance activities normally take place during the day, but normally involve a few light-delivery vehicles moving around during the course of the day, an insignificant noise source. As such maintenance activities will not be considered.

Noise models were developed considering the conceptual operational activities as discussed in **Section 5.2**, with the potential noise rating level contours illustrated in **Figure 9-4** for a worst-case WTG (using a WTG with an SPL of 112.2 dBA re 1 pW). Ambient sound levels are assumed to be 43.5 dBA as proposed in **Table 6-2** at a 10 m/s wind speed. The projected worst-case noise levels are defined per NSR in **Appendix F, Table 6**.

The potential noise rating level contours associated with the quieter WTG (with an SPL of 107.1 dBA re 1 pW) is illustrated in **Figure 9-5** with the projected noise levels defined in **Appendix F, Table 7** per NSR.

9.3 POTENTIAL CUMULATIVE NOISE IMPACTS

Cumulative noise impacts generally only occur when noise sources (such as other wind turbines) are closer than 2,000m from each other (World Bank Group, 2015 **[145]**)). The cumulative impact also only affects the area between the wind turbines of the various wind farms and normally only relate to the operational phase.

If the wind turbines of one wind farm are further than 2,000 m from the wind turbines of the other wind farm, the magnitude (and subsequently the significance) of the cumulative noise impact is reduced. If the distance between the wind turbines of two (or more) wind farms are further than 4,000m, cumulative noise impacts are non-existent. This is illustrated in **Figure 9-6**.

The following wind farms are either authorized (but not yet constructed), or proposed within approximately 10 km of the Koup 1 WEF:

- The authorized Beaufort West WEF is located just south-east of the proposed Koup 1 WEF (though there are no NSR situated between the potential area of influence of the Beaufort West and Koup 1 WEFs);
- The authorized Trakas WEF is located south-west of the proposed Koup 1 WEF (just south-west of the authorized Beaufort West WEF);
- Kwagga 1, 2 and 3 WEFs. The exact location of the WTG of these WEFs is not available to the author, with the Renewable Energy EIA Application Database indicating this project boundary approximately 8km to the east of the Koup 1 WEF. The cumulative influence of the Kwagga WEF will be insignificant;
- The Kraaltjies WEF, with its closest WTG located approximately 5km east of the closest WTG of the Koup 1 WEF.

The WTG of the Koup 1, Koup 2, Beaufort West, Trakas and Kraaltjies WEFs were included in the noise model, with the potential cumulative noise rating levels illustrated in **Figure 9-7**, with the noise rating levels defined per NSR in **Appendix F, Table 8** (considering the worst-case scenarios). The noise rating levels were calculated for the area up to 5,000m from the WTG of the Koup 1 WEF.

9.4 POTENTIAL DECOMMISSIONING, CLOSURE AND POST-CLOSURE NOISE LEVELS

The potential for a noise impact to occur during the decommissioning and closure phase will be much lower than that of the construction and/or operational phases. This is because:

- Decommissioning activities normally are limited to the daytime period, due to the lower urgency to complete this phase; and
- Decommissioning activities normally use smaller and less equipment, generating less noise than the typical construction or operational phases.

If required, the noise levels for decommissioning can be compared with the daytime construction phase noise level and the noise impact is similar or less.

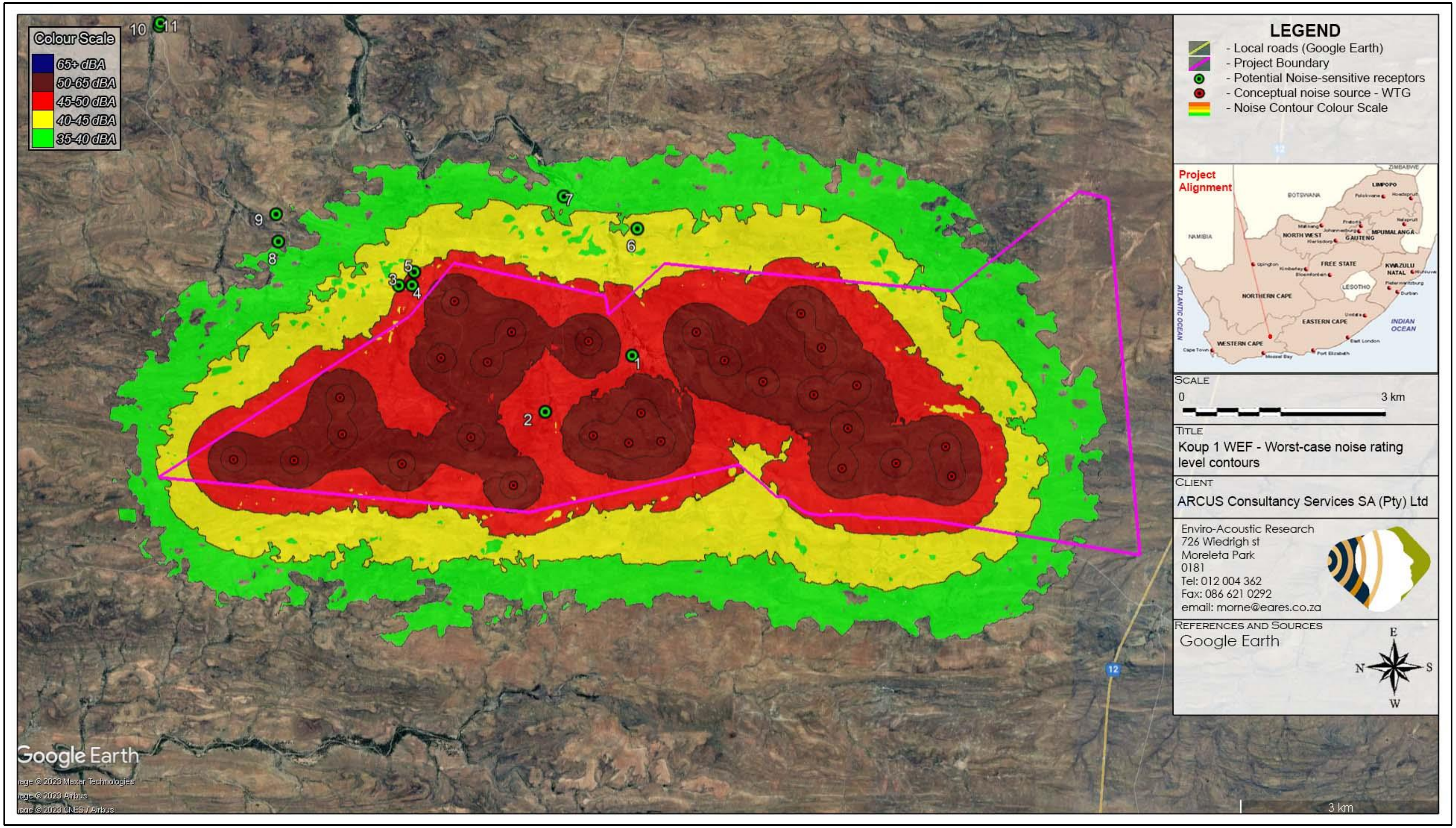

Figure 9-4: Projected future noise rating level contours (worst-case WTG with SPL of 112.2 dBA re 1 pW)

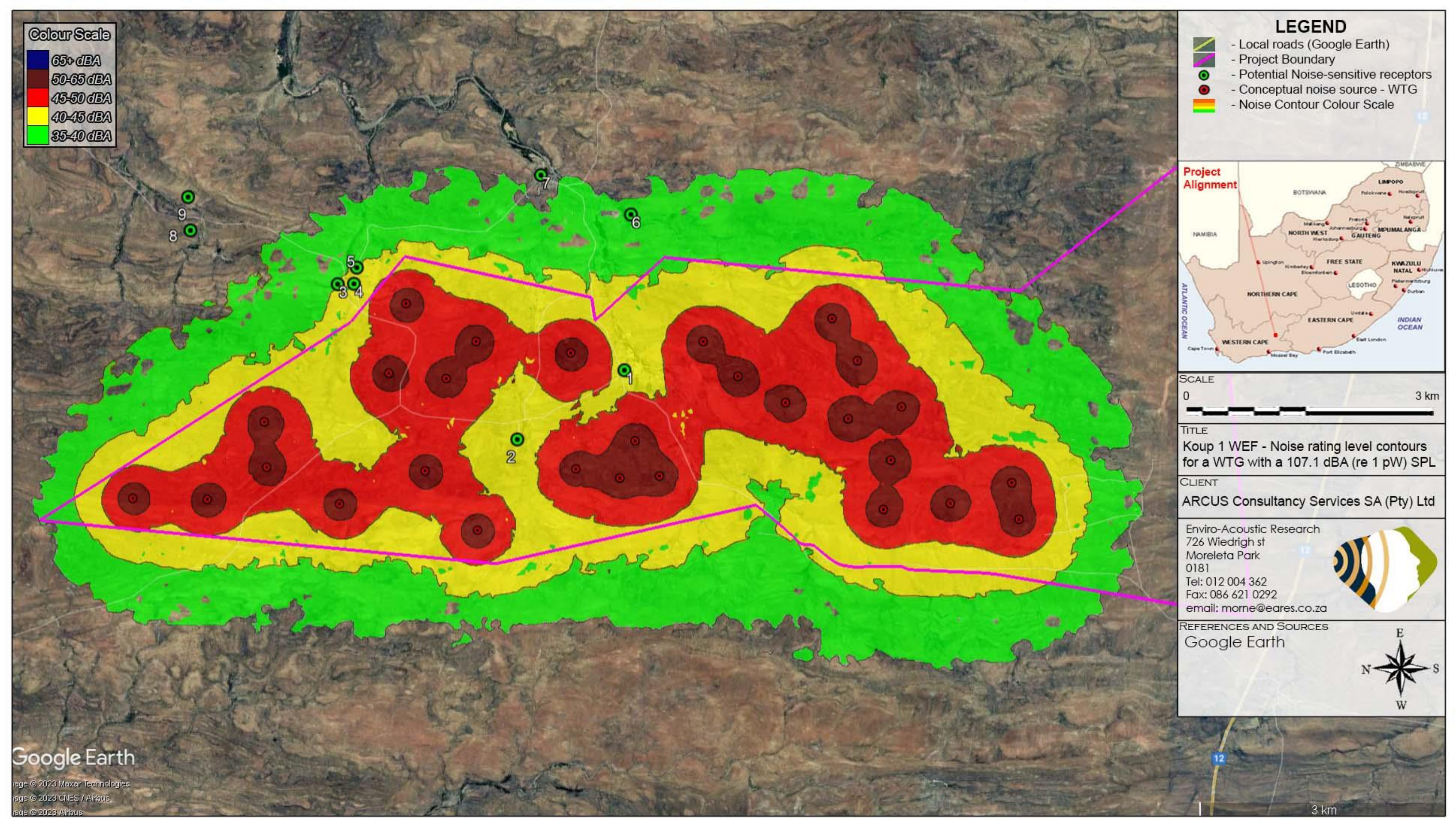

Figure 9-5: Projected future noise rating level contours (WTG with SPL of 107.1 dBA re 1 pW)

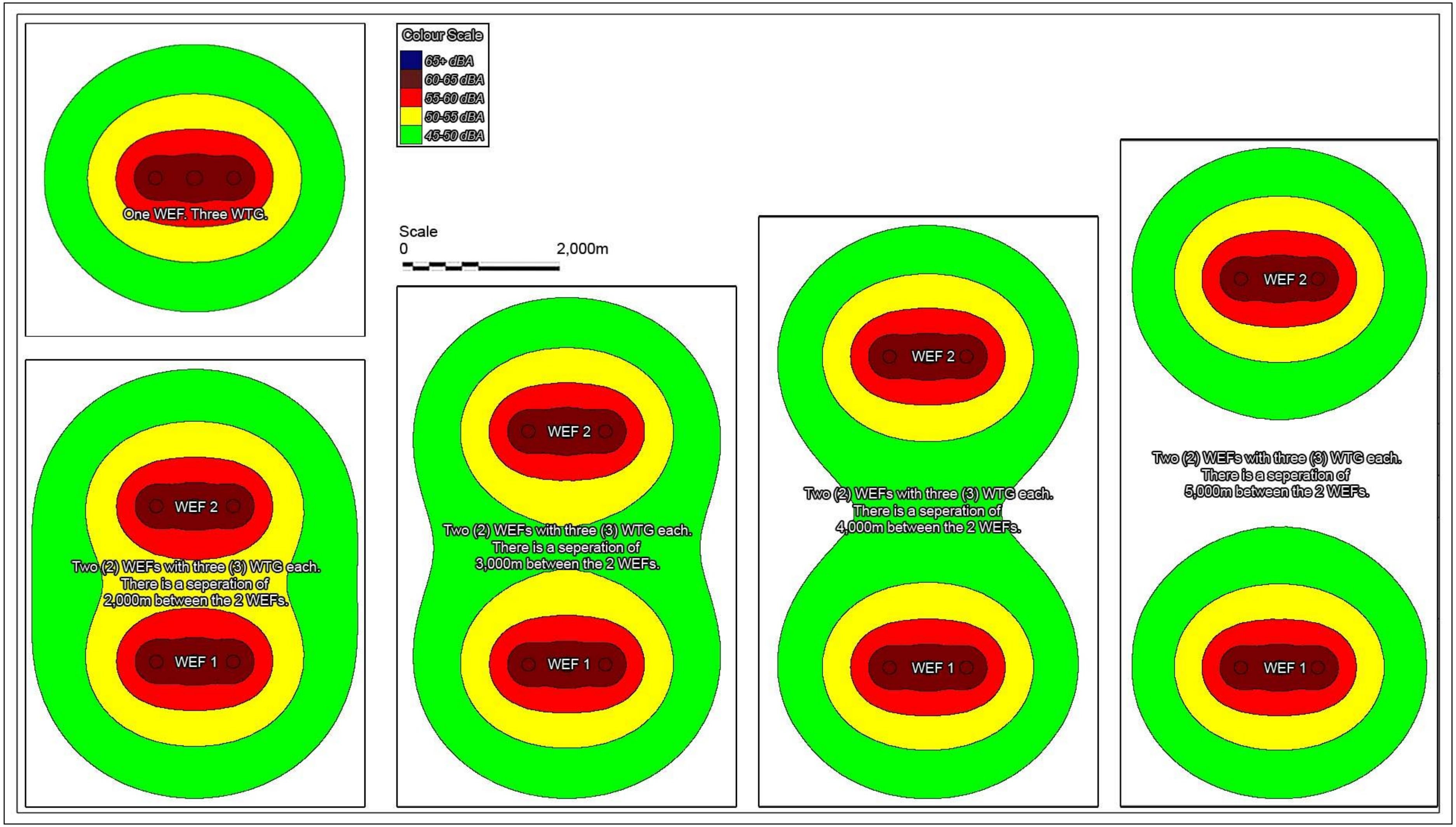

Figure 9-6: Effect of distance between wind turbines – potential cumulative noise

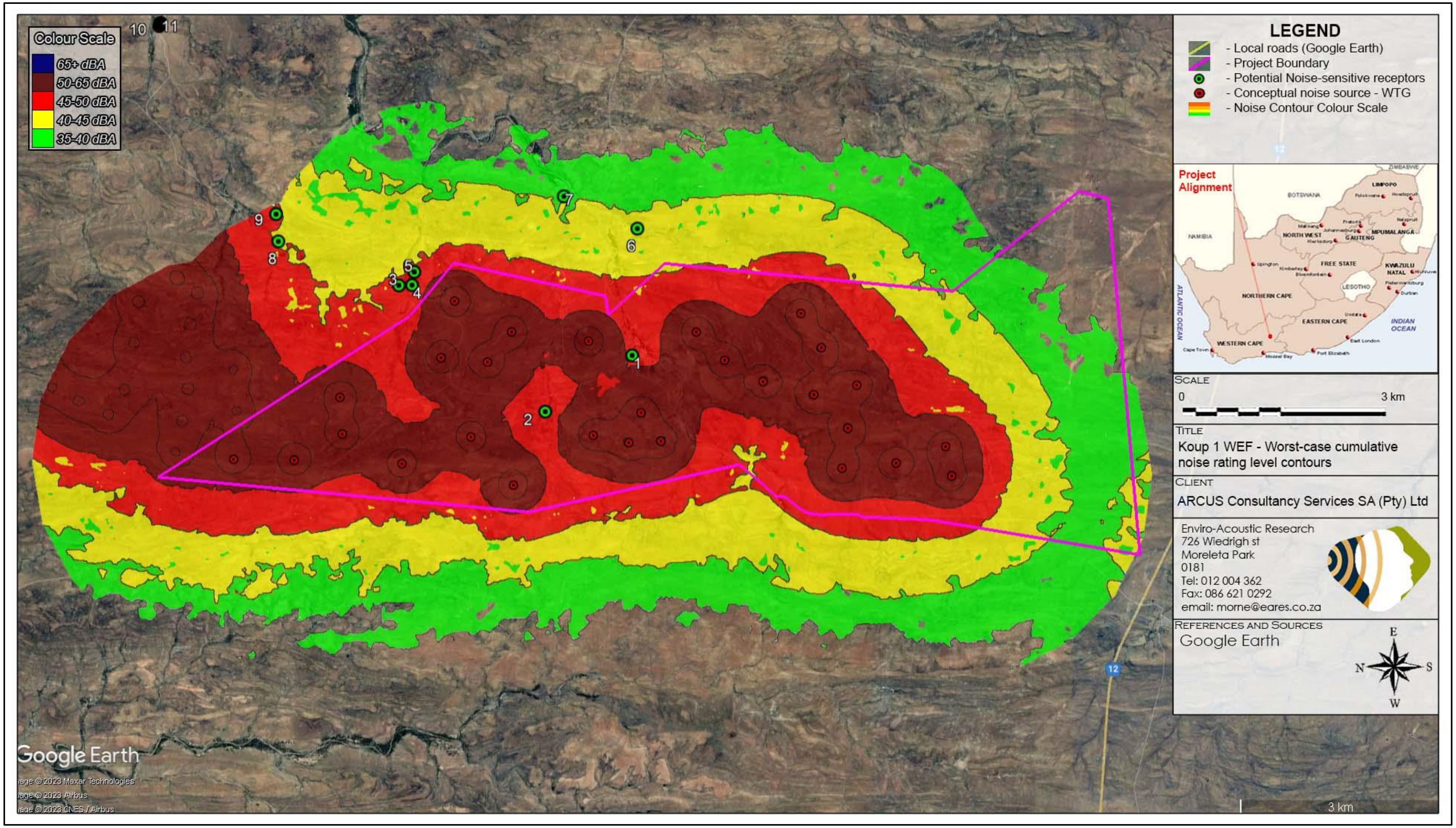

Figure 9-7: Projected future cumulative noise rating level contours (worst-case SPL of 112.2 dBA re 1 pW)

10 SIGNIFICANCE OF THE NOISE IMPACT

10.1 NOISE IMPACT DUE TO FUTURE CONSTRUCTION ACTIVITIES

10.1.1 Noises relating to the Planning and Design Phase

Activities that relate to the planning and design phases are normally limited to surveying and site visits by the applicant and specialists. These activities are normally limited to the daytime period, with the activities having temporary noise impacts of a minor consequence. Noises impacts are generally negligible (insignificant) the potential noise impact associated with the planning and design phase will not be considered in this assessment. The potential impact is summarized in Error! Reference source not found..

However, should the assessment indicate a potential noise impact of medium or high significance for the construction and/or operational phases, appropriate mitigation measures to reduce this noise impact must be designed and/or selected during the planning and design phase.

10.1.2 Noises associated with construction activities

The potential noise levels for the various construction activities (as conceptualised) were calculated in **section 9.1**. The potential significance of the construction noise impacts was:

- estimated per NSR in **Appendix F, Table 2** when considering construction activities associated with access roads, with the potential significance of the daytime noise impact summarized in **Table 10-1** (**sub-section 10.5**);
- estimated per NSR in **Appendix F, Table 3** when considering construction traffic noises, with the potential significance of the daytime noise impact summarized in **Table 10-2** (**sub-section 10.5**);
- calculated per NSR in **Appendix F, Table 4**, with the potential significance of the daytime noise impact summarized in **Table 10-3** (**sub-section 10.5**); and,
- calculated per NSR in **Appendix F, Table 5**, with the potential significance of the night-time noise impacts[37] is summarized in **Table 10-4** (**sub-section 10.5**); (**sub-section 10.5**).

[37] While night-time construction activities are not envisaged, but there may be times when activities may take place after 22:00 at night, or before 06:00 in the mornings. Considering potential delays' relating to civil works (especially concrete pouring that must be undertaken in one go).

10.2 Noise Impact due to Future Operational Activities

The noise levels associated with the operating WTG was calculated in **section 9.2**, with the noise levels illustrated in **Figure 10-1** for different wind speeds and illustrated in **Figure 9-4** for the worst-case WTG (using a SPL of 112.2 dBA re 1 pW) and **Figure 9-5** for a potential mitigated scenario (using a WTG with an SPL of 107.1 dBA re 1 pW).

The potential significance of operational noise impacts was summarized in **Table 10-5** (**sub-section 10.5**) for the daytime period and in **Table 10-6** (**sub-section 10.5**) for the night-time period.

Noise rating levels as well as the significance of a potential noise impact is calculated per NSR in **Appendix F, Table 6** for the unmitigated scenario and in **Appendix F, Table 7** for the mitigated scenario.

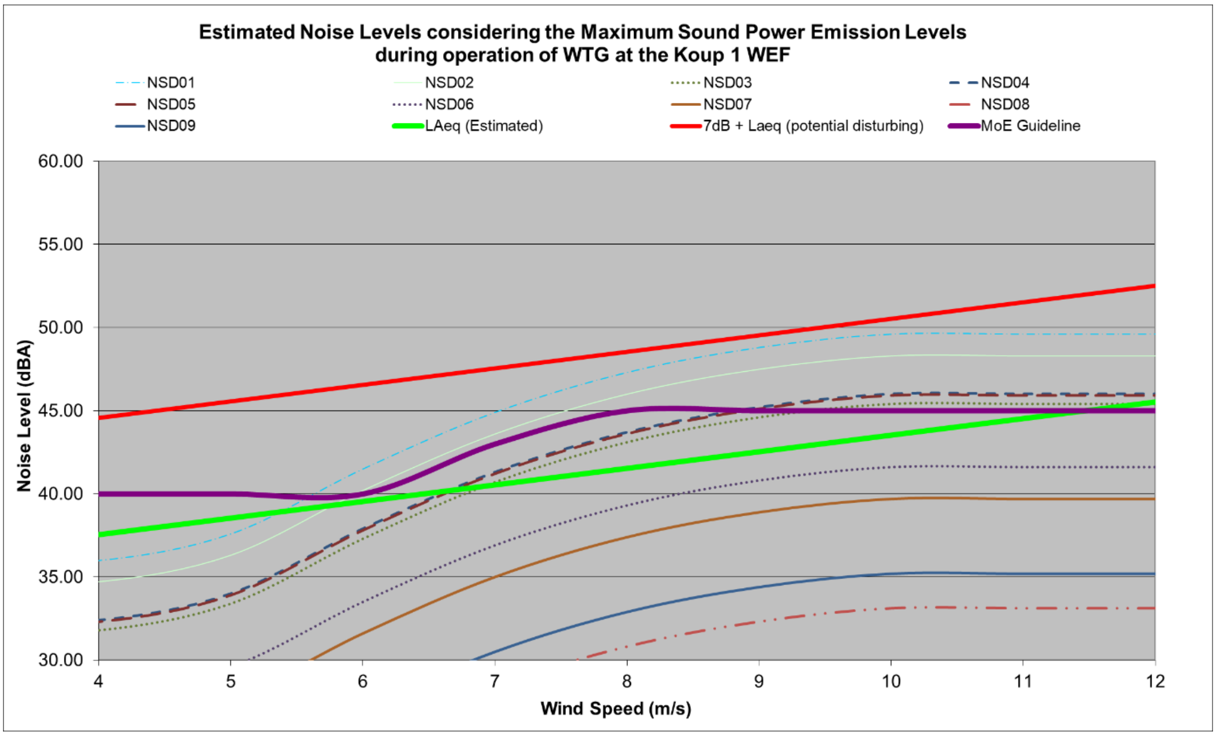

Figure 10-1: Projected noise levels at different wind speeds (worst-case SPL)

10.3 Cumulative Noise Impact from Other WEFs

There is a very low risk of cumulative noises during the construction phase, because it is unlikely that construction activities will take place simultaneously at these different WEFs.

Only NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs, and there is a potential for a cumulative impact at these NSR. Total cumulative noise levels will be higher than 45 dBA at these NSR, with most of acoustic energy originating from the Koup 1 WEF, with the WTG of the Koup 2 WEF contributing less than 2 dBA at these NSR.

Noises from other WEFs within 35 km will have an insignificant influence on the noise levels at the NSR. Potential cumulative noise impacts were calculated per NSR in **Appendix F, Table 8** for a worst-case scenario evaluated (only the night-time period was investigated), with the findings summarized in **Table 10-7**.

10.4 EVALUATION OF ALTERNATIVES

10.4.1 Alternative 1: No-go option

The ambient sound levels will remain as is and the area would keep the rural noise character.

10.4.2Alternative 2: Proposed Renewable Power Generation activities

The proposed renewable energy activities (worst-case evaluated) will slightly raise the noise levels at a number of the closest potential NSR. 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 sustainable layout.

Considering the ambient sound levels measured on-site, the projected noise rating levels will be elevated at the closest NSR, and have a similar or less than the on-site ambient sound levels at NSR located further than 2,000 m from the WTG. It is slightly possible that the noise rating levels could exceed the ambient sound levels during certain periods although it is unlikely to impact on the quality of living (at night) at receptors living further than 2,000m from WTG. Mitigation is available and included to reduce the potential noise impact on NSR identified closer to proposed WTG.

The project however 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.

10.5 Noise Impact Assessment Tables

Table 10-1: Impact Assessment: Construction of access roads

Nature of Impact: Daytime ambient sound levels could range from less than 20dBA to more than 55dBA, averaging at 29.8dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). Road construction activities will increase ambient sound levels due to air-borne noise during quiet periods. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 2** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road upgrading/construction activities will be very temporary (less than 1 year).	**Medium (40)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Very High (4)	The construction of the access road will raise the noise levels to higher than 55 dBA on a temporary basis.	
Probability (Table 6-5)	Definite (4)	It is definite that road construction (or road upgrading) activities will impact on the closest NSR.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Relocating the access roads further than 120m from structures used for residential purposes (during the construction phase) will significantly reduce the significance of the noise impact.			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road upgrading/construction activities will be very temporary (less than 1 year).	**Low (21)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Medium (2)	With management noise levels could be reduced to less than 52 dBA	
Probability (Table 6-5)	Possible (2)	With management the probability of the noise impact can be reduced to possible.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-2: Impact Assessment: Construction traffic noises

Nature of Impact: Daytime ambient sound levels could range from less than 20dBA to more than 55dBA, averaging at 29.8dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). Construction traffic passing NSR could increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 3** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road upgrading/construction activities will be very temporary (less than 1 year).	**Medium (32)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	

Magnitude (Table 6-7)	Very High (4)	Construction traffic passing NSR may increase noise levels higher than the rural rating level.	
Probability (Table 6-5)	Possible (4)	It is definite that road construction (or road upgrading) activities will impact on the closest NSR.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required. Relocating the access roads further than 120m from structures used for residential purposes (during the construction phase) will significantly reduce the significance of the noise impact.			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Short (1)	The noise impact relating to road traffic passing NSR will be temporary to short term.	**Low (16)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Medium (2)	With management noise levels could be reduced to less than 52 dBA	
Probability (Table 6-5)	Possible (2)	With management the probability of the noise impact can be reduced to possible.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-3: Impact Assessment: Daytime WTG construction activities

Nature of Impact: Daytime ambient sound levels could range from less than 20dBA to more than 55dBA, averaging at 29.8dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). Various construction activities (development of laydown areas and the hard standing areas, excavation of foundations, concreting of foundations and the assembly of the wind turbines tower and components, as well as construction of other infrastructure) taking place simultaneously during the day will increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 4** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Medium (28)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	
Magnitude (Table 6-7)	Very High (4)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential measures could include: • Applicant to minimize simultaneous construction activities when working within 1,000m from NSR (such as limiting construction activities at one WTG location); • Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life.			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Low (21)**
Extent (Table 6-4)	Site (1)	The noise impact would mostly be limited to the site.	

