Appendix H.11

ACOUSTIC ASSESSMENT

Dalmanutha Wind (Pty) Ltd

ENVIRONMENTAL ACOUSTIC IMPACT ASSESSMENT

DALMANUTHA WIND ENERGY FACILITY (ALTERNATIVE 1 AND 2)

MAY 2023

CONFIDENTIAL

Dalmanutha Wind (Pty) Ltd

ENVIRONMENTAL ACOUSTIC IMPACT ASSESSMENT

DALMANUTHA WIND ENERGY FACILITY (ALTERNATIVE 1 AND 2)

REPORT (VERSION 01) CONFIDENTIAL

PROJECT NO. 41103722

DATE: MAY 2023

WSP

Building 1, Maxwell Office Park
Magwa Crescent West, Waterfall City
Midrand, 1685
South Africa

Phone: +27 11 254 4800

WSP.com

Dalmanutha Wind (Pty) Ltd

ENVIRONMENTAL ACOUSTIC IMPACT ASSESSMENT

DALMANUTHA WIND ENERGY FACILITY (ALTERNATIVE 1 AND 2)

CONFIDENTIAL

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GLOSSARY OF TERMS

Sound	Sound is small fluctuations in air pressure, measured in Newtons per square meter (N/m2) or Pascals (Pa) that are transmitted as vibrational energy via a medium (air) from the source to the receiver. The human ear is a pressure transducer, which converts these small fluctuations in air pressure into electrical signals, which the brain then interprets as sound.
Noise	Noise is generally defined as unwanted sound.
Sound or noise level	A sound or noise level is a sound measurement that is expressed in decibels (dB or dB(A)).
dB or dB(A)	The human ear is a sensitive instrument that can detect fluctuations in air pressure over a wide range of amplitudes. This limits the usefulness of sound quantities in absolute terms. For this reason, a sound measurement is expressed as ten times the logarithm of the ratio of the sound measurement to a reference value, 20 micro (millionth) Pa. This process converts a scale of constant increases to a scale of constant ratios and considerably simplifies the handling of sound measurement quantities. The attached ‘A’ indicates that the sound measurement has been A-weighted.
dB(Z)	Historically sound levels were read off a hand-held meter and the noise levels were noted in dB, after the development of different weighting curves sound levels were noted as Z-weighting or dB(Z) to reduce the confusion with different type of weighting applied noise levels. dB(Z) refers to linear noise levels.
A-weighting	The human ear is not equally sensitive to sound of all frequencies, i.e., it is less sensitive to low pitched (or ‘bass’) than high pitched (or ‘treble’) sounds. In order to compensate when making sound measurements, the measured value is passed through a filter that simulates the human hearing characteristic. Internationally this is an accepted procedure when working with measurements that relate to human responses to sound/noise.
Ambient sound level	Ambient noise will be defined as the totally encompassing sound in a given situation at a given time, and is usually composed of sound from many sources, both near and far.
Annoyance	General negative reaction of the community or person to a condition creating displeasure or interference with specific activities.
Sound pressure	Sound pressure is the force of sound exerted on a surface area perpendicular to the direction of the sound and is measured in N/m² or Pa. The human ear perceives sound pressure as loudness and can

	also be expressed as the number of air pressure fluctuations that a noise source creates.
Sound pressure level	The sound pressure level is a relative quantity as it is a ratio between the actual sound pressure and a fixed reference pressure. The reference pressure