Magnitude (Table 6-7)	High (3)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-4: Impact Assessment: Night-time WTG construction activities

Nature of Impact: Night-time ambient sound levels could range from less than 20dBA to more than 39dBA, averaging at 23.3dBA. The low ambient sound levels relate to the low wind speeds experienced during the site visit, as well as with the site visit taking place during the winter month period (when faunal communication is generally lower). While unlikely to take place, various construction activities (likely limited to the pouring of concrete as well as erection of WTG components) taking place simultaneously at night will increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 5** and summarized in this table.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Medium (40)**
Extent (Table 6-4)	Local (2)	Construction noises may extent from the site, especially during quiet periods.	
Magnitude (Table 6-7)	Very High (4)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Possible (2)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Mitigation / Management Measures			
Mitigation: Significance of the construction noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential measures could include: • Applicant to minimize simultaneous construction activities when working within 2,000m from NSR (such as limiting construction activities at one WTG location); • Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life; • The Applicant to minimize night-time activities when working within 2,000m from any structure used for residential purposes where possible. Work should only take place at one WTG location to minimize potential night-time cumulative noises (when working at night within 2,000m from NSR used for residential purposes); • The applicant must notify the NSR when night-time activities will be taking place within 2,000m from the NSR (including construction traffic passing NSR); and • The applicant must plan the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period (even though it is expected that it is highly unlikely that this may take place at night).			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Medium (2)	The noise impact relating to construction phase will last 1 – 3 years.	**Low (20)**
Extent (Table 6-4)	Local (2)	Construction noises may extent from the site, especially during quiet periods.	
Magnitude (Table 6-7)	Medium (2)	Simultaneous construction activities may increase residual noise levels.	
Probability (Table 6-5)	Possible (2)	It is improbable that daytime construction activities will impact on NSR in the PFA.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the construction noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-5: Impact Assessment: Daytime operation of WTG considering the worst-case SPL

Nature of Impact: WTG will only operate during period with increased winds, when ambient sound levels are higher than periods with no or low winds. As discussed and motivated in **section 6.4** (as proposed in **Table 6-2** and illustrated in **Figure 4-33**), ambient sound levels will likely be higher, with this assessment assuming an ambient sound level of 43.5 dBA (for a 10 m/s wind speed). Numerous WTG of the Koup 1 WF operating simultaneously during the day will increase ambient sound levels due to air-borne noise from the WTG. Ambient sound levels are normally higher during the daytime period, with receptors generally more active and distracted which would decrease the probability of an impact occurring (when compared to the night-time period). The projected noise levels and the potential change in ambient sound levels is defined for the identified NSR in **Appendix F, Table 6**.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**Medium (44)**
Extent (Table 6-4)	Local (2)	The noise impact would extent from the site, potentially as far as 1,000 from WTG.	
Magnitude (Table 6-7)	Very High (4)	Operational noise may be audible at the closest NSR.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime operational noises will impact on NSR in the area.	
Mitigation / Management Measures			

Mitigation: Significance of the daytime operational noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential mitigation measures would include:
• The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA); **<u>or</u>**
• The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR. For the currently layout, noise levels less than 45dBA would be possible when relocating:
  ○ WTG 1 and 14 further than 2,500m from NSR01; **<u>and</u>**
  ○ WTG 17, 18 and 28 further than 2,500m from NSR02; **<u>and</u>**
  ○ WTG 2 further than 2,500m from NSR04.
• The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.			

Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**Low (16)**
Extent (Table 6-4)	Local (2)	The noise impact would extent from the site, potentially as far as 1,000 from WTG.	
Magnitude (Table 6-7)	Medium (2)	Operational noise may be audible at the closest NSR.	
Probability (Table 6-5)	Improbable (1)	It is improbable that daytime operational noises will impact on NSR in the area.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the operational noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-6: Impact Assessment: Night-time operation of WTG considering the worst-case SPL

Nature of Impact: WTG will only operate during period with increased winds, when ambient sound levels are higher than periods with no or low winds. As discussed and motivated in **section 6.4** (as proposed in **Table 6-2** and illustrated in **Figure 4-33**), ambient sound levels will likely be higher, with this assessment assuming an ambient sound level of 43.5 dBA (for a 10 m/s wind speed).

Numerous WTG of the Koup 1 WF operating simultaneously at night will increase ambient sound levels due to air-borne noise from the WTG. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix F, Table 6** (worst-case scenario) and summarized in this table. The potential noise level (and significance) when using a quieter WTG (such as a WTG with an SPL of 107.2 dBA re 1 pW) is also presented in **Appendix F, Table 7**.			
Impact description: Increase in residual noise levels in the vicinity of the project site.			
Prior to Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**High (44)**
Extent (Table 6-4)	Local (2)	The noise impact would extent from the site, likely further than 1,000 from WTG.	
Magnitude (Table 6-7)	Very High (4)	Operational noise will be audible and likely be at a disturbing level at the closest NSR.	
Probability (Table 6-5)	Probable (3)	It is probable that night-time operational noises will impact on NSR in the area.	
Mitigation / Management Measures			
Mitigation: Significance of the daytime operational noise impact is **medium** for the scenario as conceptualized and additional mitigation measures are required and recommended. Potential mitigation measures would include: • The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA); **or** • The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR. For the currently layout, noise levels less than 45dBA would be possible when relocating: o WTG 1 and 14 further than 2,500m from NSR01; **and** o WTG 17, 18 and 28 further than 2,500m from NSR02; **and** o WTG 2 further than 2,500m from NSR04. • The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.			
Post Mitigation			
	Rating	Motivation	Significance
Duration (Table 6-3)	Long (3)	The noise impact will last for the duration of the operational phase of the project.	**Low (20)**
Extent (Table 6-4)	Local (2)	The noise impact could extent from the site, potentially further than 1,000 from WTG.	
Magnitude (Table 6-7)	Medium (2)	Operational noise will be audible at the closest NSR.	
Probability (Table 6-5)	Possible (2)	It is possible that night-time operational noises will impact on NSR in the area.	
Cumulative impacts: Potential of cumulative noise impact is low.			
Residual Risks: Significance of the operational noise impact is **low** for the scenario as conceptualized and additional mitigation measures are not required.			

Table 10-7: Impact Assessment: Potential Cumulative Noise Impacts

Aspect / Impact pathway: Wind turbines from various WEFs operating simultaneously at night. Increases in ambient sound levels due to air-borne noise from all the wind turbines in area. The addition of the Koup 1 WEF will not cumulatively add to the noise levels in the area.		
Nature of potential impact: Increase in ambient sound levels.		
	Overall impact of the proposed project considered in isolation (post mitigation) – see Appendix F, Table 8	**Cumulative impact of the project and other projects in the area (post mitigation)**
Duration (Table 6-3)	Long (3)	Long (3)
Extent (Table 6-4)	Local (2)	Local (2)
Magnitude (Table 6-7)	Very High (4)	Very High (4)
Probability (Table 6-5)	Probable (3)	Probable (3)
Significance	**High (44)**	**High (44)**
Status (+ or -)	Negative	Negative
Reversibility	High	High

<table>
<tr><td>Loss of resources?</td><td>No</td><td>No</td></tr>
<tr><td>Can impacts be mitigated?</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="3">Mitigation:
The significance of the potential cumulative noise impact is high, though this mainly relate to the noises from the Koup 1 WEF project (the contribution from the Koup 2 WEF is less than 1 dBA).</td></tr>
<tr><td colspan="3">Residual Risks:
There is no risk of any residual noises.</td></tr>
</table>

11 MITIGATION OPTIONS

This study considers the potential noise impact on the surrounding environment due to the construction, operational and future decommissioning activities associated with the Koup 1 WEF project. It was determined that the potential noise impacts, without mitigation, would be:

- of a **medium significance** for the construction of access roads (or upgrading of existing roads). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** relating to noises from construction traffic. This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the assembly of the WTG and other infrastructure). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a potential **medium significance** for the night-time construction activities (the potential pouring of concrete, erection of WTG). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for daytime operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level; and
- of a **high significance** for night-time operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available and included in this assessment that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level.

There is a slight potential for a cumulative noise impact to occur during the operational phase. NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs and there is a slight cumulative impact at these NSR. Total cumulative noise levels are higher than 45 dBA at these NSR, but this noise impact mainly relates to noises from operating WTG of the Koup 1 WEF (potential noise levels due to the WTG of the Koup 2 WEF will be less than 40 dBA). Due to the **high significance** of the noise impact for the operational phase, the significance will remain high for the cumulative scenario.

The project 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 will be inaudible due to existing high ambient sound levels. The magnitude of the sound 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).

The developer must implement a line of communication (i.e., a help line where complaints could be lodged). All potential sensitive receptors should be made aware of these contact numbers. The proposed WEFs should maintain a commitment to the local community (people staying within 2,000 m from construction or operational activities) and respond to noise concerns in an expedient fashion. Sporadic and legitimate noise complaints could be raised. For example, sudden and sharp increases in sound levels could result from mechanical malfunctions or perforations or slits in the blades. Problems of this nature can be corrected quickly and it is in the developer’s interest to do so.

11.1 Mitigation options available to reduce Noise Impact during the Construction Phase

The significance of the noise impact will be of a **medium** significance for both day- and night-time activities and additional mitigation measures are required or recommended.

Night-time activities especially may generate noises at sufficient level to be annoying to some NSR and the following measures could reduce annoyance with construction activities. Potential measures could include:

- The applicant can relocate the access road further than 120m from structures used for residential purposes during the construction period;
- Applicant to minimize simultaneous construction activities when working within 2,000m from NSR (such as limiting construction activities at one WTG location);
- Applicant to discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life;
- The Applicant to minimize night-time activities when working within 2,000m from any structure used for residential purposes where possible. Work should only take place at one WTG location to minimize potential night-time cumulative noises (when working at night within 2,000m from NSR used for residential purposes);
- The applicant must notify the NSR when night-time activities will be taking place within 2,000m from the NSR (including construction traffic passing NSR); and
- The applicant must plan the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period (even though it is expected that it is highly unlikely that this may take place at night).

11.2 MITIGATION OPTIONS AVAILABLE TO REDUCE NOISE IMPACT DURING OPERATION

The significance of the noise impact during the operation phase could be **medium** for daytime activities, but of a **high** significance for night -time operations. Operating WTG however will be clearly audible at closest NSR, especially at night. Potential measures could include:

- The applicant can select a WTG with a lower SPL (e.g., a WTG with a SPL less than 107.5 dBA re 1 pw) – the scenario illustrated in **Figure 9-5**; **or**
- The applicant can relocate one or NSR located within the 45dBA noise rating level contours;
- The layout must be changed to locate WTG further from NSR, considering the potential cumulative effect of all WTG located within 2,500 m from NSR[38].
- The applicant can develop a noise abatement program to reduce the noise emission levels (the applicant must select an WTG that offer a reduced noise emission mode during the planning stage) at certain wind speeds, and/or if the wind blows in a certain direction for a number of WTG (WTG within approximately 2,500m from

- For the currently layout, noise levels less than 45dBA would be possible when relocating:
  - WTG 1 and 14 further than 2,500m from NSR01; **and**
  - WTG 17, 18 and 28 further than 2,500m from NSR02; **and**
  - WTG 2 further than 2,500m from NSR04.

NSR). The applicant should consider the potential reduction in power generation capacity of WTG operating in a reduced noise mode.

To ensure that noise does not become an issue for future residents, landowners or the local communities, it is recommended that the applicant get written agreement from current landowners/community leaders that no new residential dwellings will be developed within areas enveloped by the 42dBA noise level contour (of the Koup 1 WEF). Dwellings and structures located within the 45dBA noise rating level contour should not be used for permanent residential activities.

11.3 MITIGATION OPTIONS AVAILABLE TO REDUCE NOISE IMPACT DURING DECOMMISSIONING

The potential significance of the noise impact would be similar as the construction phase (medium significance at worst), though it is likely that it would be of a low significance because:

- Decommissioning activities normally are limited to the daytime period, due to the lower urgency to complete this phase; and
- Decommissioning activities normally use smaller and less equipment, generating less noise than the typical construction or operational phases.

Mitigation recommended for the construction phase would be applicable for the decommissioning phase.

11.4 MITIGATION AND MANAGEMENT CONDITIONS TO BE INCLUDED IN THE EMPR AND ENVIRONMENTAL AUTHORIZATION

It is recommended that the project applicant:

1. re-evaluate the noise impact should the layout be revised where:
    a. any WTG, located within 1,500 m from a confirmed NSR, are moved closer to the NSR;
    b. the number of WTG within 2,500m from an NSR are increased.
2. re-evaluate the noise impact once the final make and model of WTG was selected (if the project proceed, if the final make and model of the WTG is different from the WTG assessed in this report, considering the latest WTG layout as well as the specific characteristics of the selected WTG) to ensure that the projected maximum noise level will be less than 45 dBA;
3. design and implement a noise monitoring program, measuring ambient sound levels before construction activities start, as well as during the operational phase

(recommended at NSR01, NSR02 and NSR04). If any of these structures are not used for residential purposes, noise monitoring at these locations can be removed;

4. ensure that mobile heavy equipment is well maintained and fitted with the correct and appropriate noise abatement measures. 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;
5. include a component covering environmental noise in the Health and Safety Induction to sensitize all employees and contractors about the potential impact from noise, especially those employees and contractors that have to travel past receptors at night, or might be required to do work close (within 2,000m) to NSR at night. This should include issues such as minimising the use of vehicle horns;
6. investigates any reasonable and valid noise complaint if registered by a receptor staying within 2,000m from the location where construction activities are taking place, or where night-time construction activities are required, or where an operational WTG are located. A complaint register, keeping a full record of the complaint, must be kept by the applicant;
7. discuss the projected construction noise levels with NSR, highlighting that while noises will be clearly audible when activities are taking place within 2,000m from NSR, that measures will be implemented to minimise the potential impact on their quality of life;
8. with regard to unavoidable noisy night-time construction activities in the vicinity of NSR (closer than 2,000m from any identified NSR), the contractor and Environmental Control Officer (ECO) must liaise with local NSR on how best to minimise impact and the NSR must be kept informed of the nature and duration of intended activities; and
9. where practicable, mobile equipment should be fitted with broadband (white-noise generators/alarms [39] [40]), rather than tonal reverse alarms.

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[39] White Noise Reverse Alarms: http://www.brigade-electronics.com/products.

[40] https://www.constructionnews.co.uk/home/white-noise-sounds-the-reversing-alarm/885410.article - White noise sounds the reversing alarm

12 ENVIRONMENTAL MONITORING PLAN

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

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

Active noise monitoring is recommended because the projected noise levels are more than 38.7dBA (the level defined by the WHO where noise levels from WTG may become annoying) for the layout and WTG as assessed in this report. Noise levels may be higher than 45dBA at certain NSR for a WTG with an SPL exceeding 107.5dBA (re 1 pW).

In addition, should a reasonable and valid noise complaint be registered, the Applicant should investigate the noise complaint as per the guidelines in **sub-section 12.1** and **12.2**. These guidelines should be used as a rough guideline as site-specific conditions may require that the monitoring locations, frequency or procedure be adapted.

12.1 MEASUREMENT LOCALITIES AND FREQUENCY

The applicant must develop and implement an environmental noise monitoring programme before the construction phase starts, conducting active night-time noise measurements at NSR01, NSR02 and NSR04.

The applicant must repeat the environmental noise monitoring during the operational phase (once the WEF is fully operational) at the same locations at least once. Ambient sound levels must be measured at these NSR before the development of the WEF, with the measurements repeated after the first year of operation. Should any of these locations not being used for residential purposes, measurements at these NSR would not be required.

In addition, should there be a valid and reasonable noise complaint, once-off 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.

The noise specialist employed to do the noise monitoring must recommend and motivate the need (or not) for continued noise monitoring.

12.2 MEASUREMENT PROCEDURES

Ambient sound 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 48 hours, covering at least a full day- (06:00 – 22:00) and two full night-time (22:00 – 06:00) periods (though longer measurements are highly recommended).

13 ENVIRONMENTAL MANAGEMENT

Environmental Management Objectives are difficult to be defined for noise because ambient sound levels would slowly increase as developmental pressures increase in the area. This is due to increased traffic associated with increased development, human habitation, agriculture and even eco-tourism. While these increases in ambient sound levels may be low (and insignificant) it has the effect of cumulatively increasing the ambient sound levels over time.

The moment the WEF facility stops operation, ambient sound levels will drop to levels similar to the pre-WEF levels, or to new levels (typical of other areas with a similar developmental character) if other developments have occurred in the interim.

For the purpose of this report potential environmental management objectives would be:

- That the development of the WEF project should not result in noise levels exceeding 55dBA during the day;
- That the development of the WEF project should not result in noise levels exceeding 42dBA at night during the construction phase; and
- That the development of the WEF project should not result in noise levels exceeding 45dBA at night during the operational phase.

As noise levels will not exceed 55dBA during both the construction and operational phases, Environmental Management is mainly focusing on the night-time period as summarized in:

- **Table 13-1** for the planning phase (to ensure that noise levels are with the acceptable limits during the future operational phase:
- **Table 13-2** for night-time activities during the construction phase; and
- **Table 13-3** for the operational of the WTG.

Table 13-1: Environmental Management for planning phase

Objective: Future project activities not to result in disturbing noises		
Project Components:	Future construction activities and operation of WTG	
Potential Impact:	No noise impact during the planning phase	
Activity/Risk source	Future construction activities and operation of WTG	
Mitigation: Target	Night-time noise levels less than 42 dBA (construction phase) and 45 dBA (operational phase) at locations used for residential purposes	
Mitigation: Action / Control	**Responsibility**	**Timeframe**
Applicant to re-evaluate the noise impact should the layout be revised where any new WTG are introduced within 1,500 m from an NSR	Applicant	Planning phase, before development of WEF
Applicant to re-evaluate the noise impact should the layout be revised where the number of WTG within 2,500 m from an NSR are increased	Applicant	Planning phase, before development of WEF

Applicant to select and implement mitigation measures to ensure that operational noise levels are less than 45dBA at all verified NSR (if the dwellings will be used for residential purposes during the operational phase)	Applicant	Planning phase, before development of WEF
Applicant to re-evaluate the noise impact once the WTG layout and WTG specifications was finalised	Applicant	Planning phase, before development of WEF
Design and implementation of a noise monitoring programme to define current ambient sound levels at selected NSR before the construction phase start.	ECO	Before the construction phase start
Performance Indicator	Calculated noise levels should be less than 42 dBA at NSR (at night during the construction phase) and less than 45 dBA (at night during the operational phase) at structures used residential purposes	
Monitoring	No monitoring required during planning phase	

Table 13-2: Environmental Management for night-time construction activities

Objective: Project activities not to result in noise levels exceeding night-time noise levels of 42 dBA		
Project Components:	Construction activities and construction equipment generating disturbing and nuisance noises	
Potential Impact:	Night-time noise levels impacting on the quality of living of people living at NSR	
Activity/Risk source	Construction activities	
Mitigation: Target	Night-time noise levels less than 42 dBA at locations used for residential purposes	
Mitigation: Action / Control	**Responsibility**	**Timeframe**
ECO to ensure that equipment is well maintained and fitted with the correct and appropriate noise abatement measures;	ECO	Ongoing during construction phase
ECO to include a component covering environmental noise in the Health and Safety Induction to sensitize all employees and contractors about the potential impact from noise;	ECO	Ongoing during construction phase
ECO to notify NSR before night-time construction activities are to take place within 2,000m from any NSR (if the structures are used for residential activities during the proposed construction period).	ECO	Construction activities within 1,500 m from NSR, if NSR is used for residential purposes
Performance Indicator	Night-time noise levels less than 42 dBA	
Monitoring	Noise level monitoring before the construction phase start at NSR03 and NSR04. Inspection of equipment by ECO.	

Table 13-3: Environmental Management for night-time operational period

Objective: Project activities not to result in noise levels exceeding 45 dBA		
Project Components:	Operation of WTG within 2,000 m from structures used for residential purposes	
Potential Impact:	Noise levels impacting on the quality of living of people living at NSR	
Activity/Risk source	Operation of WTG	
Mitigation: Target	Night-time noise levels less than 45 dBA at locations used for residential purposes	
Mitigation: Action / Control	**Responsibility**	**Timeframe**
ECO to conduct noise monitoring when a reasonable and valid noise complaint are received from an NSR living within 2,000m from a WTG of the project.	ECO	Within 2 months after a noise complaint is registered
Noise monitoring to confirm that noise levels associated with operating WTG are less than 45 dBA at all NSR	ECO	During the first year once the project is operational. Noise specialist to confirm need for future measurements.
Performance Indicator	Night-time noise levels less than 45 dBA	

14 CONCLUSIONS AND RECOMMENDATIONS

This report is a comparative Environmental Noise Impact Assessment of the noise impacts due to the proposed development, operation and decommissioning of the Koup 1 WEF (and associated infrastructure) south of Beaufort West in the Western Cape Province. It considers an updated layout, as well as a WTG with a higher SPL.

This review assessment 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 was determined that the potential noise impacts, without mitigation, would be:

- of a **medium significance** for the construction of access roads (or upgrading of existing roads). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** relating to noises from construction traffic. This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the assembly of the WTG and other infrastructure). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a potential **medium significance** for the night-time construction activities (the potential pouring of concrete, erection of WTG). This finding relates to the very low ambient sound levels measured during the site visit, as well as the strict EIA criteria employed in this assessment. Mitigation however is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level;
- of a **medium significance** for daytime operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level; and

- of a **high significance** for night-time operational activities (noises from wind turbines) when considering the worst-case SPL. Mitigation is available and included in this assessment that could reduce the probability of the impact occurring as well as the intensity/magnitude of the noise level.

There is a slight potential for a cumulative noise impact to occur during the operational phase. NSR 3, 4 and 5 are located between the WTG of the proposed Koup 1 and Koup 2 WEFs and there is a slight cumulative impact at these NSR. Total cumulative noise levels are higher than 45 dBA at these NSR, but this noise impact mainly relates to noises from operating WTG of the Koup 1 WEF (potential noise levels due to the WTG of the Koup 2 WEF will be less than 40 dBA). Due to the **high significance** of the noise impact for the operational phase, the significance will remain high for the cumulative scenario.

Active noise monitoring is recommended because the projected noise levels are more than 38.7 dBA (the level defined by the WHO where noise levels from WTG may become annoying) for the layout and WTG as assessed in this report. Noise levels is projected to be higher than 45 dBA at NSR for a WTG with an SPL of 107.5 dBA (re 1 pW).

From an acoustic perspective the WTG layout is considered acceptable should the applicant select to use a WTG with a SPL less than 107.5 dBA (re 1 pW). Should the applicant select to use a WTG with an SPL exceeding 107.5 dBA (re 1 pW), additional mitigation measures must be implemented to ensure that total noise levels are less than 45 dBA at verified NSR (locations where residential activities would be taking place during the operational phase), with the potential mitigation measures highlighted in this review assessment.

Subject to the condition that the applicant limit total noise levels to less than 45 dBA at the NSR, it is recommended that the Koup 1 WEF be authorized (from an acoustic perspective).

It is also highlighted that the applicant re-evaluates the noise impact:

1. should the layout be revised where:
    a. any WTG, located within 1,500 m from any NSR are moved closer;
    b. the number of WTG within 2,500 m from any NSR are increased; and
2. should the applicant make use of a wind turbine with a maximum SPL exceeding 112.2 dBA re 1 pW.

If the project is to be developed in the future, the final layout and sound power emission levels of the selected WTG **must** be re-accessed to ensure the noise levels are less than

45 dBA at verified NSR (if the applicant changed the layout or the WTG as assessed in this report).

To ensure that noise does not become an issue for future residents, landowners or the local communities, it is recommended that the applicant get written agreement from current landowners/community leaders that no new residential dwellings will be developed within areas enveloped by the 42dBA noise level contour (of the Koup 1 WEF). Dwellings and structures located within the 45dBA noise rating level contour should not be used for permanent residential activities.

15 REFERENCES

In this report reference was made to the following documentation:

1. Ambrose, SE and Rand, RW, 2011. *The Bruce McPherson Infrasound and Low Frequency Noise Study: Adverse health effects produced by large industrial wind turbines confirmed*. Rand Acoustics, December 14, 2011.
2. Autumn, Lyn Radle, 2007: *The effect of noise on Wildlife: A literature review*
3. Atkinson-Palombo, C and Hoen, B. 2014: *Relationship between Wind Turbines and Residential Property Values in Massachusetts – A Joint Report of University of Connecticut and Lawrence Berkley National Laboratory.* Boston, Massachusetts
4. Bakker, R.H., Pedersen, E., van den Berg, G.P., Stewart, R.E., Lok,W., Bouma, J. 2012: *Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress*. Sci. Total Environ. 15 (425), 42–51
5. Barber, J.R., K.R. Crooks, and K. Fristrup. 2010. *The costs of chronic noise exposure for terrestrial organisms*. Trends Ecology and Evolution 25(3): 180–189
6. Bass JH *et al*, 1996: *Development of a wind farm noise propagation prediction model.* JH Bass, AJ Bullmore, E Sloth. Contract JOR3-CT95-0051. Renewable Energy Systems Limits, Hoare Lea & Partners Acoustics, Acoustica A/S
7. Bastasch, M; van Dam, J; Søndergaard, B; Rogers, A. 2006: *Wind Turbine Noise - An Overview*. Canadian Acoustics Vol. 34(2). pp. 7-15
8. Bayne EM *et al*, 2008: *Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest*. Conservation Biology 22(5) 1186-1193.
9. Blickley, J.L. and Patricelli, G.L. 2010. *Impacts of Anthropogenic Noise on Wildlife: Research Priorities for the Development of Standards and Mitigation*. Journal of International Wildlife Law & Policy, 13:274–292.
10. Bolin et al, 2011: *Infrasound and low frequency noise from wind turbines: exposure and health effects.* Environ. Res. Lett. 6 (2011) 035103
11. Bowdler, D. 2005: *ETSU-R-97 Why it is Wrong,* Internet White Paper, New Acoustics, Dunbartonshire, Scotland, July 2005
12. Bowdler, Dick, 2008: *Amplitude modulation of wind turbine noise: a review of the evidence*
13. Bowdler, D. Bullmore, A. Davis, B. Hayes, M. Jiggens, M. Leventhall, G. McKenzie, A. 2009: *Prediction and Assessment of Wind Turbine Noise – Agreement about relevant factors for noise assessment from wind energy projects*. Acoustics, Vol 34, No 2. March/April 2009

14. Bray, W and James, R. 2011. *Dynamic measurements of wind turbine acoustic signals, employing sound quality engineering methods considering the time and frequency sensitivities of human perception*. Noise-Con 2011.
15. Broucek, J. 2014. *Effect of Noise on Performance, Stress and Behaviour of Animals.* Slovak J. Anim. Sci., 47, 2014 (2): 111-123
16. BWEA, 2005*: Low Frequency Noise and Wind Turbines – Technical Annex*
17. CanWEA, 2007: *Wind Turbines and Sound: Review and Best Practice Guidelines*. Canadian Wind Energy Association.
18. Chapman *et al*. 2013: *Spatio-temporal differences in the history of health and noise complaints about Australian wind farms: evidence for the psychogenic, "communicated disease" hypothesis*. Sydney School of Public Health, University of Sydney
19. Chief Medical Officer of Health, 2010: *The Potential Health Impact of Wind Turbines*, Canada
20. Conrady, K; Bolin, K; Sjöblom, A; Rutgersson, A. 2019: *Amplitude modulation of wind turbine sound in cold climates*. Applied Acoustics, Vol 158, 15 January 2020.
21. Cooper, 2012: *Are Wind Farms too close to communities*, The Acoustic Group (date posted on Wind-watch.org: Referenced on various anti-wind energy websites)
22. Cooper, S. Chan, C. 2020: *Determination of Acoustic Compliance of Wind Farms*. Acoustics **2020**, 2, 416–450; doi:10.3390/acoustics2020024
23. Council of Canadian Academies, 2015: Understanding the Evidence: Wind Turbine Noise. Ottawa (ON): The Expert Panel on Wind Turbine Noise and Human Health. Council of Canadian Academies
24. Crichton *et al*. 2014: *Can expectations produce symptoms from infrasound associated with wind turbines?. Health Psychology, Vol 33(4), Apr 2014, 360-364*
25. CSES, 2016: *Evaluation of Directive 2002/49/EC relating to the assessment and management of environmental noise*. The Centre for Strategy & Evaluation Services, European Commission, Brussels.
26. CSIR, 2002: *Integrated Environmental Management Information Series: Information Series 5: Impact Assessment*. Issued by the Department of Environmental Affairs and Tourism, Pretoria
27. CSIR, 2015: *The Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa.* Issued by the Department of Environmental Affairs and Tourism, Pretoria
28. Cummings, J. 2012: *Wind Farm Noise and Health: Lay summary of new research released in 2011*. Acoustic Ecology Institute, April 2012 (online resource:

http://www.acousticecology.org/wind/winddocs/AEI_WindFarmsHealthResearch2011.pdf)

29. Cummings, J. 2009: *AEI Special Report: Wind Energy Noise Impacts*. Acoustic Ecology Institute, (online resource: http://acousticecology.org/srwind.html)
30. DEFRA, 2003: *A Review of Published Research on Low Frequency Noise and its Effects*, Report for Defra by Dr Geoff Leventhall Assisted by Dr Peter Pelmear and Dr Stephen Benton
31. DEFRA, 2007: *Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report*
32. DELTA, 2008: *EFP-06 project: Low Frequency Noise from Large Wind Turbines, a procedure for evaluation of the audibility for low frequency sound and a literature study*. Danish Energy Authority
33. Derryberry EP *et al*, 2016: *Patterns of song across Natural and Anthropogenic Soundscapes suggest that White-Crowned Sparrows minimize acoustic masking and maximize signal content*. PLOS ONE| DOI: 10.1371/journal.pone.0154456, April 29, 2016
34. Dooling, R. 2002. *Avian Hearing and the Avoidance of Wind Turbines*. National Renewable Energy Laboratory, NREL/TP-500-30844
35. Dooling R. J., and A. N. Popper. 2007. *The effects of highway noise on birds*. Report to the California Department of Transportation, contract 43AO139. California Department of Transportation, Division of Environmental Analysis, Sacramento, California, USA
36. Directive 2002/49/EC of the European Parliament and of the Council relating to the assessment and management of environmental noise
37. Duncan, E. and Kaliski, K. 2008: *Propagation Modelling Parameters for Wind Power Projects*
38. Ellenbogen, J.M., Grace, S., Heiger-Bernays,W.J., Manwell, J.F., Mills, D.A., Sullivan, K.A., Santos, S.L. 2012: *Wind Turbine Health Impact Study. Report of Independent Expert Panel*. Prepared for: Massachusetts Department of Environmental Protection. Massachusetts Department of Health
39. Enertrag, 2008: *Noise and Vibration*. Hempnall Wind Farm (http://www.enertraguk.com/technical/noise-and-vibration.html)
40. EPA, 2009: *Wind Farms Environmental Noise Guidelines*. Environmental Protection Authority, Adelaide, South Australia (Updated November 2021)
41. EPA, 2011: *Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licences Sites (NG3).* Environmental Protection Agency, Office of Environmental Enforcement,

42. ETSU R97: 1996. '*The Assessment and Rating of Noise from Wind Farms: Working Group on Noise from Wind Turbines*'
43. Evans Tom, Cooper Jonathan, 2012: *Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms*. Acoustics Australia, Vol. 40, No. 1, April 2012.
44. Evans, T. Cooper, J. Lenchine, V. 2012: *Infrasound Levels near Windfarms and in other Environments. Resonate Acoustics in conjunction with Environment Protection Authority, South Australia*
45. Fégeant, O. 2002: *Masking of Wind Turbine Noise: Influence of Wind Turbulence on Ambient Noise Fluctuations*.
46. Francis, C.D. et al, 2011: Different behavioural responses to anthropogenic noise by two closely related passerine birds. Biol. Lett. (2011) 7, 850-852 doi:10.1098 / rsbl.2011.0359
47. Francis, C.D. et al, 2012: Noise pollution alters ecological services: enhanced pollination and disrupted seed dispersal. Proc. R Soc. B doi: 10.1098 / rsbl.2012.0230
48. Garrad Hassan, 2013: *Summary of results of the noise emission measurement, in accordance with IEC 61400-11, of a WTGS of the type N117/3000. Doc.* GLGH-4286 12 10220 258-S-0002-A (extract from GLGH-4286 12 10220 258-A-0002-A)
49. Gibbons, S. 2014: *Gone with the Wind: Valuing the Visual Impacts of Wind turbines through House Prices*, Spatial Economics Research Centre
50. Goldwind, 2020: *Description of GW155-4.5 Acoustic Performance*. Edition: C No.: GSC-08AP.a0002
51. Goldwind. 2021: *Goldwind GW165-6.0 V42R01C100 Wind Turbine Noise Manual*. Document No. GW17XW.0145. Goldwind Technology Co., Ltd
52. Goldwind. 2023: *Personal communication (awaiting reference)*
53. Guillaume Dutilleux. *Anthropogenic outdoor sound and wildlife: it's not just bioacoustics!*. Soci´et´e Fran¸caise d'Acoustique. Acoustics 2012, Apr 2012, Nantes, France
54. Halfwerk, W. *et al*. 2011: *Low-frequency songs lose their potency in noisy urban conditions*. PNAS, August 30, 2011, vol. 108, no. 35, 14549-14554.
55. Hanning, 2010: *Wind Turbine Noise, Sleep and Health*. (referenced on a few websites, especially anti-wind energy. No evidence that the study has been published formally.)
56. Hartley, J.C., 1991: *Can Bush Crickets Discriminate Frequency?* University of Nottingham.
57. Havas, M and Colling, D. 2011: *Wind Turbines Make Waves: Why Some Residents Near Wind Turbines Become Ill*. *Bulletin of Science Technology & Society published online 30 September 2011*

58. Helldin, J.O., Jung, J., Neumann, W., Olsson, M., Skarin, A. and Widemo, F. 2012. *The impacts of wind power on terrestrial mammals: a synthesis*. Report 6510. Swedish Environmental Protection Agency.
59. Hessler, D. 2011: *Best Practices Guidelines for Assessing Sound Emissions From Proposed Wind Farms and Measuring the Performance of Completed Projects*. Prepared for the Minnesota Public Utilities Commission, under the auspices of the National Association of Regulatory Utility Commissioners (NARUC)
60. HGC Engineering, 2006: *Wind Turbines and Infrasound*, report to the Canadian Wind Energy Association
61. HGC Engineering, 2007: *Wind Turbines and Sound*, report to the Canadian Wind Energy Association
62. HGC Engineering, 2011: *Low frequency noise and infrasound associated with wind turbine generator systems: A literature review*. Ontario Ministry of the Environment RFP No. OSS-078696.
63. IFC, 2007: '*Environmental, Health, and Safety General Guidelines*'. International Finance Corporation, Washington
64. IFC, 2015: '*Environmental, Health, and Safety Guidelines for Wind Energy*'. International Finance Corporation, Washington
65. IOA, 2013: *A good practice guide to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*. Institute of Acoustics.
66. ISO 9613-2: 1996. '*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*'
67. Janssen, S.A., Vos, H., Eisses, A.R., Pedersen, E. 2011: *A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources*. J. Acoust. Soc. Am. **130**(6), 3746–53 (2011)
68. Jeffery *et al*, 2013: *Adverse health effects of industrial wind turbines*, Can Fam Physician, 2013 May. 59(5): 473-475
69. Journal of Acoustical Society of America, 2009: *Response to noise from modern wind farms in the Netherlands*
70. Kaliski K & Duncan E, 2008: *Propagation modelling Parameters for Wind Power Projects.*
71. Kaliski K & Wilson DK. 2011: *Improving predictions of wind turbine noise using PE modelling*. Noise-con 2011.
72. Kamperman GW & James RR, 2008: *The "How to" guide to siting wind turbines to prevent health risks from sound*
73. Karwowska, M. *et al*. 2015: *The effect of varying distances from the wind turbine on meat quality of growing-finishing pigs*. Ann. Anim. Sci., Vol. 15, No. 4 (2015) 1043–1054 DOI: 10.1515/aoas-2015-0051

74. Knopper, L.D., Ollson, C.A.,McCallum, L.C.,Whitfield Aslund, M.L., Berger, R.G., Souweine, K., McDaniel, M. 2014: *Wind turbines and human health*. Front. Public Health **19**(2), 63
75. Kroesen & Schreckenberg, 2011. *A measurement model for general noise reaction in response to aircraft noise*. J. Acoust. Soc. Am. 129 (1), January 2011, 200-210
76. Lohr, B. Wright, TF. Dooling, RJ. 2003: *Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal*. Animal Behavior 65:763-777
77. Łopucki, R. Klich, D. Gielarek, S. 2016: An assessment of non-volant terrestrial vertebrates response to wind farms – a study of small mammals. Environ Monit Assess (2016) 188: 122
78. Łopucki, R. Klich, D. Gielarek, S. 2017: *Do terrestrial animals avoid areas close to turbines in functioning wind farms in agricultural landscapes?* Environ Monit Assess (2016) 188:122
79. McCunney, R.J., Mundt, K.A., Colby, W.D., Dobie, R., Kaliski, K.,Blais, M. 2014: *Wind turbines and health: a critical review of the scientific literature*. J. Occup. Environ. Med. **56** (11), e108–30
80. McMurtry RY, 2011: *Toward a Case Definition of Adverse Health Effects in the Environs of Industrial Wind Turbines: Facilitating a Clinical Diagnosis*. Bulletin of Science Technology Society. August 2011 vol. 31 no. 4 316-320
81. MDEP: Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health. Wind Turbine Health Impact Study: Report of Independent Expert Panel
82. Merlin, T., Newton, S., Ellery, B., Milverton, J., Farah, C. 2013: Systematic review of the human health effects of wind farms. National Health & Medical Research Council, Canberra
83. Miedema, H.M., Vos, H. 2003: *Noise sensitivity and reactions to noise and other environmental conditions*. J. Acoust. Soc. Am. **113**(3), 1492–504
84. Michaud, D.S., Keith, S.E., Feder, K., Voicescu, S.A., Marro, L., Than, J., Guay,M., Bower, T., Denning, A., Lavigne, E., Whelan, C. 2016: *Personal and situational variables associated with wind turbine noise annoyance*. J. Acoust. Soc. Am. **139**(3), 1455–66
85. Mikolajczak, J. *et al*. 2013: *Preliminary studies on the reaction of growing geese (Anser anser f. domestica) to the proximity of wind turbines*. Pol J Vet Sci. 2013;16(4):679-86. doi: 10.2478/pjvs-2013-0096.
86. Minnesota Department of Health, 2009: *Public Health Impacts of Wind Farms*
87. Ministry of the Environment, 2008: *Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*

88. Møller H, 2010: *Low-frequency noise from large wind turbines*. J. Acoust. Soc. Am, 129(6), June 2011, 3727 - 3744
89. NARUC, 2011: *Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects*. National Association of Regulatory Utility Commissioners. US Department of Energy
90. Nissenbaum A, 2012: *Effects of industrial wind turbine noise on sleep and health*. Noise and Health, Vol. 14, Issue 60, p 237 – 243.
91. Noise-con, 2008: *Simple guidelines for siting wind turbines to prevent health risks*
92. Noise quest, Aviation Noise Information & Resources, 2010: https://www.noisequest.psu.edu/noiseeffects-animals.html
93. Norton, M.P. and Karczub, D.G.: *Fundamentals of Noise and Vibration Analysis for Engineers*, Second Edition, 2003
94. Nordex. 2022 : *Noise Level, Power curves, Thrust curves – Nordex N163/5.X*. Document ref. F008_276_A12_EN, Revision 07. Nordex Energy SE & Co., Hamburg
95. O'Neal, *et al*. 2011: *Low frequency noise and infrasound from wind turbines*. Noise Control Eng. J. 59 (2), March-April 2011
96. Ortega, CP. 2012. *Ornithological Monographs. Chapter 2: Effects of noise pollution on birds: A brief review of our knowledge*. 74(1), pp.6-22.
97. Oud, M. 2012: *Low-frequency noise: a biophysical phenomenon* (http://www.leefmilieu.nl/sites/www3.leefmilieu.nl/files/imported/pdf_s/2012_OudM_Low-frequency%20noise_0.pdf) (unpublished webresource)
98. Parnell, J. 2015: "*The Generation and propagation of noise from large coal mines, and how it is managed in NSW*". NSW Department of Planning and Environment, Sydney NSW, Australia
99. Parris, M. Schneider, A. 2009: *Impacts of traffic noise and traffic volume on birds of roadside habitats*. Ecology and Society 14(1): 29
100. Parry, G. 2008: *A review of the use of different noise prediction models for wind farms and the effects of meteorology*. The Journal of the Acoustical Society of America **123**, 3535 (2008); https://doi.org/10.1121/1.2934501
101. Pedersen, T. H. 2007: *The "Genlyd" Noise Annoyance Model*. DELTA report AV 1102/07
102. Pedersen, E., Hallberg, L.M., Persson, W.K. 2007: *Living in the vicinity of wind turbines—a grounded theory study*. Qual. Res. Psychol. **4**(1–2), 49–63
103. Pedersen, Eja; Halmstad, Högskolan I, 2003: '*Noise annoyance from wind turbines: a review'*. Naturvårdsverket, Swedish Environmental Protection Agency, Stockholm
104. Pedersen, E. 2011: "*Health aspects associated with wind turbine noise—Results from three field studies",* Noise Control Eng. J. 59 (1), Jan-Feb 2011

105. Phillips, CV, 2011: *"Properly Interpreting the Epidemiologic Evidence About the Health Effects of Industrial Wind Turbines on Nearby Residents"*. Bulletin of Science Technology & Society 2011 31: 303 DOI: 10.1177/0270467611412554

106. Pierpont, N. 2009: *"Wind Turbine Syndrome: A Report on a Natural Experiment",* K Select Books, 2009

107. Pollet, AP, Kordich, MM. 2000. "*User's guide for the Sound Intensity Prediction System (SIPS) as installed at the Naval Explosive Ordnance Disposal Technology Division (Naveodtechdiv)*". Systems Department. DTIC.mil

108. Punch, *et al*. 2010: *Wind Turbine Noise. What Audiologists should know.* Audiology Today. JulAug2010

109. Quinn, J.L., M.J. Whittingham, S.J. Butler, and W. Cresswell. 2006*. Noise, predation risk compensation and vigilance in the chaffinch Fringilla coelebs*. Journal of Avian Biology 37: 601-608

110. Rabin, L.A., R.G. Coss, D.H. Owings. 2006. *The effects of wind turbines on antipredator behavior in California ground squirrels (Spermophilus beecheyi)*. Biological Conservation 131: 410-420

111. Renewable Energy Research Laboratory, 2006: *Wind Turbine Acoustic Noise*

112. RenewableUK, 2013: *Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect.*

113. SANS 10103:2008. '*The measurement and rating of environmental noise with respect to annoyance and to speech communication*'.

114. SANS 10181:2003. 'The Measurement of Noise Emitted by Road Vehicles when Stationary'.

115. SANS 10210:2004. '*Calculating and predicting road traffic noise*'.

116. SANS 10328:2008. '*Methods for environmental noise impact assessments*'.

117. SANS 10357:2004. *The calculation of sound propagation by the Concave method*'.

118. Saurenman, H. Chambers, J. Sutherland, LC. Bronsdon, RL. Forschner, H. 2005: "*Atmospheric effects associated with highway noise propagation*". Final Report 555. Arizona Department of Transportation, US Dept of Transport. Federal Highway Administration.

119. Schaub, A, J. Ostwald and B.M. Siemers. 2008. "*Foraging bats avoid noise*". The Journal of Experimental Biology 211: 3174-3180

120. Schmidt, J.H., Klokker,M. 2014: *Health effects related to wind turbine noise exposure: a systematic review*. PLoS ONE **9**(12), e114183

121. SiVEST, 2022: *Environmental Noise Impact Assessment - Proposed construction of the Koup 1 Wind Energy Facility and associated Grid Infrastructure, near Beaufort West, Western Cape Province, South Africa*. Enviro-Acoustic Research, Pretoria

122. Šottník, J. 2011: Influence of noise and object noisiness on animal breeding.. Šiška, B. – Hauptvogl, M. – Eliašová, M. (eds.). Bioclimate: Source and Limit of Social Development International Scientific Conference, 6th – 9th September 2011, Topoľčianky, Slovakia
123. Shannon, G., McKenna, M.F., Angeloni, L.M., Crooks, K.R., Fristrup, K.M., Brown, E., Warner, K.A., Nelson, M.D., White, C., Briggs, J., McFarland, S. and Wittemyer, G. 2015. *A synthesis of two decades of research documenting the effects of noise on wildlife*. Biological Reviews.
124. Sheperd, D and Billington, R. 2011: *Mitigating the Acoustic Impacts of Modern Technologies: Acoustic, Health, and Psychosocial Factors Informing Wind Farm Placement*. *Bulletin of Science Technology & Society* published online 22 August 2011, DOI: 10.1177/0270467611417841
125. Shepherd. D *et al*. 2011: *Evaluating the impact of wind turbine noise on health related quality of life*. Noise & Health, September-October 2011, 13:54,333-9.
126. Smith. M (*et al*) (2012): "*Mechanisms of amplitude modulation in wind turbine noise*"; Proceedings of the Acoustics 2012 Nantes Conference
127. Stigwood, M. Large, S. Stigwood, D. 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
128. Superior Health Council, 2013: *Public health effects of siting and operating onshore wind turbines*. Publication of the Superior Health Council No. 8738
129. Szymański, P. *et al*. 2017: *The song of Skylarks Alauda arvensis indicates the deterioration of an acoustic environment resulting from wind farm start-up*. https://doi.org/10.1111/ibi.12514
130. Tachibana, H (*et al*) (2013): "*Assessment of wind turbine noise in immission areas*"; Paper presented at the 5th International Conference on Wind Turbine Noise, Denver 28 – 30 August 2013
131. The Scottish Government, 2011. Planning Advice Note PAN 1/2011: Planning and Noise. https://www.gov.scot/publications/planning-advice-note-1-2011-planning-noise/pages/5/
132. Thorne et al, 2010: *Noise Impact Assessment Report Waubra Wind Farm Mr & Mrs N Dean Report No 1537 - Rev 1*
133. Thorne, 2010: *The Problems with "Noise Numbers" for Wind Farm Noise Assessment*. Bulletin of Science Technology and Society, 2011 31: 262
134. UK Department for Communities and Local Government, 2013: Planning practice guidance for renewable and low carbon energy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attach

ment_data/file/225689/Planning_Practice_Guidance_for_Renewable_and_Low_Carbon_Energy.pdf

135. USEPA, 1971: *Effects of Noise on Wildlife and other animals*.
136. Van den Berg, G.P., 2003. '*Effects of the wind profile at night on wind turbine sound'.* Journal of Sound and Vibration
137. Van den Berg, G.P., 2004. *'Do wind turbines produce significant low frequency sound levels?'*. 11th International Meeting on Low Frequency Noise and Vibration and its Control
138. Van den Berg, F., Pedersen, E., Bouma, J., Bakker, R. 2008: *Visual and acoustic impact of wind turbine farms on residents*. Final Rep.
139. Van den Berg, F., Verhagen, C., Uitenbroek, D. 2014: *The relation between scores on noise annoyance and noise disturbed sleep in a public health survey*. Int. J. Environ. Res. Public Health **11**(2), 2314–27
140. Van Kamp, I., Davies, H. 2013: *Noise and health in vulnerable groups: a review.* Noise Health **15**(64), 153
141. Van Riet, W. Claassen, P. van Rensburg, J. van Viegen & L. du Plessis. 1998. *Environmental potential atlas for South Africa*. J.L. van Schaik, Pretoria
142. Vestas, 2023: 'Third octave noise emission EnVentus™ *V162-7.2MW 50/60 Hz*'. DMS no.: 0116-1715_03, Vestas Wind Systems A/S, Denmark
143. Wang, Z. 2011: *Evaluation of Wind Farm Noise Policies in South Australia: A Case Study of Waterloo Wind Farm*. Masters Degree Research Thesis, Adelaide University 2011
144. Whitford, Jacques, 2008: *Model Wind Turbine By-laws and Best Practices for Nova Scotia Municipalities*
145. World Bank Group, 2015: *Environmental, Health, and Safety Guidelines Wind Energy*
146. World Health Organization, 1999: *Protection of the Human Environment; Guidelines for Community Noise*
147. World Health Organization, 2009: *Night Noise Guidelines for Europe*
148. World Health Organization, 2018: *Environmental Noise Guidelines for the European Region*
149. WSP, 2016: *Wind Turbine AM Review – Phase 2 Report*. WSP Parsons Brinckerhoff for the Department of Energy and Climate Change
150. Zwart, M.C *et al.* 2014: *Wind farm noise suppresses territorial defense behavior in a songbird*. Behavioral Ecology arv128(1), July 2014

APPENDIX A

Curriculum Vitae

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 Use License Applications and EIA's), auditing of license 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 20 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 as well as blasting impacts. Since 2007 he has completed more than 400 Environmental Noise Impact Assessments and Noise Monitoring Reports as well as various acoustic consulting services, including amongst others:

Wind Energy Facilities	*Full Environmental Noise Impact Assessments for - 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), Namas (SE), Zonnequa (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), Iziduli (SE), Msenge (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), Boulders (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), Wobben (IWP), Trakas (SiVest), Beaufort West (SiVest)
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), 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), Royal Sheba Project (Cabanga Environmental), Rietkol Silica (Jacana), Gruisfontein Colliery (Jacana), Lehlabile Colliery (Jaco-K Consulting), Bloemendal Colliery (Enviro-Insight), Rondevly Colliery (REC), Welgedacht Colliery (REC), Kalabasfontein Extension (EIMS), Waltloo Power Generation Project (EScience), Buffalo Colliery (Marang), Balgarthen Colliery (Rayten), Kusipongo Block C (Rayten), Zandheuvel (Exigo), NamPower Walvis Bay (GPT), Eloff Phase 3 (EIMS), Dunbar (Enviro-Insight), Smokey Hills (Prescali), Bierspruit (Aurecon)*
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), Riverfarm Development (Terramanzi), Conakry to Kindia Toll Road (Rayten)*
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), Bank of Botswana measurements (Linnspace), Skukuza Noise Measurements (Concor), 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), Twisdraai Colliery (Lefatshe Minerals), SASOL Prospecting (Lefatshe Minerals), South32 Klipspruit (Rayten), Sibanye Stillwater Kroondal (Rayten), Rooiberg Asphalt (Rooiberg Asphalt), SASOL Shondoni (Lefatshe), SASOL Twisdraai (Lefatshe), Anglo Mototolo (Exigo), Heineken Inyaniga (AECOM), Glencore Izimbiwa (Cleanstream) Glencore Impunzi (Cleanstream), Black Chrome Mine (Prescali) Sibanye Stillwater Ezulwini (Aurecon), Sibanye Stillwater Beatrix (Aurecon), Bank of Botshwana (Linspace), Lakeside (Linspace), Skukuza (SiVest), Rietvlei Colliery (Jaco-K Consulting)
Small Noise Impact Assessments	*TCTA AMD Project Baseline (AECOM), NATREF (Nemai Consulting), Christian Life Church (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), Tiegerpoort Wedding Venue (Henwood Environmental), Monavoni Development (Marindzini), Rezoning of Portion 1 (Primo Properties), Tswaing Mega City (Makole), Mabopane Church (EP Architects), ERGO Soweto Cluster (Kongiwe), Fabio Chains (Marang), GIDZ JMP (Marang), Temple Complex (KWP Create), Germiston Metals (Dorean), Sebenza Metals (Dorean)*
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), Paul Puts WEF (ARCUS), Juno WEF (ARCUS), etc.*

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APPENDIX B

Glossary of Terms

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 micro pascals 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 C

Declaration of Independence

APPENDIX D

Site Sensitivity Verification

SITE SENSITIVITY VERIFICATION (IN TERMS OF PART A OF THE ASSESSMENT PROTOCOLS PUBLISHED IN GN 320 ON 20 MARCH 2020

Part A of the Assessment Protocols published in GN 320 on 20 March 2020 (i.e., Site sensitivity verification is required where a specialist assessment is required but no specific assessment protocol has been prescribed) is applicable where the Department of Environment, Forestry and Fisheries Screening Tool has the relevant themes to verify.

In accordance with Appendix 6 of the National Environmental Management Act (Act 107 of 1998, as amended) (NEMA) Environmental Impact Assessment (EIA) Regulations of 2014, a site sensitivity verification has been undertaken in order to confirm the current land use and environmental sensitivity of the proposed project area as identified by the National Web-Based Environmental Screening Tool (Screening Tool). The details of the site sensitivity verification are noted below:

Date of Site Visit	10 to 12 June 2021
Specialist Name	Francois Stephanus de Vries (Noise)
Professional Registration Number (if applicable)	Not applicable, there is no registration body in South Africa that could allow professional registration for acoustic consultants.
Specialist Affiliation / Company	Enviro-Acoustic Research CC

<u>Output from National Environmental Screening Tool</u>

The site was initially assessed using the National Environmental Screening tool, available at, https://screening.environment.gov.za. The output from the National Online Screening tool indicates a number of areas within, and up to 2,000 m from the project boundary is considered to be of a "very high" sensitivity to noise. These potentially "very high" sensitive areas (in terms of noise) are indicated on **Figures D.1** together with the potential noise-sensitive receptors as identified after the site visit.

<u>Description on how the site sensitivity verification was undertaken</u>

The site sensitivity was verified using:

a) *available aerial images (Google Earth®) (See **Figure D.1** for verified potential noise-sensitive receptors);*
b) *the statuses of these structures were defined during the site visit done in June 2021.*

Outcome of the Site Sensitivity Verification

Potential NSR were marked as green dots on **Figure D.1** below, highlighting:

- that the online screening tool identified a number of areas with a "very high" sensitivity to noise in the vicinity of the proposed development. There are permanent or temporary residential activities at the locations marked 1, 2, 3, 4, 5 and 6. These locations are located within 2,000 m from a potential wind turbine and considered to have a "Very High" sensitivity to noise. This report agrees with that finding.
- There are a number of areas identified to have a "Very High" sensitivity to noise. The site assessment highlighted that these are not sensitive to noise, as there are no structures used for residential activities or any other use that are considered to be noise sensitive. This report disputes those areas.

Because a number of these structures are used for residential purposes and considered to be noise-sensitive, the potential impact from noise from the project is assessed in this Noise Specialist Study.

Signature	**Signature**
Morné de Jager	**Francois Stephanus de Vries**
2023 – 06 – 26	**2023 – 06 – 26**

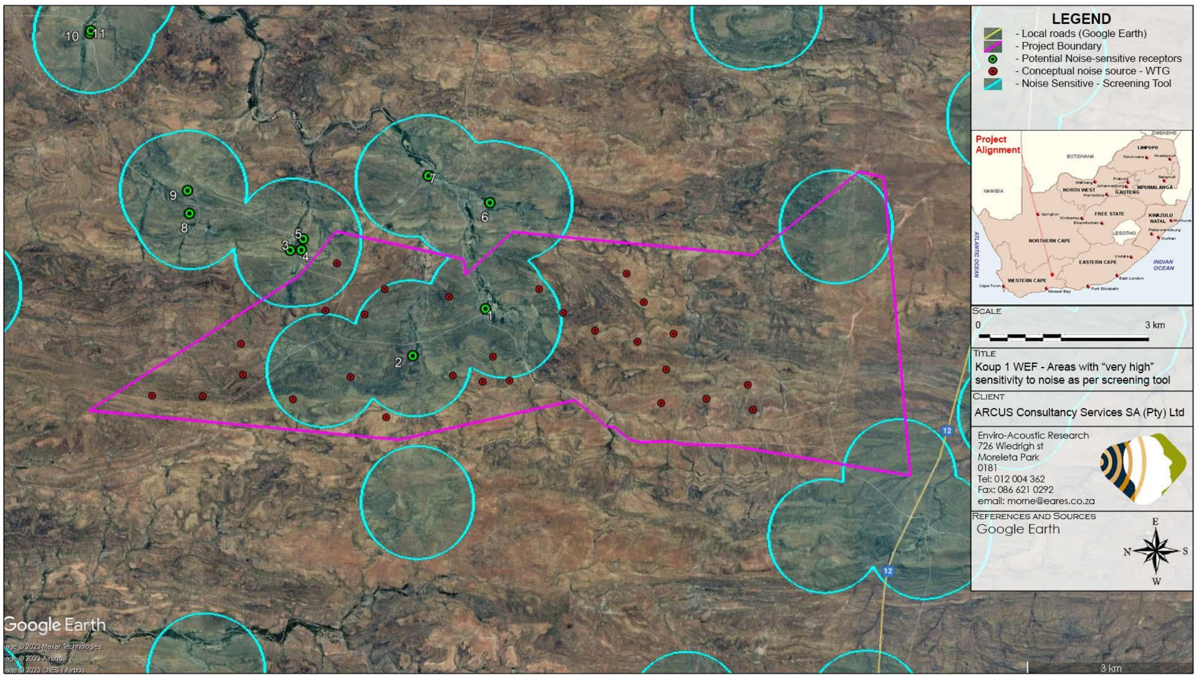

Figure D.1: Areas defined to be of "Very High" sensitivity in terms of noise by the online screening tool

APPENDIX E

Photos of Measurement Locations

Photos E.1: Measurement location at SGEKLTSL01

Photos E.2: Measurement location at SGEKLTSL02

Photos E.3: Measurement location at SGEKLTSL03

Photos E.4: Measurement location at SMKLTSL01

Photos E.5: Measurement location at SMKLTSL02

Photos E.6: Measurement location at SMHLTSL01

Photos E.7: Measurement location at SMHLTSL02

APPENDIX F

Identified NSR, calculated noise levels and significance of noise impact: Criteria of EAP (SiVEST SA (Pty) Ltd)

Appendix F, Table 1: Locations of identified NSR and perceived use of structures

Potential Noise-sensitive development / Receptor(s)	WGS 84 Longitude	WGS 84 Latitude	UTM 34 S X	UTM 34 S Y	Comment
NSR01	22.47223	-32.8556	637760	6363766	Permanent residential use
NSR02	22.45844	-32.863	636458	6362954	Permanent residential use
NSR03	22.43523	-32.8462	634311	6364848	Permanent residential use
NSR04	22.43732	-32.8462	634507	6364850	Permanent residential use
NSR05	22.43768	-32.8444	634543	6365044	Permanent residential use
NSR06	22.47306	-32.8387	637863	6365637	Permanent residential use

Appendix F, Table 2: Projected access road construction noise levels and impact significance

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted, low wind)	Projected Noise Level, Worst-case construction scenario	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	26.1	58.9	32.8	Site - 1	Probable - 3	Completely - 1	Marginal - 2	Short - 1	Very High - 4	**Medium**
NSR02	45	26.1	72.5	46.4	Site - 1	Definite - 4	Completely - 1	Marginal - 2	Short - 1	Very High - 4	**Medium**
NSR03	45	26.1	72.5	46.4	Site - 1	Definite - 4	Completely - 1	Marginal - 2	Short - 1	Very High - 4	**Medium**

Appendix F, Table 3: Projected traffic noise levels and impact significance – Construction traffic passing NSR

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted, low wind)	Projected Noise Level, Worst-case construction scenario	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	26.1	46.2	20.1	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR02	45	26.1	53.0	26.9	Site - 1	Possible - 2	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR03	45	26.1	53.0	26.9	Site - 1	Possible - 2	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**

Appendix F, Table 4: Projected construction noise levels and daytime significance

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	26.1	44.4	18.3	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR02	45	26.1	42.7	16.7	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	Very High - 4	**Medium**
NSR03	45	26.1	40.2	14.2	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	Low
NSR04	45	26.1	38.4	12.5	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	Low
NSR05	45	26.1	39.2	13.3	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	Low
NSR06	45	26.1	36.7	10.9	Site - 1	Improbable - 1	Completely - 1	Marginal - 2	Medium - 2	High - 3	Low

Appendix F, Table 5: Projected construction noise levels and night-time significance

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	23.3	44.4	21.1	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR02	45	23.3	42.7	19.5	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR03	45	23.3	40.2	17.0	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR04	45	23.3	38.4	15.2	Local - 2	Improbable - 1	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR05	45	23.3	39.2	16.0	Local - 2	Possible - 2	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**
NSR06	45	23.3	36.7	13.6	Local - 2	Improbable - 1	Completely - 1	Significant - 3	Medium - 2	Very High - 4	**Medium**

Appendix F, Table 6: Projected operational noise levels and night-time significance (using a worst-case SPL of 112.2 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level, IFC/WHO)	Potential Existing Ambient Sound Levels (Estimated considering an 10 m/s wind speed)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	43.5	49.6	7.0	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Very High - 4	**High**
NSR02	45	43.5	48.3	6.0	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	High - 3	**Medium**
NSR03	45	43.5	45.4	4.1	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	**Low**

NSR04	45	43.5	46.0	4.4	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR05	45	43.5	45.9	4.4	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR06	45	43.5	41.6	2.2	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low

Appendix F, Table 7: Projected operational noise levels and night-time significance (option - mitigated WTG with an SPL of 107.5 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level, IFC/WHO)	Potential Existing Ambient Sound Levels (Estimated considering an 10 m/s wind speed)	Projected Noise Level	Change in rating level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	45	43.5	44.9	3.8	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR02	45	43.5	43.6	3.1	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR03	45	43.5	40.7	1.8	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR04	45	43.5	41.3	2.0	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR05	45	43.5	41.2	2.0	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR06	45	43.5	36.9	0.9	Local - 2	Improbable - 1	Completely - 1	Marginal - 2	Long -3	Low - 1	Low

Appendix F, Table 8: Projected cumulative operational noise levels and night-time significance (using a worst-case SPL of 112.2 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Potential Existing Ambient Sound Levels (Estimated considering an 10 m/s wind speed)	Projected Noise Level for the Koup 1 WEF operating in isolation (dBA)	Projected Cumulative Noise Level (For all operating WEFs in area)	Potential change in ambient sound level considering Cumulative Noise Level	Extent (E)	Probability of Impact Occurring (P)	Reversibility (R)	Irreplaceable Loss of Resources (L)	Duration (D)	Magnitude / Intensity (I / M)	Significance (S)
NSR01	43.5	49.6	49.6	7.0	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Very High - 4	High
NSR02	43.5	48.3	48.4	6.1	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	High - 3	Medium
NSR03	43.5	45.4	45.8	4.3	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR04	43.5	46.0	46.4	4.7	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR05	43.5	45.9	46.3	4.6	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low
NSR06	43.5	41.6	41.6	2.2	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR07	43.5	39.7	39.7	1.5	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR08	43.5	33.1	43.1	2.8	Local - 2	Possible - 2	Completely - 1	Marginal - 2	Long -3	Low - 1	Low
NSR09	43.5	35.2	45.4	4.1	Local - 2	Probable - 3	Completely - 1	Marginal - 2	Long -3	Medium - 2	Low

End of Report

BAT SITE WALK-THROUGH REPORT

THE KOUP 1 WIND ENERGY FACILITY NEAR BEAUFORT WEST, WESTERN CAPE PROVINCE

September 2024

Project No.: 5200 Koup 1 Wind Farm

(DFFE REF: 14/12/16/3/3/2/2120)

GENESIS ENERTRAG KOUP 1 WIND (Pty) Ltd.

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Document details	The details entered below are automatically shown on the cover and the main page footer. PLEASE NOTE: This table must NOT be removed from this document.
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Project No.	5200 Koup 1 Wind Farm
Date	September 2024
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Arcus Review and Approval	Ashlin Bodasing	NA	
Signature		NA	
ERM Review and Approval	Dieter Rodewald	Dieter Rodewald	
Signature			

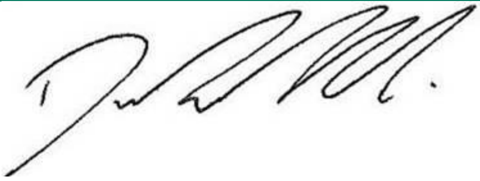
Signature Page

September 2024

BAT SITE WALK-THROUGH REPORT

THE KOUP 1 WIND ENERGY FACILITY NEAR BEAUFORT WEST, WESTERN CAPE PROVINCE

Stephanie Gopaul
Partner and EAP



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CONTENTS

1. INTRODUCTION

Genesis Enertrag1 Wind (Pty) Ltd (the applicant) received Environmental Authorisation (EA) from the Department of Forestry, Fisheries and the Environment (DFFE) for the construction of the Koup 1 Wind Energy Facility (WEF) (the development) near Beaufort West in the Western Cape Province, (DFFE Ref: 14/12/16/3/3/2/2120) on 12 September 2022.

Arcus Consultancy Services South Africa (Pty) Ltd. (an ERM group company) (hereinafter referred to as 'Arcus') were appointed by the applicant to conduct a bat specialist site walk-through of the final layout as part of the process for approval of the final site development layout and Environmental Management Programme (EMPr).

The final bat pre-construction monitoring and impact assessment report (EkoVler 2021) outlined the requirements for further consideration during the project design phase, construction phase, operational phase, decommissioning phase and cumulative impacts. Consequently, this report serves to assess the acceptability of the final WEF layout and include any additional recommendations into the EMPr (where relevant), further to the requirements already laid out in the final bat pre-construction monitoring and impact assessment report. An assessment of the corresponding grid connection will be assessed separately. The findings presented in this report are based on a specialist site visit conducted from 6 to 10 March 2023.

1.1 Project Details

The Koup 1 Wind Energy Facility comprises 43 Wind Turbine Generators (WTG) with a contracted capacity of approximately 184MW. To achieve this, the WTG's that have been selected have rotor diameters and hub heights of up to 200 m. Additional infrastructures include:

- Permanent compacted hardstanding areas;
- Temporary laydown areas;
- Concrete foundations to support the wind turbines;
- Electrical transformers adjacent to each wind turbine;
- One new 33/132kV on-site substation and/or combined collector substation;
- Internal 33kV medium voltage cables connecting turbines to the substation;
- A Battery Energy Storage System (BESS), with up to 40MW of batteries using solid state / liquid flow batteries;
- Internal roads providing access to each turbine;
- One construction/laydown area;
- One permanent Operation and Maintenance (O&M) building, including an on-site spares storage building, a workshop and an operations building to be located on the site identified for the construction laydown area;
- A wind measuring lattice (approximately 120m in height) has already been installed;
- One temporary concrete batching plant extent to facilitate the concrete requirements for turbine foundations.

The development site is located ~55km south of Beaufort West and includes the following land portions:

- Portion 11 of the Farm Brits Eigendom No. 374;
- The Farm Rietpoort No. 231;
- Portion 15 of the Farm Brits Eigendom No. 374;
- Portion 5 of the Farm Kaatjies Kraal No. 380;

- Portion 10 of the Farm Kaatjies Kraal No. 380;
- Portion 11 of the Farm Kaatjies Kraal No. 380.

2. TERMS OF REFERENCE

The terms of reference for the site walk-through, as agreed on in discussion with Genesis Eco-Energy Developments Pty (Ltd), were to:

- Conduct a walk-through of the development area;
- Verify sensitive features in the area and assess the significance thereof for the development;
- Compile a report which includes any inputs for further recommendations and potential mitigation measures, as well as update and finalise the bat monitoring programme, where relevant.

Although care was taken to ensure the proper investigation of all areas of the development, it is only reasonable to expect that not all-important bat features could be located during a single site survey.

It is emphasised that information, as presented in this report, only has bearing on the development site itself. This information cannot be applied to any other area, however similar in appearance or any other aspect, without proper investigation.

2.1 Relevant Legislation and Guidelines

The following policies and guidelines have informed the methodologies employed during the specialist site walk-through and will ensure the applicant meets all legislative requirements regarding construction and operation of the Koup 1 WEF.

- Chapter 1 of the National Environmental Management Act, 1998 (NEMA) (Act 107 of 1998).
- Convention on the Conservation of Migratory Species of Wild Animals (1979).
- Convention on Biological Diversity (1993).
- Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996).
- National Environmental Management Act, 1998 (NEMA, Act No. 107 of 1998).
- National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004).
- The Equator Principles (2013).
- The Red List of Mammals of South Africa, Swaziland and Lesotho (2016).
- National Biodiversity Strategy and Action Plan (2005).
- South African Best Practice Guidelines for Pre-construction Monitoring of Bats at Wind Energy Facilities - ed 5. South African Bat Assessment Association of June 2020.
- South African Good Practice Guidelines for Operational Monitoring for Bats at Wind Energy Facilities – ed 2. South African Bat Assessment Association of June 2020.
- Species Environmental Assessment Guidelines (April 2022).

3. REVIEW OF DATA COLLECTED TO DATE

Based on the pre-construction monitoring data captured by EkoVler (2021), the most important aspect **of the project that would affect bat populations adversely is the wind turbines themselves, through direct** collisions and barotrauma. Other potential impacts to bats due to WEF developments include the loss of existing and potential roosts. Bat droppings of insectivorous bats were found at all farm dwellings and one small roost with less than 20 bats were identified. Derelict buildings, koppies with rocky ridges, low trees with associated denser vegetation along the riverbeds and livestock water points could also potentially attract bats to the study area. The sporadic rainfall seasons that sometimes occur in arid areas like the Karoo reflect on periods of insect emergence and accompanying higher bat activity (EkoVler 2021).

Bat occurrence between ground level and approximately 30 m altitude were alike, although a higher activity was recorded in the north-western part of the wind farm. The abundance of veld flowers might attract more insects, which would subsequently attract more bats. The highest likelihood of fatality at Koup 1 is attributed to Tadarida aegyptiaca (Egyptian free-tailed bat) (EkoVler 2021).

The Koup 1 site is covered by distribution map overlays of five families and approximately 12 bats species. Four species have conservation status of Near Threatened, while one is Vulnerable and three Near Threatened. Eptesicus hottentotus (the Long-tailed serotine) and Cistugo seabrae (the Angolan wing-gland bat) are considered endemic to Southern Africa (EkoVler 2021).

51% of the recorded activity represents the clutter-edge forager Neoromicia capensis, which was the dominant species on site. The second highest percentage of calls (48%) represents the Molossidae family, namely 44% of calls from Tadarida aegyptiaca and 4% from Sauromy petrophilus. Both of these are classified as high-risk species, as they are physiologically adapted to fly at medium or high altitudes (in the vicinity of the turbine blades), allowing for the risk of collision and barotrauma to be high. The endangered Miniopterus natalensis comprised 1% of the activity. Species diversity was considered to be generally higher at lower altitudes (EkoVler 2021).

Although the overall significance of impacts to bats varied among the different phases and type impacts, the impacts to bats, overall, were assessed to be of a medium significance before mitigation and low after mitigation. Cumulative impacts were determined to likely to be of a high significance before mitigation and medium after mitigation (EkoVler 2021).

Numerous mitigation measures, as per EkoVler (2021) were recommended, including (but not limited to):

- Operational monitoring and mitigation to be implemented upon construction of the WEF to try to curb the high collected impact.
- Turbines need to be controlled below the cut-in speed and freewheeling is not to be allowed from the onset of operations.
- Curtailment to be implemented immediately from the onset (as soon as the turbines start spinning), in areas where turbines are situated within high-medium sensitivity zones. Curtailment should be refined as more data becomes available during the operational bat monitoring programme. If the number of turbines are reduced, the developer could consult with the operational bat specialist as to whether curtailment could be reduced, after more data becomes available.
- Curtailment for those turbines situated in the medium sensitivity zone must be implemented, if necessary, and with the advice of the operational bat specialist.
- Freewheeling: The cut-in speed is the lowest wind speed at which turbines generate power. Freewheeling should be prevented to an extent that bat mortality is avoided below cut-in speed, and feathering applied to all turbine blades during periods when no power is generated for the duration of the project to prevent bat mortality.
- Bat deterrents could be an option for mitigation but will have to be investigated

- .Operational monitoring should inform the extent of the mitigation required.

4. SITE VISIT AIM

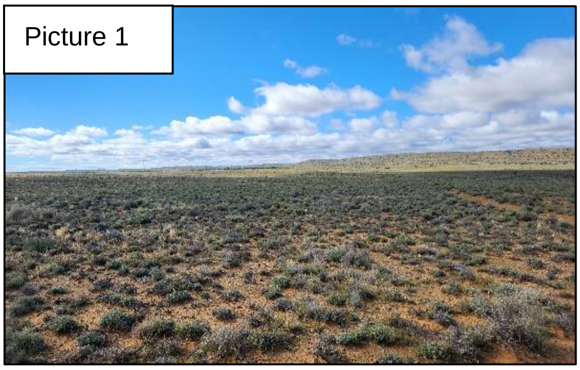
The aim of the site visit was to conduct a site walk-through and micro-siting process to ground truth important bat features and to ensure that all turbine blades and other infrastructure are positioned outside of their respective bat sensitivity buffers.

5. METHODOLOGY

The site walk-through visit took place from 6 to 10 March 2023. Important bat features, sensitivities and final layouts were loaded onto the Avenza Maps app[1] to to ground truth the features and update the sensitivities, where relevant. All sensitive features and buffers developed during the initial pre-construction monitoring campaign were used as a baseline for the assessment during the field survey. Additional sensitive areas were then also searched for in the field to identify any potential gaps in the existing sensitivity data. The positions of the turbines, powerline, switching station, laydown area, O&M building, BESS and substation were prioritised.

6. ON-SITE OBSERVATIONS

The site is characterised by mostly flat topography with undulating hills, dominated by low karoo scrub and grasses (Picture 1) where bat activity is expected to be lower. Areas where drainage lines or other water sources are prevalent were noted to be associated with denser shrub/thicket vegetation (Picture 2) and is expected to serve as suitable foraging habitat for bats, likely accommodating higher bat activity. Overall, the sensitivities defined during the pre-construction monitoring and impact assessment phase of the project remain applicable to the site at the time of this assessment. The bat sensitive areas are mostly around drainage lines with established riparian vegetation, water points, slopes and dwellings (Appendix A).


Picture 1


Picture 2

[1] Avenza Maps: 4.2.2(182) Build 11 ARCH64. Map Store Interface: f3b5ecc9

7. RECCOMMNDATIONS AND CONCLUSION

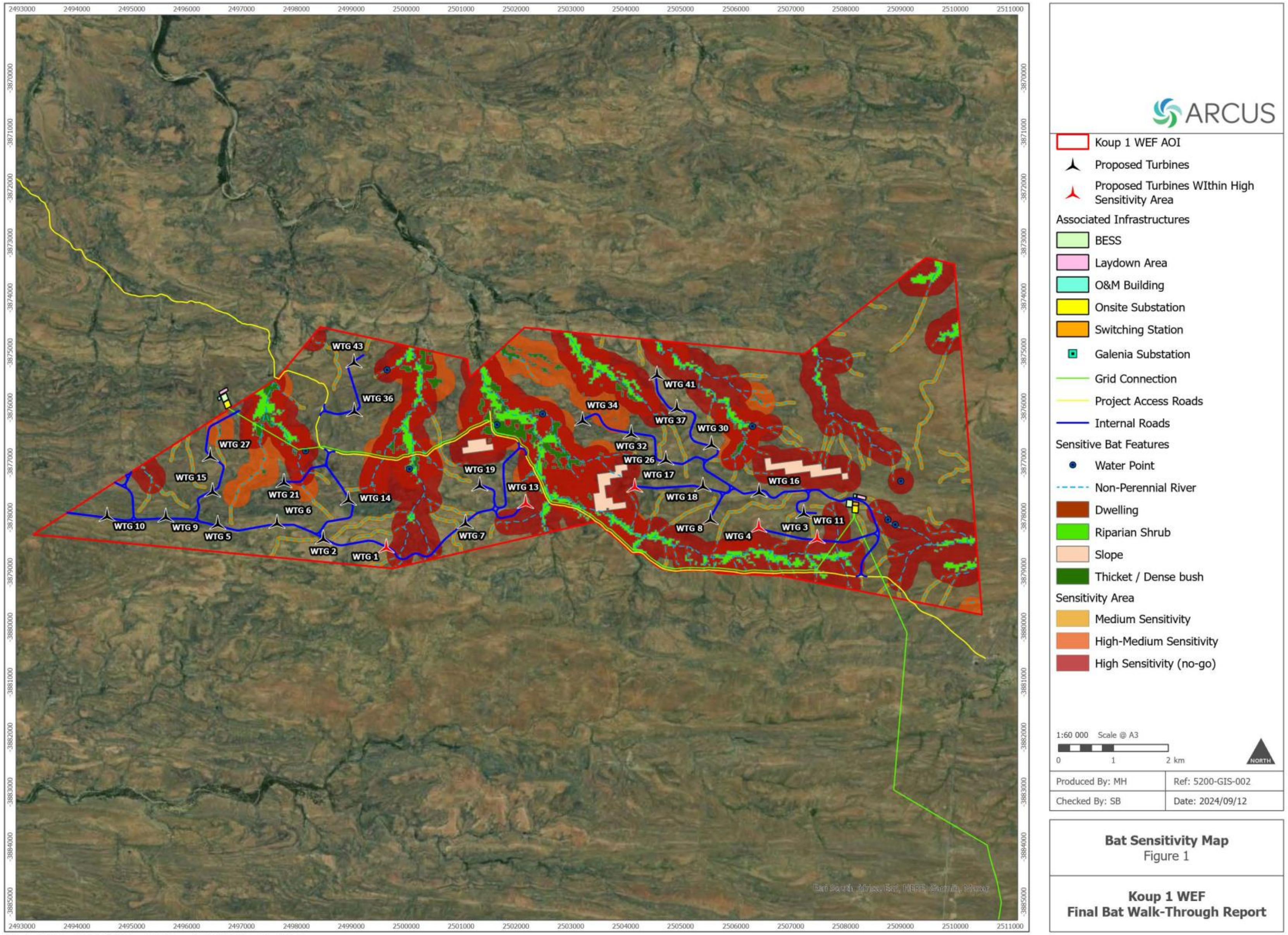
The original sensitivity buffers defined in the pre-construction monitoring and impact assessment report defined high sensitivity zones as areas where all turbine components (including the full blade length) should be placed outside of such zones (i.e no-go areas). The motivation for these no-go zones were mostly due to the occurrence of suitable bat foraging and roosting habitat. High-Medium sensitivity zones were defined as areas mainly comprising thicket vegetation bordering high sensitivity zones, but demonstrated lower bat activity levels – which negated the need for such areas to be defined as being highly sensitive. Placement of wind turbines within these areas would be allowed, provided that strict mitigation measures are adhered to. Medium sensitivity zones were defined as areas whereby a 35m buffer was applied around first and second order gullies, which are known to mostly contain water when there is run-off during periods of rain. These areas, in general, do not support thicket or riparian vegetation and have been associated with lower bat activity. They are subsequently not deemed relevant enough to be assigned with a higher sensitivity rating and do not warrant curtailment from the onset of the project. Turbines are however recommended to be placed outside of these zones, as far as possible. Where turbines are placed inside such zones, then results from the operational bat monitoring campaign should inform whether or not further mitigation is required, and implemented as soon as it becomes relevant.

The observations made on site confirm that the buffers previously defined during the preconstruction monitoring and impact assessment phase are sufficient and adequately represent the sensitivities expected to occur on site today. No further sensitive features were identified to be included into the existing sensitivity layout. As such, it is compulsory for the recommendations made in the original bat specialist monitoring and impact assessment report (EkoVler 2021) to be strictly adhered to, and for the original bat sensitivity buffers to be considered when finalising the wind turbine layout. No wind turbines (including the full blade length) are to be located within high sensitivity (i.e. no-go) buffers. Turbines may be sited in high-medium sensitivity buffers, provided that strict mitigation measures (as outlined in EkoVler 2021) are adhered to from the onset of project development. Turbines may also be sited within medium sensitivity areas, provided that operational monitoring results inform the need for potential future mitigation/curtailment measures. Associated infrastructures, including laydown areas, O&M buildings, an on-site substation, internal roads and the BESS are deemed permissible in sensitive areas due to the small extent and type of impacts associated with such infrastructures. However, such infrastructures should avoid high sensitivity (i.e. no-go) areas as far as possible. As recommended in the final bat monitoring and impact assessment report (EkoVler 2021), roost searches should be conducted before the construction of these components commence.

Presently, five wind turbines (including the maximum blade length of 100m) encroach into areas of high sensitivity (Appendix A). These turbines include T1, T3, T4, T13, andT17. It will be mandatory for all five of these wind turbines to be micro-sited out of these sensitivity zones prior to the construction of the facility taking place. All further recommendations made in the final bat pre-construction monitoring and impact assessment report (EkoVler 2021) for turbines encroaching into high-medium and medium sensitivity buffers apply. No further inclusions, other than those already identified in EkoVler 2021, are required for consideration into the final EMPr.

All mitigation measures and findings proposed by EkoVler (2021) remain valid and the overall impact of turbines on bats remains low after mitigation, assuming all recommendations are adhered to. Based on the above, it is the specialists opinion that the final layout and EMPr can be approved.

APPENDIX A FIGURES



G:\Ecology\5200 Koup 1 & 2 Bats\5200 Koup 1 & 2 Bats.aprx\5200-GIS-002 Koup 1 Sensitivity Map

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ARCHAEOLOGICAL WALKDOWN SURVEY REPORT FOR THE FINAL LAYOUT OFTHE KOUP 1 WIND ENERGY FACILITY, SOUTH OF BEAUFORT WEST, WESTERN CAPE PROVINCE

(Assessment conducted under Section 38 (8) of theNational Heritage Resources Act as part of an Environmental Impact Assessment)

Prepared for

Arcus Consultancy Services South Africa (Pty) Ltd

On behalf of

Genesis Entertrag Koup 1 Wind Farm (Pty) Ltd

Draft: 20 March 2023

ACO Associates cc
Archaeology and Heritage Specialists

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EXECUTIVE SUMMARY

ACO Associates cc was appointed by Arcus Consultancy Services South Africa (Pty) Ltd, on behalf of Genesis Entertrag Koup 1 Wind Farm (Pty) Ltd, to undertake an archaeological walkdown survey of the final layout of the authorised Koup 1 Wind Energy Facility (Figure 1).

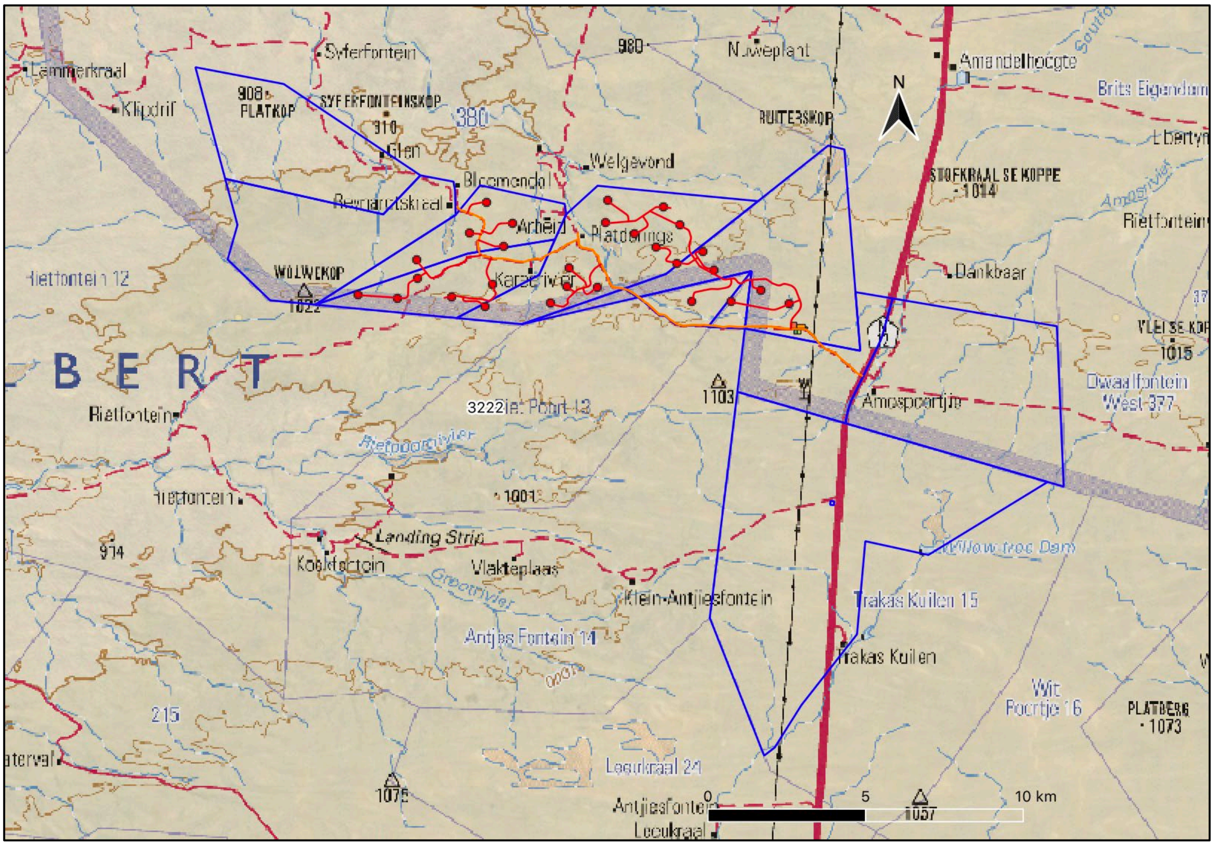


Figure 1: Extract from the 1:250,000 topographic map showing the final layout plan of the Koup 1 WEF, south of Beaufort West (Source: 1:250,000 chart 3222: Beaufort West, National Geo-spatial Information, http://www.ngi.gov.za).

The walkdown survey was conducted between 17 and 24 January 2023. A previous survey conducted by PGS Heritage (Pty) Ltd in June and July 2021 informed this report.

The 2023 archaeological walkdown survey aimed to ground truth the final WEF layout to:

- Assess compliance of final layout plan with recommendations of the heritage impact assessment and the Environmental Authorisation conditions.
- Identify any further heritage resources which may be impacted by the construction, operation and decommissioning of the wind energy facility and assess their significance.
- Provide recommendations for any specific mitigation measures to be included in the updated project Environmental Management Programme.

Findings

The walkdown survey noted the same widespread but fairly thin occurrence of mainly Middle Stone Age archaeological material of relatively low significance reported across much of the study area by PGS Heritage and concluded that the overall impacts to this material arising from the construction, operation and decommissioning of the wind energy facility will be low.

The survey found that although the bulk of the archaeological occurrences identified in 2021-2022 were assessed to be not conservation-worthy, all these sites have been avoided in the final layout of the wind energy facility and no impacts to these previously identified archaeological sites and materials are anticipated.

A handful of additional archaeological occurrences were recorded during the walkdown survey, the bulk of which were ephemeral scatters of Middle Stone Age flaked stone, with some Later Stone Age lithics also present. Most of these scatters were ungradable and are considered not to be conservation-worthy. Two, more dense lithic scatters (JG014 and G003) were graded 3C and should be avoided during the construction and use of the nearby turbine access road.

In respect of the built environment, the 2021 PGS Heritage survey identified a number of historical structures located close to the current farm access road which runs through the wind energy facility. PGS Heritage recommended 30 m buffers around three of these structures which the final wind energy facility layout has addressed.

It should be noted that the proposed overhead powerline passes almost directly over a modern labourers' cottage (KO-04), and while this is not a heritage issue, given the building's age, it may be health / living environment issue.

The walkdown survey identified three additional historical buildings at Arbeid on Portion 10 of Farm 380 but none of these will be directly affected by the construction or operation of the wind energy facility.

The final Koup 1 wind energy facility layout avoids the formal graveyard (KO-07) and possible grave (KO-08) associated with the Kareerivier farm complex and the informal graveyard (KO-06) possibly associated with the Platdoring complex. The proposed access road and overhead powerline are more than 200 m from these two sites and well beyond the 50 m buffer recommended in the heritage impact assessment.

The informal graveyard (KO-06), however, is approximately 45 m from the roadway and while this is likely to be sufficient to ensure that it is not impacted by the access road, it means that the imposition of the recommended 50 m buffer is not practical. It is also possible that the proposed final cable alignment will pass almost directly over the graves and the potential for impacts is high.

The single isolated grave, KO-09, is directly adjacent to the access road and is very likely to be impacted by its upgrade for the wind energy facility unless the road alignment is amended.

The walkover survey identified an apparent isolated grave (G001) inside a wire fence next to the road to the Arbeid farm werf. This grave will not be affected by activities associated with the construction, operation or decommissioning of the wind energy facility.

Recommendations

Archaeology: Although no archaeological mitigation was recommended by PGS Heritage in the 2022 heritage impact assessment, most of the archaeological occurrences identified are nonetheless avoided by the final layout of the wind energy facility. The exceptions are KO-14 and KO-16, but both occurrences are described by as low-density scatters of low significance and not conservation worthy.

The fieldwork undertaken during the January 2023 walkdown survey confirmed the occurrence of mainly Middle Stone Age with some Later Stone Age archaeological material in relatively low quantities and of relatively low significance within the wind energy facility. Only two of the six lithic scatters recorded in the 2023 walkdown survey were graded (JG014 and G003). The remainder are considered not to be conservation worthy.

It is recommended that a buffer of 20 m is implemented around JG014, and that the buffer is physically marked off during construction to ensure that the site is safeguarded.

There is always a chance that buried archaeological material will be exposed during earthworks for the wind energy facility. All archaeological material over 100 years of age is protected and may only be altered or removed from its place of origin under a permit issued by Heritage Western Cape.

In the event of anything unusual being encountered, the project archaeologist and Heritage Western Cape must be notified and consulted immediately so that mitigatory action can be determined and be implemented, if necessary. Mitigation is at the cost of the developer, while time delays and diversion of machinery/plant may be necessary until mitigation in the form of conservation or archaeological/palaeontological sampling is completed.

Overall impacts to archaeological material arising from activities related to the construction, operation and decommissioning of the wind energy facility will be low.

Built Environment: Of the five built structures identified in the 2022 heritage impact assessment, PGS Heritage recommended the implementation of 30 m buffer zones around the outer limits of the medium significance KO-03 (Kareerivier) and KO-05 (Platdorings) farmsteads. In the final layout of the Koup 1 wind energy facility, the nearest project elements - the access road and OHPL - are both more than 30 m from these farmsteads and they will thus be subject to no direct project-related impacts.

The final wind energy facility layout also meets the requirements of guidelines published by the Western Cape Provincial Government (2006) which recommend a minimum distance of at least 500 m between wind turbine generators and buildings/structures older than 60 years. There are no wind turbine generators located less than 800 m of KO03 or KO-05.

With respect to the other three structures identified in the heritage impact assessment, only the modern labourers' cottage KO-04 may be affected by the overhead powerline which on its current alignment passes almost directly over the building. While this is not a heritage issue, given the building's current age, it may be health / living environment issue if the cottage is still used.

It should also be noted that none of these three structures (KO-01, KO-02 and KO-04) are less than 750 m from the nearest wind turbine generator position.

None of the historical structures identified in the 2023 walkdown survey on Arbeid on Portion 10 of Farm 380 (JG008 and JG009) will be directly affected by the construction or operation of the wind energy facility and all are at least 820 m from the nearest project infrastructure. No mitigation measures are required in respect of these structures.

Impacts to the bult environment from activities related to the construction, operation and decommissioning of the wind energy facility will be low.

Graves and Burials: Because of their sensitivity, the 2022 heritage impact assessment gave the formal graveyard (KO-07) adjacent to the Kareerivier farm complex, the informal burial ground (KO-06) between the labourers' cottage KO-04 and the Platdorings farm complex and the two possible isolated graves (KO-08 and KO-09) a high heritage significance rating and graded them 3A. The heritage impact assessment recommended that all the graves and burial grounds should be subject to a 50 m buffer and should be avoided and left in situ.

This review of the final WEF layout of the Koup 1 wind energy facility can confirm that the proposed access road and OHPL are more than 200 m from the formal graveyard (KO-07) and possible grave (KO-08) associated with the Kareerivier farm complex and from the informal graveyard (KO-06) possibly associated with the Platdoring complex.

However, the informal graveyard (KO-06) is approximately 45 m from the roadway and while this is likely to be sufficient to ensure that it is not impacted by the access road, it means that the imposition of a 50 m buffer is not practical, and it is thus recommended that this buffer is reduced to 40 m.

Regarding the overhead powerline and KO-06, the proposed final cable alignment shown on Figure 5 does not have pylons indicated at the points marked by the red stars on the figure. This suggests that the alignment of the cable may instead follow the most direct line between the two marked pylon locations. If this is the case, the overhead powerline will pass almost directly over the graves and the potential for impacts is high. It is recommended that the alignment of the overhead powerline in the vicinity of KO-06 follows that indicated in the final wind energy facility layout to ensure that there are no impacts to this informal burial ground.

Lastly, the single isolated grave, KO-09, is directly adjacent to the access road and is more likely than not to be impacted by its upgrade for the wind energy facility unless the road alignment is amended. It is recommended that the proposed access road alignment is amended in the vicinity of KO-09 to ensure that the grave is not impacted. It is suggested that the 50 m buffer may be reduced to 20 m, but that should this occur, it must be a requirement that KO-09 is physically marked off during construction to ensure that grave is not damaged or disturbed.

If any of the identified graves need to be relocated because of the development of the wind energy facility, a Grave Management Plan must be drafted and approved Heritage Western Cape, before graves are moved.

Unmarked, pre-colonial graves may occur within the wind energy facility, particularly along river courses and within valleys where there is soft soil suitable for interment. In the event that any human remains be disturbed, exposed or uncovered during excavations and earthworks for the wind energy facility, work in the vicinity must cease immediately, the remains made secure and left in situ, and the project archaeologist and Heritage Western Cape notified so that a decision can be made about how to mitigate the find.

Provided the mitigation measures above are implemented, impacts to graves and burials from activities related to the construction, operation and decommissioning of the wind energy facility will be low.

Conclusions

In terms of the acceptability of the proposed final wind energy facility layout to heritage resources, although there remains some potential for impacts to heritage resources arising from the construction, operation or decommissioning of the project, these impacts are not likely to be significant given the overall nature of archaeological resources in the area.

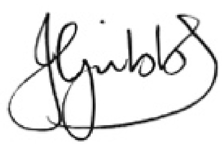
It is our reasoned opinion, therefore, that the final Koup 1 wind energy facility layout has avoided and excluded most identified heritage resources and, provided the recommendations made and mitigation measures set out above are included in the Environmental Management Programme and effectively implemented before and during construction, the final site layout plan is considered acceptable from a heritage perspective and development can proceed.

DECLARATION OF SPECIALISTS' INDEPENDENCE

I, John Gribble, as the appointed independent specialist hereby declare that I:

- Acted as the independent specialist in this application.
- Regard the information contained in this report as it relates to my specialist input/study to be true and correct, and do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act.
- Have and will not have no vested interest in the proposed activity proceeding.
- Have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act.
- Am fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R. 543) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification.
- Have ensured that information containing all relevant facts in respect of the specialist input/studywas distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study.
- Have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application.
- Have ensured that the names of all interested and affected parties that participated in terms of the specialist input/study were recorded in the register of interested and affected parties who participated in the public participation process;
- Have provided the competent authority with access to all information at my disposal regardingthe application, whether such information is favourable to the applicant or not; and
- Am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Signature of the specialist:



Name of company: ACO Associates cc

Date: 20 March 2023

THE AUTHOR

John Gribble has an MA (UCT, 1989), in archaeology and has been working in cultural resource management since the early 1990s. He has worked in both the regulatory and commercial heritage management fields: the former during 13 years at the National Monuments Council / South African Heritage Resources Agency (SAHRA), and the latter as both a terrestrial and maritime archaeological consultant in South Africa and the UK.

He holds archaeological accreditation with the Association of Southern African Professional Archaeologists CRM section (Member #43) as follows:

- Principal Investigator: Maritime Archaeology and Colonial Archaeology; and
- Field Director: Stone Age Archaeology.

A signed and certified specialist statement of independence is attached to this report as Appendix 1 and the author's CV is attached as Appendix 2.

GLOSSARY

Archaeology: Remains resulting from human activity which is in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.

Early Stone Age: The archaeology of the Stone Age between 700 000 and 2 500 000 years ago**.**

Heritage: That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999.

Hornfels: A type of indurated shale used in the production of stone tools in the Karoo.

Late Stone Age: The archaeology of the last 20 000 years associated with fully modern people.

Middle Stone Age: The archaeology of the Stone Age between 20 000-300 000 years ago associated with early modern humans.

SAHRA: South African Heritage Resources Agency – the compliance authority which protects national heritage.

ACRONYMS

EA	Environmental Authorization
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
ESA	Early Stone Age
GPS	Global Positioning System
HIA	Heritage Impact Assessment
HWC	Heritage Western Cape
LSA	Late Stone Age
MSA	Middle Stone Age
NCW	Not Conservation Worthy
NHRA	National Heritage Resources Act
OHPL	Overhead Powerline
SAHRA	South African Heritage Resources Agency
WEF	Wind Energy Facility
WTG	Wind Turbine Generator

Table of Contents

1 INTRODUCTION AND TERMS OF REFERENCE

ACO Associates cc were appointed by Arcus Consultancy Services South Africa (Pty) Ltd, on behalf of Genesis Entertrag Koup 1 Wind Farm (Pty) Ltd, to undertake an archaeological walkdown survey of the final layout of the authorised Koup 1 Wind Energy Facility (WEF).

The Koup 1 WEF will be located some 55 km south of Beaufort West in the Western Cape Province (Figure 1 and Figure 2).

As part of the Environmental Impact Assessment (EIA) process, the Koup1 WEF was subject to an archaeological assessment conducted by PGS Heritage (Pty) Ltd, which included a survey of the WEF project area in June and July 2021 (Fourie 2022).

This current, pre-construction archaeological walkdown report draws on information presented by PGS Heritage in the archaeological impact assessment (AIA) which supported their HIA (Mann 2022a).

The 2023 archaeological walkdown survey aimed to ground truth, as far as possible, the authorised wind turbine generator (WTG) positions, internal WEF cable and road alignments, substation sites, laydown areas, etc., to:

- Assess compliance of final layout plan with recommendations of the HIA and the Environmental Authorisation (EA) conditions.
- Identify heritage resources which may be impacted by the construction, operation and decommissioning of the WEF and assess their significance.
- Provide recommendations for any specific mitigation measures to be included in the updated project Environmental Management Programme (EMPr).

2 PROJECT DESCRIPTION

(TO BE INSERTED BY ERM / ARCUS)

3 LEGISLATION

The basis for all heritage impact assessment is the National Heritage Resources Act 25 (NHRA) of 1999. The Act has defined certain kinds of heritage as being worthy of protection, by either specific or general protection mechanisms.

In South Africa the law is directed towards the protection of human made heritage, although places and objects of scientific importance, such as palaeontology, are also included. The NHRA also protects intangible heritage such as traditional activities, oral histories and places where significant events happened. Generally protected heritage which must be considered in any heritage assessment includes:

- Buildings and structures (older than 60 years of age)
- Archaeological sites (older than 100 years of age)
- Palaeontological sites and specimens
- Shipwrecks and aircraft wrecks
- Graves and graveyards
- Cultural landscapes.

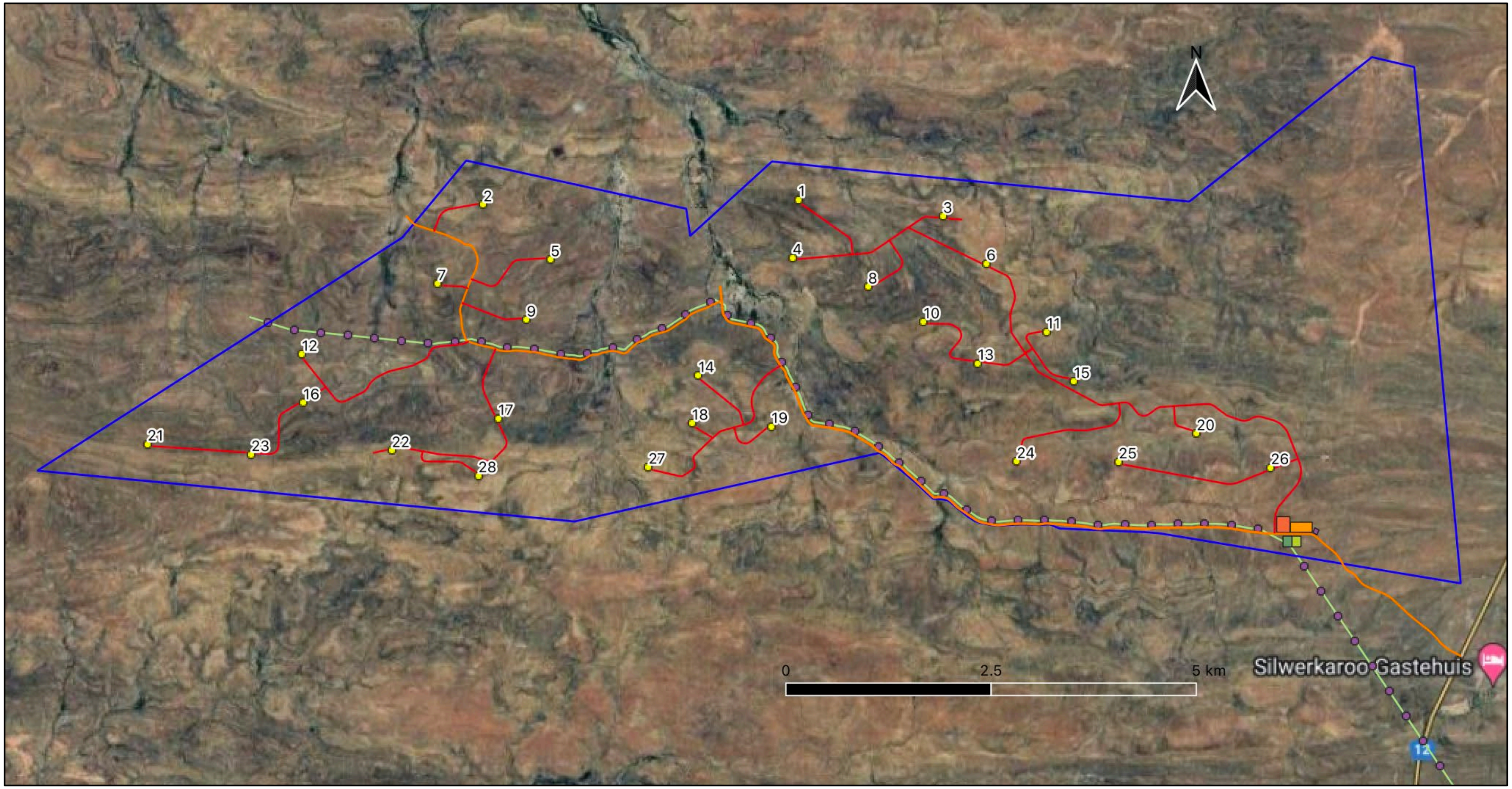


Figure 2: Final layout plan of the Koup 1 WEF south of Beaufort West, showing WTG positions (numbered yellow dots), turbine roads (red lines), access road (orange line), 33 kV powerline with pylons (green line/purple dots), and construction laydown, onsite substation and other work areas (coloured rectangles). The dark blue line marks the WEF boundary (Source: Google Earth).

4 METHODOLOGY

This report is based on:

- The 2021 archaeological fieldwork and 2022 impact assessment for the Koup 1 WEF contained in the AIA and HIA.
- Available archaeological reports and impact assessments conducted in the vicinity of the project.
- The results of the pre-construction archaeological walkdown survey undertaken by ACO Associates in January 2023.

The pre-construction walkdown was undertaken John Gribble and Gail Euston-Brown between 17 and 24 January 2023.

The archaeological team each carried a hand-held GPS receiver (using the WGS84 datum), pre-loaded with the footprint of the project elements and other data such as the WEF and farm boundaries and the positions of the sites previously recorded by PGS. These were used to log the survey tracks and record the positions of new heritage resources identified (Figure 3).

No archaeological material was removed from the project area during either of the field assessments but was, instead, recorded and photographed *in situ*, and each site was given a significance rating and assessed in terms of whether it required mitigation.

Both archaeologists were suitably qualified and experienced to date and characterise any heritage resources encountered during the survey.

4.1 Limitations and Assumptions

Parts of the WEF are remote and difficult to access. In some areas, roads and tracks marked on maps or visible in historical satellite imagery were overgrown, making access by vehicle to some areas challenging. One area could not be accessed due to a locked gate.

Heat was also a factor during the survey with daytime temperatures of 40 degrees + for much of the fieldwork period.

Despite these limitations, the coverage of the WEF site achieved by the archaeological walkdown survey is deemed adequate.

Ground visibility across most of the WEF area was good with vegetation cover not unduly affecting the archaeological survey outcomes (Plate 1).

Given the substantial body of spatial information generated by the 2021 and 2023 archaeological surveys of the WEF area, we are confident that the significant heritage issues have been identified and suitable mitigation measures have been proposed for inclusion in the updated EMPr, and that no further heritage survey is necessary.

Plate 1: View of landscape from south-eastern corner of Koup 1 WEF (Photo: J Gribble)

5 SITE DESCRIPTION AND HERITAGE BACKGROUND

The Koup 1 WEF is located approximately 55 km south of Beaufort West, west of the N12 which connects Beaufort West to Oudtshoorn.

The underlying geology of the WEF is continental (fluvial/lacustrine) sediments of the Abrahamskraal Formation (Lower Beaufort Group) and rock types encountered on site include mudstones, siltstone, carbonates, and fine-grained sandstones, some of which have been silicified and metamorphosed (Webley 2021, Fourie 2022).

The site is on the wide plain called "*Die Vlakte*" or The Koup, between the Nieuweveld mountains in the north and the Swartberg range in the south, and is characterized by low relief, gently rolling to hilly terrain between 1000 to 1100 m above mean sea level (Webley 2021).

The area has undergone extensive erosion which has resulted in the development of scree slopes and rocky gullies. The low-lying flat area between the hills are frequently cut by ephemeral streams and areas sheet wash are common (Fourie 2022).

The vegetation is predominantly karroid bossieveld, with trees confined to shallow, intermittent-flowing drainage lines and shallow, gravelly soils (Webley 2021).

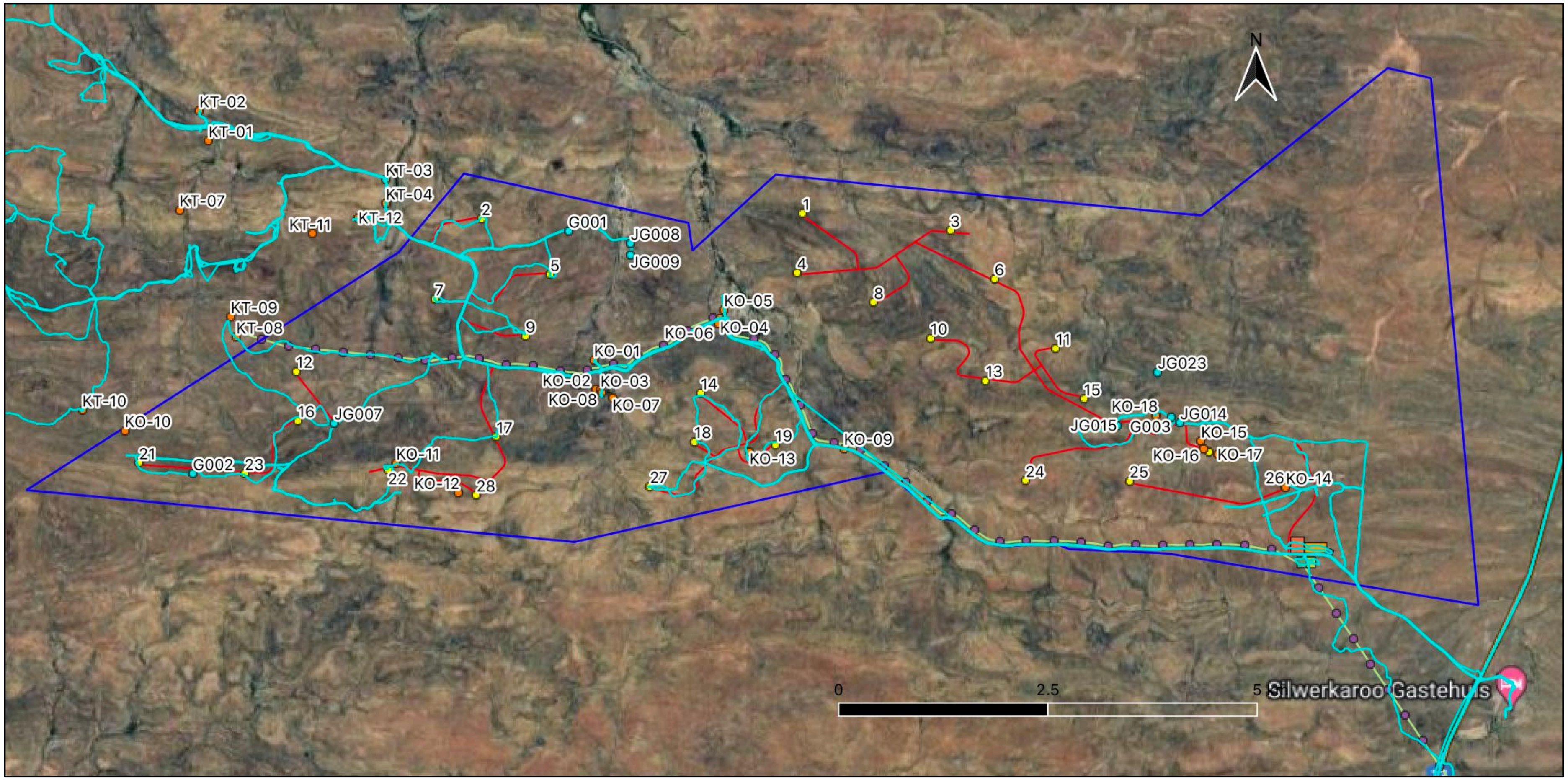


Figure 3: Archaeological survey coverage of the Koup 1 WEF. 2021 sites identified by PGS = orange points numbered "KO"; 2023 walkdown survey = pale blue lines and points numbered "JG" and "G" (Source: Google Earth).

5.1 The Archaeological Context

The area is known to have been inhabited since the Early Stone Age (ESA) and throughout the Middle Stone Age (MSA). MSA surface lithic scatters predominate as a background “litter” of material across the landscape but can occur in denser concentrations in certain localities (Webley 2021). Cape Archaeological Survey & Associates (2016) recorded a few such MSA ‘sites’ on nearby Trakaskuilen which they described as “a dense scatter of artefacts comprising cores, flakes and blades of fine-grained chert, frequently occurring on elevated ridges” (Webley 2021:19).

Webley (2021:19) also cites a 2019 PGS Heritage (2019) heritage assessment in the same area which reports “two sites characterised by low to medium density scatters of lithics consisting of cores and flaked debitage”. The “raw material varied from medium to fine-grained quartzite pebbles used in the production of ESA choppers and cleavers to fine grained chert associated with MSA cores and flaked debitage”. Webley (2021) notes that these lithics were Later Stone Age (LSA) rather than ESA, however.

The LSA is generally associated with the ancestors of the San hunter-gatherer groups who roamed this area periodically and depending on rainfall during the last 30 000 years. Within the last 2 000 years pastoralists (Khoekhoen) arrived in the area and although their remains have been recorded in the Zeekoei River Valley to the north-east, none have been reported in the Koup area.

Rock art is rare in this area but when found more usually takes the form of rock engravings on the dark dolerite boulders that characterise parts of the Karoo rather than paintings. No rock engravings have been reported by the projects referred to above (Cape Archaeological Survey 2016, PGS Heritage 2019, Webley 2021, Fourie 2022).

5.2 The Historical Context

The most recent archaeological layer in the Karoo landscape relates to the historical occupation of the area by stock farmers of European descent from the late 18th century. These European pastoralists, were highly mobile – hence the name trekboers – tending to move between winter and summer grazing on and off the Great Escarpment respectively.

Land ownership was originally informal and only became regulated after the implementation of the quitrent system of the 19th century used by the Government to control the lives and activities of the farmers. However, judging by the kinds of artefacts and structures found on the landscape, many of the farms in the Karoo are likely to have been used before land was formally granted or loaned in the early 19th century (Sampson et al, 1994).

Although the Roggeveld and Nuweveld were extensively settled between 1740 and 1770, farms to the south of Beaufort West (in the vicinity of the study area) were settled relatively late, as they lacked permanent water (Guelke & Shell, 1992).

6 FINDINGS OF THE 2020-2021 and 2023 SURVEYS

6.1 2020-2021 Survey

PGS Heritage conducted a “selective archaeological, palaeontological, and cultural landscape survey of the study area” between November 2020 and July 2021 to support the

HIA. The survey focussing on the areas "identified for the placement of the proposed turbines and associated internal roads, laydown areas and substation sites within the larger assessment area. Farmsteads and structures were documented from their property boundaries when access was restricted" (Fourie 2022:viii).

This PGS Heritage survey identified nine (9) archaeological occurrences, five (5) historical built structures and four graves, burial grounds or possible graves.

A full list of these sites and materials is provided in Appendix 3 below.

6.1.1 Archaeology

Eight of the archaeological occurrences (KO-10 – KO-17) were described as find spots consisting of low densities of mainly MSA flakes and debitage, although some ESA and LSA artefacts were observed. Most of these find spots were found to coincide with ridges and areas of sheet wash and were assessed to be of low heritage significance and graded as Not Conservation Worthy (NCW).

The single archaeological site (KO-18) recorded was described as a low to medium density surface scatter of 5-10 artefacts/10m^2 of mostly MSA lithics and visible in an area of approximately 20m^2. PGS Heritage indicated that it was unlikely that this archaeological material was in primary context as the material was exposed due to some sheet erosion. The artefacts consist mostly of flakes, chips, chunks and some cores, produced from silicified mudstone. This site was rated as having a low heritage significance and graded 3C.

Isolated single artefacts were noted widely across the study area.

No mitigation was recommended for any of the archaeological occurrences.

6.1.2 Built Environment

Of the five built structures identified, PGS Heritage (Fourie 2022) reports that two - labourers' houses KO-01 and KO-04 - are modern based both on their construction and on mapping information which shows that these building are both currently less than 60 years old. They were thus graded NCW.

KO-02 is the ruin of a packed stone and mudbrick structure, clearly more than 60 years of age, assessed to be of low heritage significance and graded 3C.

The two structures given a medium heritage significance are a flat-roofed stone house and associated modern kraal (KO-03) on the farm Kareerivier (Portion 11 of Farm 380) and the Platdorings farmstead (Portion 5 of Farm 380) which consists of four buildings and associated farm structures (KO-05). These structures are older than 60 years of age and given a grading of 3B.

6.1.3 Graves and Burials

The 2021-2022 survey recorded a formal graveyard (KO-07) adjacent to the Kareerivier farm complex. The fenced graveyard contains four graves (6 burials) with headstones and granite grave furniture all of which are of members of the Bothma family. The burials date between 1947 and 2006. A possible unmarked grave (KO-08) indicated by a pile of rocks was recorded adjacent to the house. The location of the site in the middle of the farm werf suggests that this may not be a grave, but as a precaution PGS Heritage's assessment is retained.

Another possible single grave (KO-09), indicated by vertical rocks marking the head and foot of the grave, was recorded next to the access road on the southern boundary of the farm Platdorings.

Lastly, an informal burial ground (KO-06) with four stone-packed graves was found, approximately 85 and 175 m from the labourers' cottage KO-04 and the Platdorings farm complex respectively.

All the graves and possible graves were given a high heritage significance rating and graded 3A.

6.1.4 Recommendations of the 2022 HIA

The HIA (Fourie 2022) made the following site-specific recommendations:

- **Archaeology**: No mitigation of any of the recorded sites was required.

- **Built Environment**: No mitigation was required in respect of KO-01, KO-02 and KO-04 as they were unlikely to be affected by the proposed development of the WEF.

  30 m buffer zones were recommended around the outer limits of the KO-03 (Kareerivier) and KO-05 (Platdorings) farmsteads. If development occurs within 30 m of KO-03, the main house will need to be satisfactorily studied and recorded before impact occurs.

- **Graves and Burials**: All the graves and burial grounds should be subject to a 50 m buffer and should be avoided and left in situ.

  If, for any reason, any of the graves need to be relocated because of the development of the WEF, a Grave Management Plan should be developed and approved HWC, before graves are moved.

6.2 2023 Pre-Construction Walkdown Survey

6.2.1 Assessment of 2021-2022 Recommendations against Final Layout

The final layout for the Koup 1 WEF was amended after the completion of the 2022 HIA and one of the aims of the recent 2023 walkdown survey was to assess compliance of the final layout plan with HIA recommendations and EA conditions.

The survey found that:

- Although the bulk of the **archaeological occurrences** identified in 2021-2022 were assessed to be NCW, all sites, including the grade 3C KO-18, have been avoided in the final layout of the WEF and no impacts to these previously identified archaeological sites and materials are anticipated.

- The **built structures** identified by PGS Heritage are all located close to the current farm access road which runs through the WEF. This road will be upgraded to form the Koup 1 and 2 WEF access road and the proposed OHPL will run parallel to it for much of its length.

Except for the modern labourers' cottage KO-04, none of the built structures will be directly affected by the upgraded access road, OHPL or other WEF infrastructure.

With regard to KO-04, as indicated in Figure 4 below, the building is approximately 25 m from the current roadway and is will thus not to be directly affected by the upgrade of the road required to serve the WEFs.

It should be noted, however, that the OHPL as shown in Figure 4 passes almost directly over the building and while this is not a heritage issue, given the building's age, it may be health / living environment issue.

Figure 4 also indicates the distance of the Platdorings farm complex (KO-05) from the access road and OHPL (approximately 100 m) which respects the 50 m buffer around the complex recommended by the HIA (Fourie 2022).

Figure 4: Proximity of access road (orange line) and OHPL (green line) to modern labourers' cottage KO-04 (red circle). The cottage is approximately 25 m from the current roadway (red arrow) and will not be affected by the roadway upgrade, but the proposed OHPL appears to pass directly over the structure. Note also the location of the Platdorings farm complex (KO-05) approximately 100 m from the access road and OHPL.

- With respect to the **graves and burial grounds** identified in 2021-2022, the final layout of the Koup 1 WEF avoids the formal graveyard (KO-07) and possible grave (KO-08) associated with the Kareerivier farm complex and the informal graveyard (KO-06) possibly associated with the Platdoring complex.

  The proposed access road and OHPL are more than 200 m from the two former sites and well beyond the 50 m buffer recommended around each in the HIA.

The informal graveyard (KO-06), however, is approximately 45 m from the roadway and while this is likely to be sufficient to ensure that it is not impacted by the access road, it means that the imposition of a 50 m buffer is not practical, and it is recommended that this is reduced to 40 m.

Regarding the OHPL and KO-06, the proposed final cable alignment shown on Figure 5 does not have pylons indicated at the points marked by the red stars on the figure. This suggests that the alignment of the cable may instead follow the most direct line between the two marked pylon locations. If this is the case, the OHPL will pass almost directly over the graves and the potential for impacts is high.

The single isolated grave, KO-09, is directly adjacent to the access road (Figure 6) and is very likely to be impacted by its upgrade for the WEF unless the road alignment is amended.

Figure 5: Location of informal graveyard KO-06 in relation to the access road (orange line) and OHPL (green line). The lack of pylon positions shown at the two red-starred points on the OHPL suggests that it will follow the line between the two marked pylons (red line) which means it will cross almost directly over the graveyard.

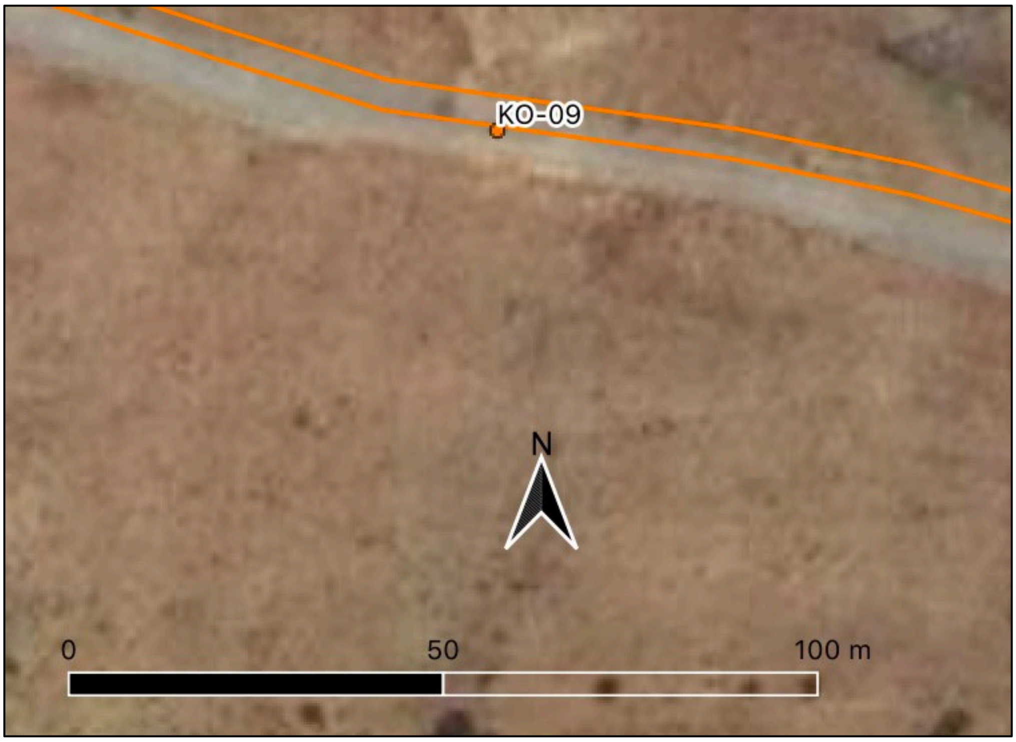


Figure 6: Location of grave KO-09 directly adjacent to the current farm road and proposed WEF access road.

6.3 2023 Walkdown Survey Results

The survey tracks and archaeological sites recorded during the 2023 walkdown survey are shown on Figure 7 and a list of sites recorded is attached as Appendix 4.

The walkdown survey found the following:

6.3.1 Archaeology

A handful of archaeological occurrences were recorded, the bulk of which were ephemeral scatters of mainly MSA flaked stone, but with some LSA lithics present. These scatters were ungradable and are considered NCW.

Two, more dense lithic scatters (JG014 and G003) were located high on a hillside adjacent to the existing farm road. Approximately 100 m apart, these two scatters may be manifestations of a single large MSA lithic scatter, possibly associated with an outcrop of tuffite.

The lithics appear to be eroding out of the surrounding slope and are made on fine-grained greenish tuff. They include cores and a long scraper with retouch on each side, some showing patination (Plate 2). A long, thin naturally squared-off piece of shale with a shaped, chisel-like end which has been rubbed on both sides was recorded on G003. Dr Janette Deacon (pers. comm.) reports seeing something similar in Bushmanland and her information is that it was used as an upper grindstone to flatten fence wire into arrowheads during the historical period (Plate 2).These two a scatters were given a grading of 3C and should be avoided during the construction and use of the adjacent turbine access road.

6.3.1 Built Environment

Three historical buildings (i.e. older that 60 years of age) were recorded at Arbeid on Portion

10 of Farm 380.

JG008 consists of an abandoned farmhouse. The front of the building is built of stone and the rear of brick. This, and it's two-room depth suggests that it may have been built in two phases. There is a chimney on northern end of the building and a double-doored shed at other end. A small ruinous, one-roomed building is located directly behind the house (Plate 3). These buildings were graded 3C.

JG009 is a stone-walled, flat-roofed labourers' cottage located approximately 120 m south of JG008, on the same farm werf. The building is in good condition and still in use (Plate 4). This building has been graded 3C.

Neither JG008 or JG009 will be directly affected by the construction or operation of the WEF.

6.3.2 Graves and Burials

An apparent isolated grave (G001) inside a wire fence was recorded next to the farm track which leads to the Arbeid farm werf. The grave has a head- and footstone but is otherwise unmarked. It has been given a 3A grading but will not be affected by activities associated with the construction or operation of the WEF (Plate 5).

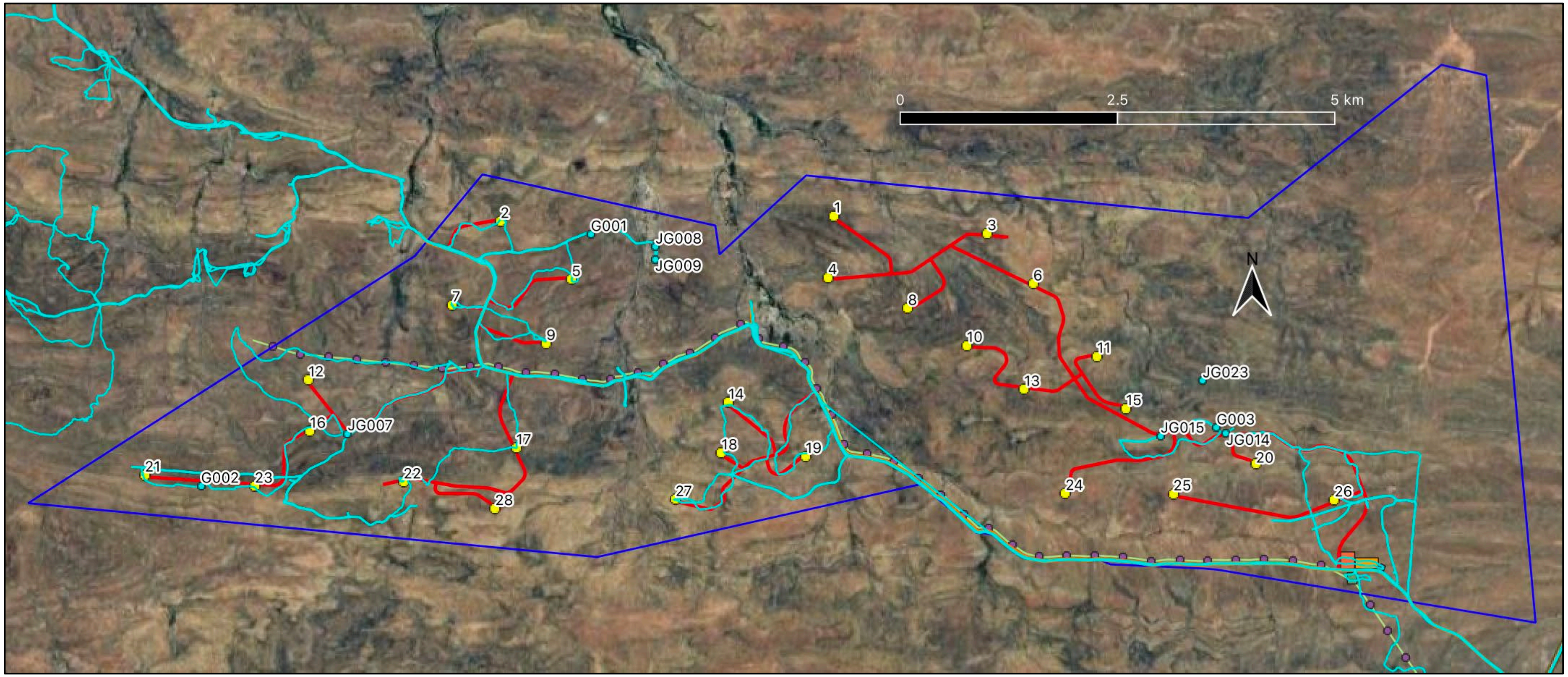


Figure 7: 2023 walkdown survey tracks (pale blue lines) and waypoints (numbered pale blue dots) overlaid on the final WEF layout.

Plate 2: Selection of tuffite lithics from JG014 (top) and rubbed shale piece from G003 (bottom left and right) (Photos: J Gribble).

Plate 3: Historical farm building JG008 (Photo: J Gribble).

Plate 4: Stone-built labourers' cottage JG009 (Photo: J Gribble).

Plate 5: Isolated grave G001 (Photos: J Gribble & G Euston-Brown).

7 POTENTIAL IMPACTS AND RECOMMENDED MITIGATION MEASURES FOR INCLUSION IN THE EMPR

7.1 Archaeology

Although no archaeological mitigation was recommended by PGS Heritage in the 2022 HIA, most of the archaeological occurrences identified are nonetheless avoided by the final layout of the WEF. The exceptions are KO-14 which is next to an access road and WTG26, and KO-16 which also lies very close to an access road. However, both occurrences are described by Fourie (2022) as low-density scatters of low significance and not conservation worthy.

The fieldwork undertaken during the January 2023 walkdown survey confirmed the occurrence of mainly MSA with some LSA archaeological material in relatively low quantities and of relatively low significance within the WEF.

Only two of the six lithic scatters recorded were graded (JG014 and G003). The remainder are considered not conservation worthy.

G003 is located more than 70 m from one of the turbine access roads and is thus unlikely to be impacted by WEF-related activities. JG014, however, is within 10 m of the proposed road alignment and is likely to suffer impacts.

It is recommended that a buffer of 20 m is implemented around JG014, and that is marked off during construction to ensure that the site is safeguarded.

There is always a chance that buried archaeological material will be exposed during earthworks for the WEF. All archaeological material over 100 years of age is protected and may only be altered or removed from its place of origin under a permit issued by HWC.

In the event of anything unusual being encountered, the project archaeologist and HWC must be notified and consulted immediately so that mitigatory action can be determined and be implemented, if necessary. Mitigation is at the cost of the developer, while time delays and diversion of machinery/plant may be necessary until mitigation in the form of conservation or archaeological/palaeontological sampling is completed.

Overall impacts to archaeological material arising from activities related to the construction, operation and decommissioning of the WEF will be low.

7.2 Built Environment

Of the five built structures identified in the HIA (Fourie 2022), PGS Heritage recommended the implementation of 30 m buffer zones around the outer limits of the medium significance KO-03 (Kareerivier) and KO-05 (Platdorings) farmsteads.

In the final layout of the Koup 1 WEF the nearest project elements - the access road and OHPL - are both more than 30 m from these farmsteads and they will thus be subject to no direct project-related impacts.

The final WEF layout also meets the requirements of guidelines published by the Western Cape Provincial Government (2006) which recommend a minimum distance of at least 500 m between WTGs and buildings/structures older than 60 years. There are no WTGs located less than 800 m of KO03 or KO-05.

With respect to the other three structures identified in the HIA, only the modern labourers' cottage KO-04 may be affected by the OHPL which on its current alignment passes almost directly over the building. While this is not a heritage issue, given the building's current age, it may be health / living environment issue if the cottage is still used.

It should also be noted that none of these three structures (KO-01, KO-02 and KO-04) are less than 750 m form the nearest WTG position.

None of the historical structures identified in the 2023 walkdown survey on Arbeid on Portion 10 of Farm 380 (JG008 and JG009) will be directly affected by the construction or operation of the WEF and all are at least 820 m from the nearest WEF infrastructure elements. No mitigation measures are required in respect of these structures.

Impacts to the bult environment from activities related to the construction, operation and decommissioning of the WEF will be low.

7.3 Graves and Burials

Because of their sensitivity, the 2022 HIA gave the formal graveyard (KO-07) adjacent to the Kareerivier farm complex, the informal burial ground (KO-06) between the labourers' cottage KO-04 and the Platdorings farm complex and the two possible isolated graves (KO-08 and KO-09) a high heritage significance rating and graded them 3A. The HIA recommended that all the graves and burial grounds should be subject to a 50 m buffer and should be avoided and left in situ.

This review of the final WEF layout of the Koup 1 WEF can confirm that the proposed access road and OHPL are more than 200 m from the formal graveyard (KO-07) and possible grave (KO-08) associated with the Kareerivier farm complex and from the informal graveyard (KO-06) possibly associated with the Platdoring complex.

However, the informal graveyard (KO-06) is approximately 45 m from the roadway and while this is likely to be sufficient to ensure that it is not impacted by the access road, it means that the imposition of a 50 m buffer is not practical, and it is thus recommended that this buffer is reduced to 40 m.

Regarding the OHPL and KO-06, the proposed final cable alignment shown on Figure 5 does not have pylons indicated at the points marked by the red stars on the figure. This suggests that the alignment of the cable may instead follow the most direct line between the two marked pylon locations. If this is the case, the OHPL will pass almost directly over the graves and the potential for impacts is high. It is recommended that the alignment of the OHPL in the vicinity of KO-06 follows that indicated in the final WEF layout to ensure that there are no impacts to this informal burial ground.

Lastly, the single isolated grave, KO-09, is directly adjacent to the access road and is more likely than not to be impacted by its upgrade for the WEF unless the road alignment is amended. It is recommended that the proposed access road alignment is amended in the vicinity of KO-09 to ensure that the grave is not impacted. It is suggested that the 50 m buffer may be reduced to 20 m, but that should this occur, it must be a requirement that KO-09 is physically marked off during construction to ensure that grave is not damaged or disturbed.

If any of the identified graves need to be relocated because of the development of the WEF, a Grave Management Plan must be drafted and approved HWC, before graves are moved.

Unmarked, pre-colonial graves may occur within the WEF, particularly along river courses and within valleys where there is soft soil suitable for interment. In the event that any human remains be disturbed, exposed or uncovered during excavations and earthworks for the WEF, work in the vicinity must cease immediately, the remains made secure and left in situ, and the project archaeologist and HWC notified so that a decision can be made about how to mitigate the find.

Provided the mitigation measures above are implemented, impacts to graves and burials from activities related to the construction, operation and decommissioning of the WEF will be low.

8 CONCLUSIONS

In terms of the acceptability of the proposed final WEF layout to heritage resources, although there remains some potential for impacts to heritage resources arising from the construction of the WEF, these impacts are not likely to be significant given the overall nature of archaeological resources in the area.

It is our reasoned opinion, therefore, that the final Koup 1 WEF layout has avoided and excluded most identified heritage resources and, provided the recommendations made and mitigation measures set out above are included in the EMPr and effectively implemented before and during construction, the final site layout plan is considered acceptable from a heritage perspective and development can proceed.

9 REFERENCES

Cape Archaeological Survey (CAS) cc and Associates. 2016. *Heritage Impact Assessment: Proposed Construction of Two Power Lines & Three Substations for the Mainstream Wind Energy Facility. Land Parcel Beaufort West, Remainder of Farm Trakaskuilen No 15, Portion 1 Trakaskuilen No 15, Portion 1 of Witpoortje No 16*. Unpublished report prepared for SiVEST Environmental Division. Cape Archaeological Survey. Cape Town.

Fourie, W. 2022. *Heritage Impact Assessment for the proposed construction of the Koup 1 Wind Energy Facility and Associated Grid Infrastructure, Near Beaufort West, Western Cape Province, South Africa*. Unpublished report produced for SiVEST SA (Pty) Ltd. Pretoria. PGS Heritage (Pty) Ltd.

Guelke, L. and Shell, R. 1992. Landscape of Conquest: Frontier water alienation and Khoikhoi strategies for survival, 1652 – 1780. *Journal of Southern African Studies* 18(4):803-824.

Mann, N. 2022a. *Proposed Construction of the Koup 1 Wind Energy Facility and Associated Grid Infrastructure, near Beaufort West, Western Cape Province, South Africa: Archaeological Impact Assessment*. Unpublished report produced for SiVEST SA (Pty) Ltd. Pretoria. PGS Heritage (Pty) Ltd.

PGS Heritage. 2019. *Proposed construction of a linking station, two (2) power lines and two (2) on-site substations for the Beaufort West and Trakas Wind Farms, near Beaufort West in the Western Cape Province*. Unpublished report prepared for SiVest. PGS Heritage. Pretoria.

Provincial Government of the Western Cape, 2006. *Strategic Initiative to Introduce Commercial Land Based Wind Energy Development in the Western Cape. Towards a Regional Methodology for wind energy site selection*. Dated May 2006.

Sampson, CG., Sampson, BE & Neville, D. 1994. An early Dutch Settlement pattern on the north east frontier of the Cape Colony. *Southern African Field Archaeology* 3: 74-81.

Webley, L. 2021. *Proposed Beaufort West Wind Farm 33kv / 132kv Substation, 132kv Powerline and Associated Infrastructure Projects*. Unpublished report prepared for 3Foxes Biodiversity Solutions. Lita Webley. Cape Town.

APPENDIX 1: SPECIALIST DECLARATION

(See separate PDF file)

APPENDIX 2: CURRICULUM VITAE – JOHN GRIBBLE

(Last updated – 12 January 2023)

Name:	John Gribble
Profession:	Archaeologist (Maritime)
Date of Birth:	15 November 1965
Parent Firm:	ACO Associates cc
Position in Firm:	Senior Archaeologist
Years with Firm:	5+
Years of experience:	33
Nationality:	South African
HDI Status:	n/a

Education:

1979-1983	Wynberg Boys' High School
1986	BA (Archaeology), University of Cape Town
1987	BA (Hons) (Archaeology), University of Cape Town
1990	Master of Arts, (Archaeology) University of Cape Town

Employment:

- September 2017 – present: ACO Associates, Senior Archaeologist and Consultant
- 2014-2017: South African Heritage Resources Agency, Manager: Maritime and Underwater Cultural Heritage Unit
- 2012-2018: Sea Change Heritage Consultants Limited, Director
- 2011-2012: TUV SUD PMSS (Romsey, United Kingdom), Principal Consultant: Maritime Archaeology
- 2009-2011: EMU Limited (Southampton, United Kingdom), Principal Consultant: Maritime Archaeology
- 2005-2009: Wessex Archaeology (Salisbury, United Kingdom), Project Manager: Coastal and Marine
- 1996-2005: National Monuments Council / South African Heritage Resources Agency, Maritime Archaeologist
- 1994-1996: National Monuments Council, Professional Officer: Boland and West Coast, Western Cape Office

Professional Qualifications and Accreditation:

- Member: Association of Southern African Professional Archaeologists (ASAPA) (No. 043)
- Principal Investigator: Maritime and Colonial Archaeology, ASAPA CRM Section
- Field Director: Stone Age Archaeology, ASAPA CRM Section
- Class III Diver (Surface Supply), Department of Labour (South Africa) / UK (HSE III)

Experience:

I have more than 30 years of professional archaeological and heritage management experience. After completing my postgraduate studies and a period of freelance archaeological work in South Africa and aboard, I joined the National Monuments Council (NMC) (now the South African Heritage Resources Agency (SAHRA)) in 1994. In 1996 I become the NMC's first full-time maritime archaeologist and in this regulatory role was responsible for the management and protection of underwater cultural heritage in South Africa under the National Monuments Act, and subsequently under the National Heritage Resources Act.

In 2005 I moved to the UK to join Wessex Archaeology, one of the UK's biggest archaeological consultancies, as a project manager in its Coastal and Marine Section. In 2009 I joined Fugro EMU Limited, a marine geosurvey company to set up their maritime archaeological section. I then spent a year at TUV SUD PMSS, an international renewable energy consultancy, where I again provided maritime archaeological consultancy services to principally the offshore renewable and marine aggregate industries.

In August 2012 I established Sea Change Heritage Consultants Limited, a maritime archaeological consultancy. Sea Change traded until 2018, providing archaeological services to a range of UK maritime sectors, including marine aggregates and offshore renewable energy.

In the UK I was also involved in strategic projects which developed guidance and best practice for the UK offshore industry with respect to the marine historic environment. This included the principal authorship of two historic environment guidance documents for COWRIE and the UK renewable energy sector (*Historical Environment Guidance for the Offshore Renewable Energy Sector* (2007) and *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector* (2010)). I was also manager and lead author in the development of the archaeological elements of the first Regional Environmental Assessments for the UK marine aggregates industry, and in the 2009 *UK Continental Shelf Offshore Oil and Gas and Wind Energy Strategic Environmental Assessment* for Department of Energy and Climate Change. In 2013-14 I was lead author and project co-ordinator on *The UNESCO Convention on the Protection of the Underwater Cultural Heritage 2001: An Impact Review for the United Kingdom* and in 2016 I was co-author of a Historic England / Crown Estate / British Marine Aggregate Producers Association funded review of marine historic environment best practice guidance for the UK offshore aggregate industry.

I returned to South African in mid-2014 where I was re-appointed to my earlier post at SAHRA: Manager of the Maritime and Underwater Cultural Heritage Unit. In July 2016 I was appointed as Acting Manager of SAHRA's Archaeology, Palaeontology and Meteorites Unit.

I left SAHRA in September 2017 to join ACO Associates as Senior Archaeologist and Consultant. Since being at ACO I have carried out a wide range of terrestrial and maritime archaeological assessments, many of which are listed in the following section.

In 2018 of the potential impacts of marine mining on South Africa's palaeontological and archaeological heritage for the Council for Geoscience, on behalf of the Department of Mineral Resources.

I have been a member of the Association of Southern African Professional Archaeologists (No. 043) for more than thirty years and am accredited by ASAPA's Cultural Resource Management section.

I have been a member of the ICOMOS International Committee for Underwater Cultural Heritage since 2000 and served as a member of its Bureau between 2009 and 2018.

Since 2010 I have been a member of the UK's Joint Nautical Archaeology Policy Committee.

I am a member of the Advisory Board of the George Washington University / Iziko Museums of South Africa / South African Heritage Resources Agency / Smithsonian Institution 'Southern African Slave Wrecks Project'.

I have served on the Heritage Western Cape Archaeology, Palaeontology and Meteorites Committee since 2014.

Selected Project Reports:

Gribble, J. 2017. *Archaeological Assessment of Farm No 8/851, Drakenstein*. Unpublished report prepared for Balwin Properties Pty Ltd. ACO Associates.

Gribble, J. 2017. *Archaeological Assessment of Bosjes Phase 2, Farm 218 Witzenberg*. Unpublished report prepared for Farmprops 53 (Pty) Ltd. ACO Associates.

Gribble, J. 2017. *Canal Precinct, V&A Waterfront: Heritage Impact Assessment*. Unpublished report prepared for Nicolas Baumann Urban Conservation and Planning. ACO Associates.

Gribble, J. 2017. *Archaeological Assessment of the proposed dam on the farm Constantia Uitsig, Erven 13029 and 13030, Cape Town*. Unpublished report prepared for SLR Consulting (South Africa) (Pty) Ltd). ACO Associates.

Gribble, J. 2017. *Archaeological Assessment of Erf 4722 Blouvlei, Wellington*. Unpublished report prepared for Urban Dynamics Western Cape (Pty) Ltd. ACO Associates.

Hart, T.G., Gribble, J. & Robinson, J. 2017 *Heritage Impact Assessment for the Proposed Phezukomoya Wind Energy Facility to be Situated in the Northern Cape*. Unpublished report prepared for Arcus Consulting. ACO Associates.

Hart, T.G., Gribble, J. & Robinson, J. 2017 *Heritage Impact Assessment for the Proposed San Kraal Wind Energy Facility to be Situated in the Northern Cape*. Unpublished report prepared for Arcus Consulting. ACO Associates.

Gribble, J. 2018. *Integrated Heritage Impact Assessment of the Peter Falke Winery on Farm 1558 Groenvlei, Stellenbosch*. Unpublished report prepared for Werner Nel Environmental Consulting Services. ACO Associates.

Gribble, J. & Halkett, D. 2018. *Heritage Impact Assessment for a Proposed Extension of the Kaolin Mine on Portion 1 of the Farm Rondawel 638, Namaqualand District, Northern Cape*. Unpublished report prepared for Rondawel Kaolien (Pty) Ltd. ACO Associates.

Gribble, J. 2019. *Archaeological Impact Assessment for Proposed Sand Mining on Portion 2 of Farm Kleinfontein 312, Klawer District, Western Cape*. Unpublished report prepared for Green Direction Sustainability Consulting (Pty) Ltd. ACO Associates.

Halkett, D. & Gribble, J. 2018. *Archaeological/Heritage Report for the Expansion of the Current Granite Mining at Oeranoep and Ghaams, Northern Cape Province*. Unpublished report prepared for Klaas Van Zyl. ACO Associates.

Gribble, J. 2018. *Potential Impacts of Marine Mining on South Africa's Palaeontological and Archaeological Heritage*. Report prepared for Council for Geoscience. ACO Associates.

Gribble, J. 2018. *Maritime Heritage Impact Assessment: Block ER236, Proposed Exploration Well Drilling*. Unpublished report prepared for ERM Southern Africa (Pty) Ltd. ACO Associates.

Gribble, J. 2018. *Maritime Heritage Impact Assessment: IOX Cable Route*. Unpublished report prepared for ERM Southern Africa. ACO Associates.

Gribble, J. 2018. *Archaeological Assessment of the Terrestrial Portion of the IOX Cable Route*. Unpublished report prepared for ERM Southern Africa. ACO Associates.

Gribble, J. 2018. *Archaeological Assessment: Erven 11122, 11123, 11124, 11125, 11126, 11127 and Re 11128, Corner Frere Street and Albert Road, Woodstock, Cape Town*. Unpublished report prepared for Johan Cornelius. ACO Associates.

Gribble, J. 2018. *Maritime Heritage Impact Assessment: Expansion of Diamond Coast Aquaculture Farm on Farm 654, Portion 1, Kleinzee, Northern Cape*. Unpublished report prepared for ACRM. ACO Associates.

Gribble, J. 2018. *Heritage Impact Assessment: Ship Repair Facility, Port of Mossel Bay*. Unpublished report prepared for Nemai Consulting. ACO Associates.

Gribble, J. 2018. *Archaeological Assessment: Sites B and C, Portswood Ridge Precinct, V&A Waterfront*. Unpublished report prepared for Urban Conservation. ACO Associates.

Gribble, J. 2018. *Heritage Impact Assessment: Zandrug, Farm Re 9/122, Cederberg*. Unpublished report prepared for Cederberg Environmental Assessment Practice. ACO Associates.

Gribble, J. and Hart, T.G. 2018. *Initial Assessment Report and Motivation for Exploratory Permit, Erf 4995, corner of Waterfall and Palace Hill Roads, Simonstown*. Unpublished report prepared for Regent Blue Sayers' Lane (Pty) Ltd. ACO Associates.

Gribble, J. and Hart, T.G. 2018. *Initial investigation report with respect to human remains found at Erf 4995, corner of Waterfall and Palace Hill Roads, Simonstown*. Unpublished permit report prepared for Regent Blue Sayers' Lane (Pty) Ltd. ACO Associates.

Gribble, J. 2019. *Maritime Heritage Impact Assessment: ASN Africa METISS Subsea Fibre Optic Cable System*. Unpublished report prepared for ERM Southern Africa. ACO Associates.

Gribble, J. 2019. *Maritime Archaeological Impact Assessment of Proposed Aquaculture Areas 1, 6 And 7, Algoa Bay, Eastern Cape Province*. Unpublished report prepared for Anchor Research & Monitoring (Pty) Ltd. ACO Associates.

Gribble, J. 2019. *Heritage Impact Assessment: Rooilandia Farm Dam, Pipeline and New Irrigation Areas*. Unpublished report prepared for Cornerstone Environmental Consultants. ACO Associates.

Gribble, J. 2019. *Maritime Archaeological Impact Assessment of Proposed Equiano Cable System, landing at Melkbosstrand, Western Cape Province*. Unpublished report prepared for Acer (Africa) Environmental Consultants. ACO Associates.

Gribble, J. 2019. *Heritage Baseline for Prospecting Right Applications: Sea Concession Areas 14b, 15b and 17b, West Coast, Western Cape Province*. Unpublished report prepared for SLR Consulting. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2019. *Archaeological Amendment Report: San Kraal Wind Energy Facility, Noupoort, Northern Cape*. Unpublished report prepared for Arcus Consulting. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2019. *Archaeological Amendment Report: Phezukomoya Wind Energy Facility, Noupoort, Northern Cape*. Unpublished report prepared for Arcus Consulting. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2019. *Archaeological Amendment Report: Hartebeeshoek West Wind Energy Facility, Noupoort, Northern Cape*. Unpublished report prepared for Arcus Consulting. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2019. *Archaeological Amendment Report: Hartebeeshoek East Wind Energy Facility, Noupoort, Northern Cape*. Unpublished report prepared for Arcus Consulting. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2019. *Heritage Assessment: Infrastructure Associated with the San Kraal, Phezukomoya and Hartebeeshoek East and West Wind Energy Facilities, Noupoort, Northern Cape*. Unpublished report prepared for Arcus Consulting. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2020. *Heritage Impact Assessment: Proposed Grid*

Connection for the De Aar 2 South Wind Energy Facility, De Aar, Northern Cape. Unpublished report prepared for Arcus Consulting. ACO Associates.

Gribble, J., Euston-Brown, G.L. & Hart, T. 2020. *Heritage Impact Assessment: Proposed Construction of Five Guest Cottages on the Farm Groenfontein (Farm 96), Outside Ceres, Western Cape*. Unpublished report prepared for Doug Jeffery Environmental Consultants. ACO Associates.

Gribble, J. 2020. *Maritime Archaeological Impact Assessment for Prospecting Rights Applications: Sea Concession Areas 14b, 15b and 17b, West Coast, Western Cape Province*. Unpublished report prepared for SLR Consulting. ACO Associates.

Gribble, J. 2020. *Maritime Archaeological Impact Assessment for Prospecting Rights Applications: Sea Concession Areas 13C and 15C - 18C, West Coast, Western Cape Province*. Unpublished report prepared for SLR Consulting. ACO Associates.

Gribble, J. 2020. *Heritage Impact Assessment for Proposed Sand Mining on Portion 2 Of Farm Kleinfontein 312, Klawer District, Western Cape*. Unpublished report prepared for Green Direction Sustainability Consulting (Pty) Ltd. ACO Associates.

Gribble, J. 2020. *Archaeological Assessment: Erven 10712 and Re 14932, Corner Railway Street and Albert Road, Woodstock, Cape Town*. Unpublished report prepared for Claire Abrahamse. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2020. *Heritage Impact Assessment: Leliefontein to Conmarine Bulk Water Pipeline, between Paarl and Wellington*. Unpublished report prepared for Aurecon South Africa (Pty) Ltd. ACO Associates.

Gribble, J. & Euston-Brown, G.L. 2020. *Heritage Impact Assessment: Proposed Expansion of the Sand Mine on Portion 4 of The Farm Zandbergfontein, Robertson, Western Cape*. Unpublished report prepared for Greenmined Environmental. ACO Associates.

Gribble, J. 2021. *Maritime Archaeological Impact Assessment of Proposed 2AFRICA/GERA (East) Submarine Fibre Optic Cable System, Landing at Duynefontein, Western Cape Province*. Unpublished report prepared for Acer (Africa) Environmental Consultants. ACO Associates.

Gribble, J. 2021. *Maritime Archaeological Impact Assessment of Proposed 2AFRICA/GERA (West) Submarine Fibre Optic Cable System, Landing at Yzerfontein, Western Cape Province*. Unpublished report prepared for Acer (Africa) Environmental Consultants. ACO Associates.

Gribble, J. 2021. *Heritage Impact Assessment: Beaufort West Photovoltaic Project, outside Beaufort West, Western Cape*. Unpublished report prepared for Nemai Consulting (Pty) Ltd. ACO Associates.

Gribble, J. 2021. *Heritage Impact Assessment: Proposed Esizayo 132KV Transmission Integration Project, on Farms Standvastigheid 210 Remainder and Aurora 285, Western and Northern Cape*. Unpublished report prepared for WSP Group Africa (Pty) Ltd. ACO Associates.

Gribble, J. 2022. *Heritage Impact Assessment: Proposed Oceana 10 MW Solar Photovoltaic Facility, on Portion 4 of Farm 6 Duyker Eiland, St Helena Bay, Western Cape*. Unpublished report prepared for SRK Consulting (South Africa) (Pty) Ltd. ACO Associates.

Gribble, J. & Euston-Brown, G. 2021. *Heritage Impact Assessment: Proposed Photovoltaic Facility on Remainder of Farm Vaal Rivier 261, Farm Vaal Kloof 262, Portion 1 of Farm Jurgens Fontein 263, Portion 2 of Farm Kolkies Rivier 234 and Portion 1 of Farm Eiberg West 260, East of Ceres, Western Cape*. Unpublished report prepared for Ecocompliance. ACO Associates.

Publications:

Gribble, J. and Scott, G., 2017, *We Die Like Brothers: The sinking of the SS Mendi*, Historic England, Swindon.

Sharfman, J., Boshoff, J. and Gribble, J. 2017. Benefits, Burdens, and Opportunities in South Africa: The Implications of Ratifying the 2001 UNESCO Convention on the Protection of Underwater Cultural Heritage, in L. Harris (ed) *Sea Ports and Sea Power: African Maritime Cultural Landscapes*, Springer International Publishing, Switzerland, pp 101-110.

Lloyd Jones, D., Langman, R., Reach, I., Gribble, J., and Griffiths, N., 2016, Using Multibeam and Sidescan Sonar to Monitor Aggregate Dredging, in C.W. Finkl and C. Makowski (eds) *Seafloor Mapping along Continental Shelves: Research and Techniques for Visualizing Benthic Environments, Coastal Research Library 13*, Springer International Publishing, Switzerland, pp 245-259.

Athiros, G. and Gribble, J., 2015, *Wrecked at the Cape Part 2*, The Cape Odyssey 105, Historical Media, Cape Town.

Gribble, J. and Sharfman, J., 2015, The wreck of SS Mendi (1917) as an example of the potential trans-national significance of World War I underwater cultural heritage, *Proceedings of the UNESCO Scientific Conference on the Underwater Cultural Heritage from World War I*, Bruges, 26-28 June 2014.

Gribble, J., 2015, Underwater Cultural Heritage and International Law. Cambridge by Sarah Dromgoole, in *South African Archaeological Bulletin*, 70, 202, pp 226-227.

Athiros, G. and Gribble, J., 2014, *Wrecked at the Cape Part 1*, The Cape Odyssey 104, Historical Media, Cape Town.

Gribble, J., 2014, Learning the Hard Way: Two South African Examples of Issues Related to Port Construction and Archaeology, in Dredging and Port Construction: Interactions with Features of Archaeological or Heritage Interest*, PIANC Guidance Document 124*, pp 97-107.

UK UNESCO 2001 Convention Review Group, 2014, *The UNESCO Convention on the Protection of the Underwater Cultural Heritage 2001: An Impact Review for the United Kingdom*, ISBN 978-0-904608-03-8.

Sadr, K., Gribble, J. and Euston-Brown, G, 2013, Archaeological survey on the Vredenburg Peninsula, in Jerardino et al. (eds), *The Archaeology of the West Coast of South Africa*, BAR International Series 2526, pp 50-67.

Gribble, J. and Sharfman, J, 2013, Maritime Legal Management in South Africa, *Online Encyclopaedia of Global Archaeology*, pp 6802-6810.

Gribble, J., 2011, The UNESCO Convention on the Protection of the Underwater Cultural

Heritage 2001, *Journal of Maritime Archaeology* 6:1 77-86.

Gribble, J., 2011, The SS Mendi, the Foreign Labour Corps and the trans-national significance of shipwrecks, in J. Henderson (ed.): *Beyond Boundaries, Proceedings of IKUWA 3, The 3rd International Congress on Underwater Archaeology*, Römisch-Germanische Kommission (RGK), Frankfurt.

Gribble, J., 2011, Competence and Qualifications, in Guèrin, U., Egger, B. and Maarleveld, T. (eds) *UNESCO Manual for Activities directed at Underwater Cultural Heritage*, UNESCO - Secretariat of the 2001 Convention, Paris.

Gribble, J. and Leather, S. for EMU Ltd., 2010, *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector*. Commissioned by COWRIE Ltd (Project reference GEOARCH-09).

Sadr, K and Gribble, J., 2010, The stone artefacts from the Vredenburg Peninsula archaeological survey, west coast of South Africa, *Southern African Humanities* 22: 19–88.

Gribble, J., 2009, HMS Birkenhead and the British warship wrecks in South African waters in *Proceedings of the Shared Heritage Seminar*, University of Wolverhampton, 8 July 2008.

Gribble, J., Parham, D. and Scott-Ireton, D., 2009, Historic Wrecks: Risks or Resources? In *Conservation and Management of Archaeological Sites*, Vol. 11 No. 1, March, 2009, 16–28.

Gribble, J. and Athiros, G., 2008, *Tales of Shipwrecks at the Cape of Storms*, Historical Media, Cape Town.

Gribble, J., 2008, The shocking story of the ss Mendi, in *British Archaeology*, March/April 2008.

Gribble, J., 2007, The Protection of the Underwater Cultural Heritage: National Perspectives in light of the UNESCO Convention 2001 by Sarah Dromgoole, in *The International Journal of Nautical Archaeology*, 36, 1, pp 195-6.

Gribble, J., 2006, The Sad Case of the ss Maori, in Grenier, R., D. Nutley and I. Cochran (eds) *Underwater Cultural Heritage at Risk: Managing Natural and Human Impacts*, pp 41-43, ICOMOS, Paris.

Gribble, J., 2006, Pre-Colonial Fish Traps on the South Western Cape Coast, South Africa, in Grenier, R., D. Nutley and I. Cochran (eds) *Underwater Cultural Heritage at Risk: Managing Natural and Human Impacts*, pp 29-31, ICOMOS, Paris.

Forrest, C.S.J., and Gribble, J., 2006, The illicit movement of underwater cultural heritage: The case of the Dodington coins, in *Art and Cultural Heritage: Law, Policy and Practice*, (ed B.T. Hoffman), New York, Cambridge University Press.

Forrest, C.S.J., and Gribble, J., 2006, Perspectives from the Southern Hemisphere: Australia and South Africa, in *The UNESCO Convention for the Protection of the Underwater Heritage: Proceedings of the Burlington House Seminar*, October 2005, JNAPC / NAS.

Gribble, J., 2003, "Building with Mud" – Developing historical building skills in the Karoo, in ICOMOS South Africa, in *The Proceedings of Symposium on Understanding and using urban heritage in the Karoo*, Victoria West, South Africa, 3-5 March 2002.

Forrest, C.S.J., and Gribble, J., 2002, The illicit movement of underwater cultural heritage: The case of the Dodington coins, *International Journal of Cultural Property*, Vol II (2002) No 2, pp 267-293.

Gribble, J. 2002, The Past, Present and Future of Maritime Archaeology in South Africa, *International Handbook of Underwater Archaeology* (eds Ruppe and Barstad), New York, Plenum Press.

Thackeray, F. and Gribble, J., 2001, Historical Note on an Attempt to Salvage Iron from a Shipwreck, *Looking Back*, Vol 40, November 2001, pp 5-7.

Gribble, J., 1998, Keeping Our Heads Above Water – the development of shipwreck management strategies in South Africa, *AIMA Bulletin*, Vol 22, pp 119-124.

Gribble, J. 1996, Conservation Practice for Historical Shipwrecks, Monuments and Sites of South Africa, Colombo, Sri Lanka, ICOMOS 11th General Assembly.

Gribble, J. 1996, National Databases on Monuments and Sites, Monuments and Sites of South Africa, Colombo, Sri Lanka, ICOMOS 11th General Assembly.

Sadr, K, Gribble, J, & Euston-Brown, G L, 1992 The Vredenburg Peninsula survey, 1991/1992 season, *Guide to Archaeological Sites in the South-western Cape, Papers compiled for the South African Association of Archaeologists Conference*, July 1992, by A.B. Smith & B. Mutti, pp 41-42.

Smith, AB, Sadr, K, Gribble, J, & Yates, R., 1992 Witklip and Posberg Reserve, *Guide to Archaeological Sites in the South-western Cape*, Papers compiled for the South African Association of Archaeologists Conference, July 1992, by A.B. Smith & B. Mutti, pp 31-40.

Smith, AB, Sadr, K, Gribble, J & Yates, R., 1991, Excavations in the south-western Cape, South Africa, and the archaeological identity of prehistoric hunter-gatherers within the last 2000 years, *The South African Archaeological Bulletin* 46: 71-91.

APPENDIX 3: LIST OF HERITAGE SITES RECORDED IN 2020-2021 ARCHAEOLOGICAL SURVEY

Site Number	Location	Description	Grade
KO-01	-32.860144° 22.457773°	A brick labourers' house located immediately adjacent to the main farm road. The construction materials and technique are consistent with modern building methods. There was also rubbish scattered around the site. The structure was not depicted at this locality on the 3222CD topographical sheet dating to 1965 but was instead depicted on the 1987 topographical sheet. The site is therefore younger than 60 years. As no additional information was available, the site is provisionally rated as NCW as it has no research potential or is of other cultural significance. **Extent:7mx4m** **Recommendation:** Located approximately 100 m from to an existing farm road so unlikely that it will be impacted. No mitigation required.	NCW
KO-02	-32.862803° 22.457924°	The ruin of a stone-packed and mud brick structure. There are the remains of stone walling and wooden roof support beams. Located approximately 180 m from the main farm road. There is other building materials and rubbish dumped around the site. A structure is depicted near this locality on the 3222CD topographical sheet dating to 1965. The site is therefore older than 56 years. As no additional information was available, the site is provisionally rated as IIIC with low heritage significance. **Extent:10mx5m** **Recommendation:** Located approximately 150 m from the existing farm road, it is unlikely that it will be impacted.	IIIC
KO-03	-32.862867° 22.458450°	The site comprises a stone house and modern kraal situated on the eastern side of the property and other farm infrastructure. The site is located approximately 30m west of KO-02. A number of structures were identified at this locality on the 3222CD topographical sheet dating to 1965. The site is therefore older than 56 years. As no additional information was available, the site is provisionally rated as IIIB with medium heritage significance. **Extent: 12mx7m** **Recommendation:** Located approximately 170 m from an existing farm road. It is recommended that a no-go-buffer-zone of at least 30 m from the outer permitter of the farmstead (which is currently occupied) is kept to the closest WEF infrastructure (including turbines, substation facilities and roads). If development occurs within 30m of KO-03 the main house will need to be satisfactorily studied and recorded before impact occurs. Recording of the buildings i.e. (a) map indicating the position and footprint of all the buildings and structures (b) photographic recording of all the buildings and structures (c) measured drawings of the floor plans of the principal buildings.	IIIB
KO-04	-32.856379° 22.471279°	Brick labourers' house and outhouse immediately adjacent to the main farm road and Platdorings farmstead (KO-05). The construction materials and technique are consistent with modern building methods. Access to the property was not possible, so an approximate size of the site was calculated. No other cultural material was identified around the site. The structure was only depicted at this locality on the 3222CD topographical sheet dating to 2005. The site is therefore younger than 60 years. As no additional information was available, the site is provisionally rated as NCW as it has no research potential or is of other cultural significance.	NCW

		Extent:4mx7m **Recommendation:** As KO-04 is located within the immediate vicinity of an existing farm road, it is possible that it will be impacted if the road is expanded. No mitigation is required.	
KO-05	-32.855620° 22.471717°	Platdorings farmstead consisting of four buildings and associated farm structures. Part of the farmstead falls within the proposed development area. Access to the property was not possible, so it was not possible to thoroughly assess the site. The main house is most probably the newest addition to the farmstead, with the smaller stone built flat roof structures part of the original farmstead that is older than 60 years. A farmstead is depicted at this locality on the 3222CD topographical sheet dating to 1965. The site is therefore older than 56 years. As no additional information was available, the site is provisionally rated as IIIB with medium heritage significance. **Extent:120x130m** **Recommendation:** KO-05 is located adjacent farm road. Therefore, it is recommended that a no-go-buffer-zone of at least 30 m from the outer permitter of the farmstead (which is currently occupied) is kept to the closest WEF infrastructure (including turbines, substation facilities and roads).	IIIB
KO-06	-32.856898° 22.471120°	Informal burial ground with four stone-packed graves. The site is situated approximately 80 m from an intersection of farm roads. **Recommendation:** The site should be demarcated with a 50 m buffer and the graves should be avoided and left in situ. A Grave Management Plan should be developed for the graves which also needs to be approved by HWC, if graves are to be relocated. If the site is going to be impacted and the graves need to be removed, a grave relocation process for site KO-06 is recommended as a mitigation and management measure.	IIIA
KO-07	-32.863574° 22.459759°	Graves of the Bothma family located on the eastern side of an ephemeral stream, approximately 140 m south-east of KO-03. Formal burial ground with four graves with headstones and granite grave Fenced. **Recommendation:** The site should be demarcated with a 50 m buffer and the graves should be avoided and left in situ. A Grave Management Plan should be developed for the graves which also needs to be approved by HWC, if graves are to be relocated. If the site is going to be impacted and the graves need to be removed, a grave relocation process for site KO-07 is recommended as a mitigation and management measure.	IIIA
KO-08	-32.863077° 22.458603°	Possible grave situated adjacent to the stone house KO-03 on the western side of the property. Indicated by stacked stones. **Recommendation:** The site should be demarcated with a 50-meter buffer and the grave should be avoided and left in situ. A Grave Management Plan should be developed for the grave which also needs to be approved by HWC, if graves are to be relocated. If the site is going to be impacted and the grave needs to be removed, a grave relocation process for site KO-08 is recommended as a mitigation and management measure.	IIIA
KO-09	-32.868100° 22.484592°	Possible grave situated adjacent to a farm road. Indicated by a number of rocks placed at the head and foot of a section of ground. **Recommendation:** The site should be demarcated with a 50 m buffer and the grave should be avoided and left in situ.	IIIA

		A Grave Management Plan should be developed for the grave which also needs to be approved by HWC, if graves are to be relocated.	
KO-10	-32.866502° 22.407414°	Low density LSA and MSA scatter	NCW
KO-11	-32.869424° 22.436545°	Low density MSA scatter	NCW
KO-12	-32.872076° 22.443193°	Low density MSA scatter	NCW
KO-13	-32.868403° 22.474457°	Low density LSA and MSA scatter	NCW
KO-14	-32.871633° 22.532015°	Low density MSA scatter	NCW
KO-15	-32.867462° 22.522904°	Low density LSA and MSA scatter	NCW
KO-16	-32.868114° 22.523218°	Low density MSA and LSA scatter	NCW
KO-17	-32.868621° 22.524661°	Low density MSA scatter	NCW
KO-18	-32.865126° 22.518090°	A low to medium density surface scatter (5-10 artefacts/10m2) of mostly MSA artefacts was identified at this location. The scatter is situated on a gravel and rocky slope. It is unlikely that these artefacts were observed in their primary context due to the nature of the environment. The artefacts are exposed due to some sheet erosion which occurs across the surface. The artefacts consist mostly of debitage (flakes, chips and chunks) which were produced from silicified mudstone. Some cores were also recognised. Extent: approximately 20m x 20m. No mitigation required.	3C

APPENDIX 4: LIST OF HERITAGE SITES RECORDED IN 2022 ARCHAEOLOGICAL WALKDOWN SURVEY

Name	Location	Description	Grading
JG007	-32.865823042 22.429886973	Ephemeral stone scatter on slope with sheetwash next to small stream. Occasional flakes on fine-grained tuff. 1 x possible MSA. Others are LSA. Approximately 5 m^2 in extent. Very low density.	Ungradable
JG008	-32.849619985 22.461698977	Abandoned stone house. Part of corrugated iron roof missing. Rear half of the building is brick, added later with shed an double door at one end. Hearth/chimney at other. Small ruinous building behind house.	3C
JG009	32.850694042 22.461673999	Labourers' cottage. Stone built. Flat-roofed. In use.	3C
JG014	-32.865790017 22.520675976	Scatter of flakes lithics at farm boundary / gate. Eroding out of the surrounding slope. Made on fine-grained greenish tuff. Mostly flakes and chunks. Includes 1 x core and 1 x long scraper with retouch on each side. MSA? 1 x quartzite (?) flake. Some pieces patinated. Seen in an area approximately 20 m^2. Up to 3 pieces/m^2.	3C
JG015	-32.866019011 22.513912031	Ephemeral lithic scatter, mainly made on tuff. MSA	Ungradable
JG023	-32.861229 22.518252	Biface made on tuff. Recorded by John Almond (Waypoint 7602a)	Ungradable
G001	-32.848532014 22.455027988	Apparent isolated grave inside a wire fence. Has a head- and footstone	3A
G002	-32.870371984 22.414735006	Handful of rough hornfels lithics. Fresh. LSA? Located on top of a hill. Isolated MSA lithics noted on the vicinity.	Ungradable
G003	-32.865313003 22.519692024	Appears to the an extension of the same lithic scatter as JG014 but not as dense. Number of cores made on tuff. Visible across approximately 15 m2. 4-5 pieces per m^2. Includes a long, thin naturally squared-off piece of shale with a shaped, chisel-like end which has been rubbed on both sides (Note: J Deacon had seen something similar in Bushmanland. Her information was that it was used as an upper grindstone to flatten fence wire into arrowheads during the historical period).	3C

KOUP WIND ENERGY FACILTIES, WESTER CAPE PROVINCE

AQUATIC WALKDOWN REPORT

FOR

ERM (Pty) Ltd

BY

EnviroSci (Pty) Ltd

Dr Brian Colloty

1 Rossini Rd
Pari Park
Gqeberha
6070

DATE

28 January 2024

REVISION 1

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Report prepared by: Dr. Brian Colloty Pr.Sci.Nat. (Ecology) / Member SAEIES.

Expertise / Field of Study: BSc (Hons) Zoology, MSc Botany, Ph.D Botany Conservation Importance rating and interior wetland / riverine assessment consultant from 1996 to present. Brian has also been working in the study region for the last 10 years, with respect to various renewable projects in the greater region as well as mining and road upgrade related projects.

I, **Dr. Brian Michael Colloty** declare that this report has been prepared independently of any influence or prejudice as may be specified by the National Department of Environmental Affairs and or Department of Water and Sanitation.

Signed:… ……………… Date:…28 February 2024…………

Appendix 1 of this report contains a detailed CV

1. INTRODUCTION

ERM (Pty) Ltd appointed EnviroSci (Pty) Ltd to conduct the pre-commencement walkdown of the Koup Wind Energy Facilities (Figure 1). The authorised WEFs are located south-west of Beaufort West in the Western Cape Province.

This assessment was based on a 2-day walkdown (20-21 January 2024) of the current site layout provided, in December 2024. The aim of which, to confirm any sensitive aquatic ecological features, that may be affected by the revised layouts and provide the engineering team with additional information to further avoid and or reduce the potential impacts on the aquatic environment.

Further, the layout/alignment may also be adjusted based on additional input provided by the Terrestrial, Bat, Avifaunal and Heritage specialists and this report should be read in conjunction with those reports to contextualise the overall constraints provided to the development team.

1.1 Aims and objectives

- Conduct a pre-commencement ecological (aquatic) walk-through survey / assessment of the development areas:
  - Provide a professional opinion on ecological issues relating to the aquatic environment within the footprint areas to optimise the layout;
  - Report on the presence of potential wetlands that could be affected and where the relevant mitigation measures need to be implemented if needed;
  - Serve as additional ecological information for the Proponent, contractors and Environmental Control Officers (ECOs) and/or Environmental Officers (EOs) involved in the development, i.e. demarcated no-go areas before construction starts.
- This is also to facilitate micro-siting of footprint areas, where possible and by taking cognisance of other constraints, with the aim to further reduce negative impacts of the development.
- Aid in future decisions and environmental management regarding the project.

1.2 Assumptions and Limitation

To obtain a comprehensive understanding of the dynamics of both the flora and fauna of the aquatic communities within a study site, as well as the status of endemic, rare or threatened species in any area, assessments should always consider investigations at different time scales (across seasons/years) and through replication. No long-term monitoring was undertaken as part of this assessment. However, a concerted effort was made to assess the entire site, as well as make use of any available literature, species distribution data and aerial photography. The EIA (spanning several years) and walkdown assessments were also conducted in peak rainfall/flowering seasons, so the results of this assessment are provided with a high level of confidence.

It should be emphasised that information, as presented in this document, only has reference to the study area as indicated on the accompanying maps. Therefore, this information cannot be applied to any other area without detailed investigation.

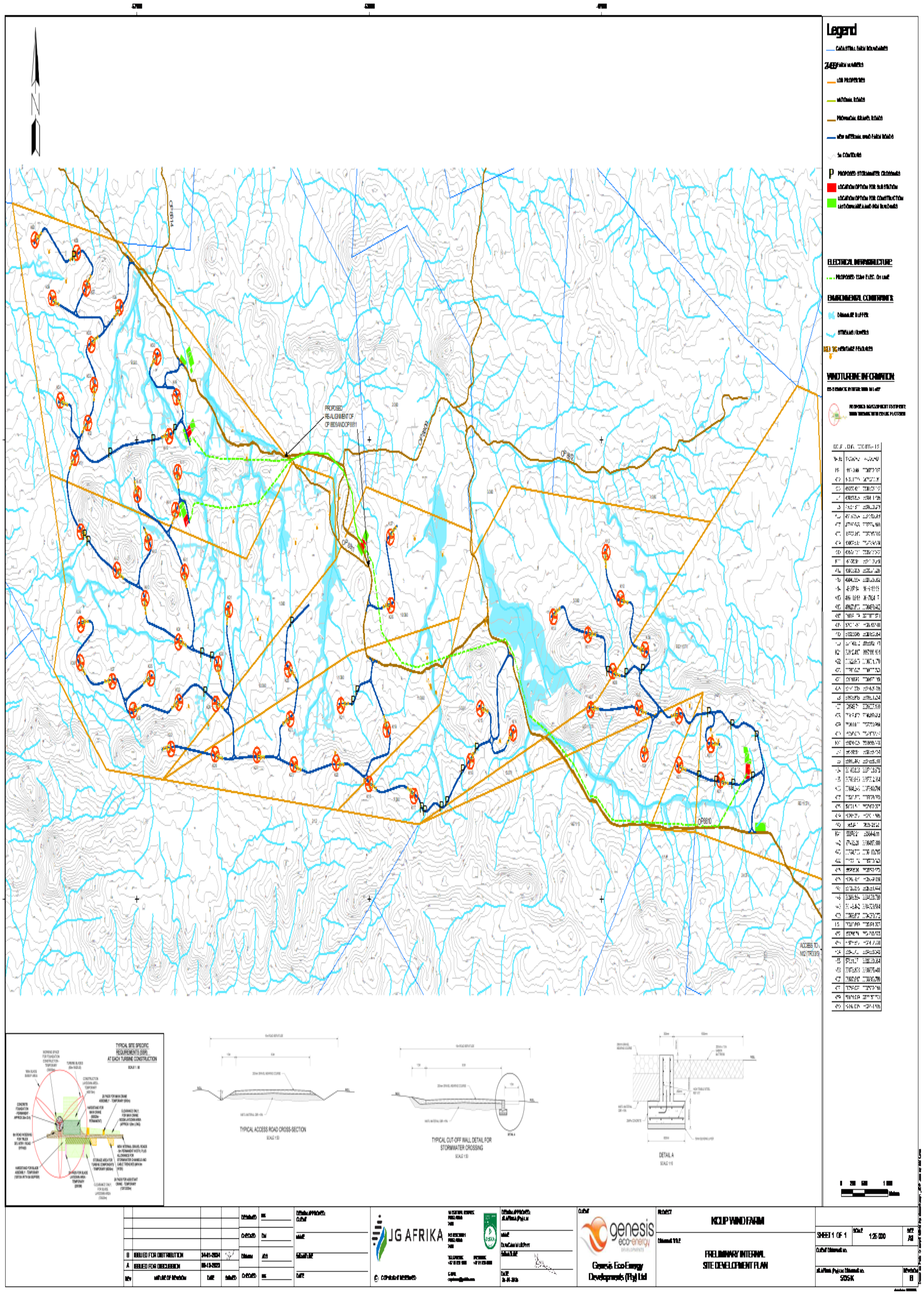


Figure 1: The proposed project layout used in the walk down assessment conducted in 2024, with the new internal roads and turbine positions in relation to the aquatic features delineated during the EIA phase of the project

2. RESULTS

The study area does contain a variety of aquatic features associated, and were characterised as follows:

- Non perennial rivers alluvial dominated channels with or without riparian vegetation. These ranged from narrow channels within small canyons with steep cliffs to broad flood plain areas in the lower valleys. Some of these did contain small seeps/fountains which sustained small pools of water inhabited by invertebrates and amphibians. However, broad riparian zones are only found within the lower valley areas, dominated by a small number of trees, while obligate instream vegetation is limited to a small number of sedges (nut grasses).
- Minor drainage lines, with no obligate aquatic vegetation and were mostly 2 – 8m in width
- Dams or weirs with no wetland or aquatic features, although not many of these were located within the study area.

The features listed above, drain the study area in a north westerly region, forming part of a tributary of the Veldmans River (J21E) and Groot River (J23B) Quinary Catchment of the Great Karoo Ecoregion in the Breede-Gouritz Catchment Management Agency (George Regional Office). The Veldmans and Groot rivers in turn drain into the Gamka River.

No wetlands were found within the proposed development areas, only the riverine features such as alluvial floodplains and riparian thickets dominated by *Vachellia karroo, Searsia lancea, Euclea undulata, Gymonsporia buxifolia Ficinia nodusa, Carex spp, Centella asiatica, Erianthus capensis*, *Sporobolus fimbriatus, Cynodon incompletes, Prosopis spp (Exotic,) Eragrostis curvula, Erharta calcynia Merxmuellera disticha*, and *Cynodon dactylon* are found in close proximity to any of the proposed infrastructure.

Currently there are no formalised riverine or wetland buffer distances provided by the provincial authorities and as such the buffer model as described Macfarlane & Bredin (2017) for wetlands, rivers and estuaries was used. These buffer models are based on the condition of the waterbody, the state of the remainder of the site, coupled to the type of development, as wells as the proposed alteration of hydrological flows. Based then on the information known for the site the buffer model provided the following:

- Construction period: 10 m
- Operation period: 8 m
- Final: 10 m

Artificial dams were not buffered.

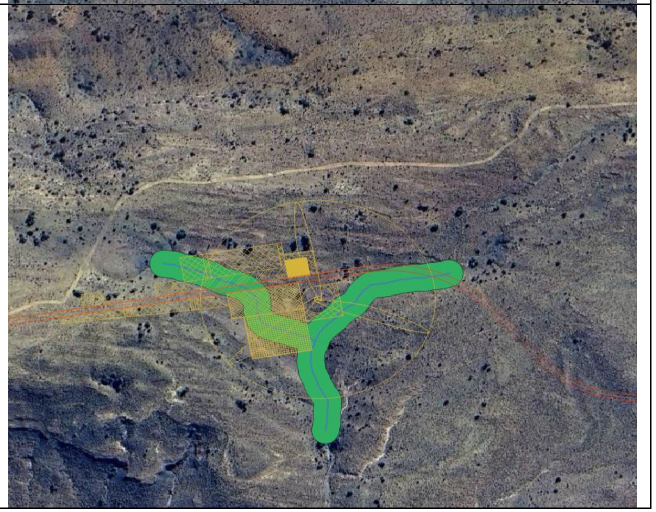
Therefore, the Table 1 below assesses the various watercourse units that may be affected by the new internal roads, hardstands, laydown areas, site camps.

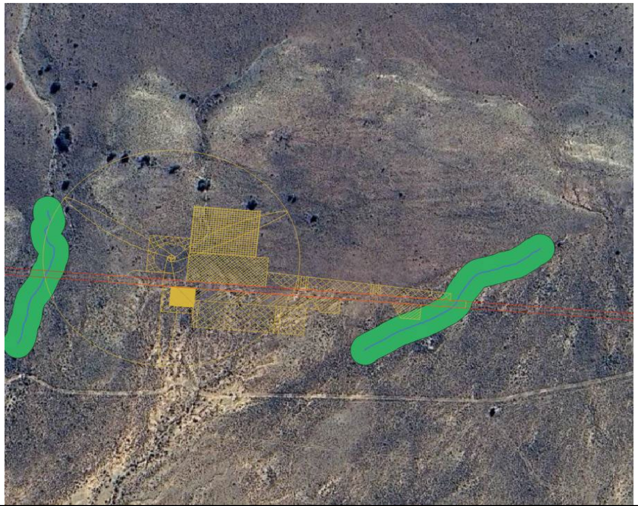
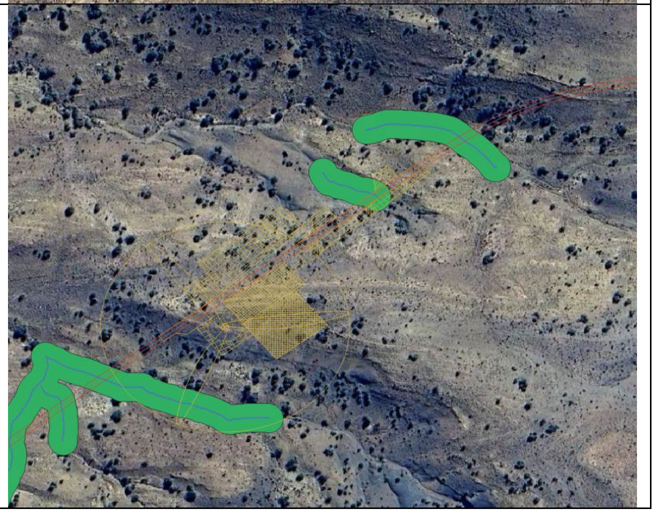
All wind turbine towers, were confirmed to be outside of these areas.

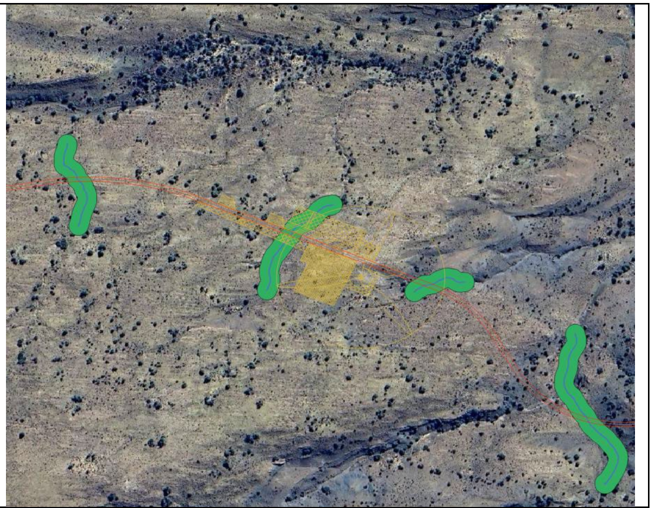
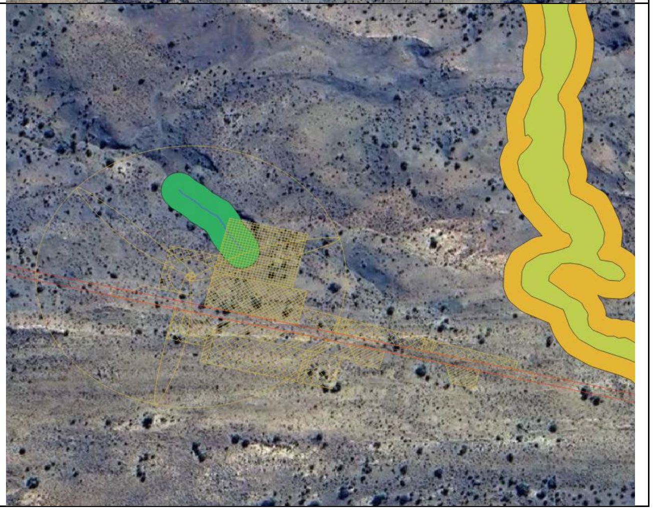
Plate 1:

Plate 2:

Table 1: Findings of the walkdown surveys for the structures shown in Figure 1 with specific reference to habitats observed within the development layout only

Construction Features #	HGM Units	Description	Current state comment & potential impacts	Map
1	Minor watercourse with no riparian vegetation and or aquatic vegetation	WTG K58	This small drainage feature (drainage line) will be avoided by the WTG, however the associated infrastructure spans this system. It is advised that the hardstand / blade laydown is rotated to avoid this area	
2	Minor watercourse with no riparian vegetation and or aquatic vegetation	WTG K05	These small drainage features (drainage line) will be avoided by the WTG, however the associated infrastructure spans this system. It is advised that the hardstand / blade laydown is rotated to avoid this area	

3	Minor watercourse with no riparian vegetation and or aquatic vegetation	WTG K01	The WTG and associated areas has avoided all aquatic features, but is located in and areas with past erosion, thus due care must be undertaken to improve drainage via appropriate stormwater management to prevent additional scour/erosion of the area. The remaining areas should then also be rehabilitated during the works period were located within the project footprint	
4	Minor watercourse with no riparian vegetation and or aquatic vegetation	WTG K016	These small drainage features (drainage line) will be avoided by the WTG, however the associated infrastructure spans this system. It is advised that the hardstand / blade laydown is rotated to avoid this area	

5	Minor watercourse with no riparian vegetation and or aquatic vegetation	WTG K17	These small drainage features (drainage line) will be avoided by the WTG, however the associated infrastructure spans this system. It is advised that the hardstand / blade laydown is rotated to avoid this area	
6	Minor watercourse with no riparian vegetation and or aquatic vegetation	WTG K22	These small drainage features (drainage line) will be avoided by the WTG, however the associated infrastructure spans this system. It is advised that the hardstand / blade laydown is rotated to avoid this area	

7	Minor watercourse with no riparian vegetation and or aquatic vegetation – found within lower valley areas – dominated by alluvial features	New internal roads for the development footprint	It is recommended that were a new road or existing road will be upgraded, that were several drainage features will be crossed, that low level causeways are used. This especially where no river banks or bank incision occurs, in the lower valley areas.	

3. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the walkdown, several sensitive areas are present within the region, but based on the field assessments, the final layouts and alignments were found to be located outside the majority of the high sensitive area identified during the EIA. All that remains are the recommendations made in Table 1, that will then see the avoidance of any additional impacts on the minor drainage lines shown.

The further the following recommendations are reiterated:

- Vegetation clearing should occur in a phased manner in accordance with the construction programme to minimise erosion and/or run-off.
- All construction materials including fuels and oil should be stored in demarcated areas that are contained within berms / bunds to avoid spread of any contamination. Washing and cleaning of equipment should also be done in berms or bunds, in order to trap any cement and prevent excessive soil erosion. Mechanical plant and bowsers must not be refuelled or serviced within or directly adjacent to any channel. It is therefore suggested that all construction camps, lay down areas, batching plants or areas and any stores should be outside of any demarcated water courses.
- All cleared areas must be re-vegetated after construction has been completed.
- All alien plant re-growth must be monitored, and should it occur, these plants should be eradicated. The scale of the operation does however not warrant the use of a Landscape Architect and / or Landscape Contractor.

4. APPENDIX 1 – SPECIALIST CV

CURRICULUM VITAE

- **Dr Brian Michael Colloty**
- **7212215031083**

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Pari Park

Port Elizabeth, 6070

brianc@envirosci.co.za

083 498 3299

Profession: Ecologist (Pr. Sci. Nat. 400268/07)

Member of the South African Wetland Society

Specialisation: Ecology and conservation importance rating of inland habitats, wetlands, rivers & estuaries

Years experience: 25 years

SKILLS BASE AND CORE COMPETENCIES

- 25 years experience in environmental sensitivity and conservation assessment of aquatic and terrestrial systems inclusive throughout Africa. Experience also includes biodiversity and ecological assessments with regard sensitive fauna and flora, within the marine, coastal and inland environments. Countries include Mozambique, Kenya, Namibia, Central African Republic, Zambia, Eritrea, Mauritius, Madagascar, Angola, Ghana, Guinea-Bissau and Sierra Leone. Current projects also span all nine provinces in South Africa.
- 15 years experience in the coordination and management of multi-disciplinary teams, such as specialist teams for small to large scale EIAs and environmental monitoring programmes, throughout Africa and inclusive of marine, coastal and inland systems. This includes project and budget management, specialist team management, client and stakeholder engagement and project reporting.
- GIS mapping and sensitivity analysis

TERTIARY EDUCATION

- 1994: B Sc Degree (Botany & Zoology) - NMU
- 1995: B Sc Hon (Zoology) - NMU
- 1996: M Sc (Botany - Rivers) - NMU
- 2000: Ph D (Botany – Conservation Rating Systems (wetlands) – NMU

EMPLOYMENT HISTORY

- 1996 – 2000 Researcher at Nelson Mandela University – SAB institute for Coastal Research & Management. Funded by the WRC to develop estuarine importance rating methods for South African Estuaries

- 2001 – January 2003 Training development officer AVK SA (reason for leaving – sought work back in the environmental field rather than engineering sector)
- February 2003- June 2005 Project manager & Ecologist for Strategic Environmental Focus (Pretoria) – (reason for leaving – sought work related more to experience in the coastal environment)
- July 2005 – June 2009 Principal Environmental Consultant Coastal & Environmental Services (reason for leaving – company restructuring)
- June 2009 – August 2018 Owner / Ecologist of Scherman Colloty & Associates cc
- August 2018 Owner / Ecologist - EnviroSci (Pty) Ltd

SELECTED RELEVANT PROJECT EXPERIENCE

World Bank IFC Standards

- Botswana South Africa 400kv transmission line (400km) biodiversity assessment on behalf of Aurecon - current
- Farim phosphate mine and port development, Guinea Bissau – biodiversity and estuarine assessment on behalf of Knight Piesold Canada – 2016.
- Tema LNG offshore pipeline EIA – marine and estuarine assessment for Quantum Power (2015).
- Colluli Potash South Boulder, Eritrea, SEIA marine baseline and hydrodynamic surveys co-ordinator and coastal vegetation specialist (coastal lagoon and marine) (on-going).
- Wetland, estuarine and riverine assessment for Addax Biofeuls Sierra Leone, Makeni for Coastal & Environmental Services: 2009
- ESHIA Project manager and long-term marine monitoring phase coordinator with regards the dredge works required in Luanda bay, Angola. Monitoring included water quality and biological changes in the bay and at the offshore disposal outfall site, 2005-2011

South African

- Plant search and rescue, for NMBM (Driftsands sewer, Glen Hurd Drive), Department of Social Development (Military veterans housing, Despatch) and Nxuba Wind Farm, - current
- Wetland specialist appointed to update the Eastern Cape Biodiversity Conservation Plan, for the Province on behalf of EOH CES appointment by SANBI – current. This includes updating the National Wetland Inventory for the province, submitting the new data to CSIR/SANBI.
- CDC IDZ Alien eradication plans for three renewable projects Coega Wind Farm, Sonop Wind Farm and Coega PV, on behalf of JG Afrika (2016 – 2017).
- Nelson Mandela Bay Municipality Baakens River Integrated Wetland Assessment (Inclusive of Rehabilitation and Monitoring Plans) for CEN IEM Unit - Current
- Rangers Biomass Gasification Project (Uitenhage), biodiversity and wetland assessment and wetland rehabilitation / monitoring plans for CEM IEM Unit – current.
- Gibson Bay Wind Farm implementation of the wetland management plan during the construction and operation of the wind farm (includes surface / groundwater as well wetland rehabilitation & monitoring plan) on behalf of Enel Green Power - current
- Gibson Bay Wind Farm 133kV Transmission Line wetland management plan during the construction of the transmission line (includes wetland rehabilitation & monitoring plan) on behalf of Eskom – 2016.
- Tsitsikamma Community Wind Farm implementation of the wetland management plan during the construction of the wind farm (includes surface / biomonitoring, as well wetland rehabilitation & monitoring plan) on behalf of Cennergi – completed May 2016.
- Alicedale bulk sewer pipeline for Cacadu District, wetland and water quality assessment, 2016
- Mogalakwena 33kv transmission line in the Limpopo Province, on behlaf of Aurecon, 2016
- Cape St Francis WWTW expansion wetland and passive treatment system for the Kouga Municipality, 2015
- Macindane bulk water and sewer pipelines wetland and wetland rehabilitation plan 2015

- Eskom Prieska to Copperton 132kV transmission line aquatic assessment, Northern Cape on behalf of Savannah Environmental 2015.
- Joe Slovo sewer pipeline upgrade wetland assessment for Nelson Mandela Bay Municipality 2014
- Cape Recife Waste Water Treatment Works expansion and pipeline aquatic assessment for Nelson Mandela Bay Municipality 2013
- Pola park bulk sewer line upgrade aquatic assessment for Nelson Mandela Bay Municipality 2013
- Transnet Freight Rail – Swazi Rail Link (Current) wetland and ecological assessment on behalf of Aurecon for the proposed rail upgrade from Ermelo to Richards Bay
- Eskom Transmission wetland and ecological assessment for the proposed transmission line between Pietermaritzburg and Richards Bay on behalf of Aurecon (2012).
- Port Durnford Exarro Sands biodiversity assessment for the proposed mineral sands mine on behalf of Exxaro (2009)
- Fairbreeze Mine Exxaro (Mtunzini) wetland assessment on behalf of Strategic Environmental Services (2007).
- Wetland assessment for Richards Bay Minerals (2013) – Zulti North haul road on behalf of RBM.
- Biodiversity and aquatic assessments for 125 renewable projects in the past 9 years in the Western, Eastern, Northern Cape, KwaZulu-Natal and Free State provinces. Clients included RES-SA, RedCap, ACED Renewables, Mainstream Renewable, GDF Suez, Globeleq, ENEL, Abengoa amongst others. Particular aquatic sensitivity assessment and Water Use License Applications on behalf of Mainstream Renewable Energy (8 wind farms and 3 PV facilities.), Cennergi / Exxaro (2 Wind farm), WKN Wind current (2 wind farms & 2 PV facilities), ACED (6 wind farms) and Windlab (3 Wind farms) were also conducted. Several of these projects also required the assessment of the proposed transmission lines and switching stations, which were conducted on behalf of Eskom.
- Vegetation assessments on the Great Brak rivers for Department of Water and Sanitation, 2006 and the Gouritz Water Management Area (2014)
- Proposed FibreCo fibre optic cable vegetation assessment along the PE to George, George to Graaf Reinet, PE to Colesburg, and East London to Bloemfontein on behalf of SRK (2013-2015).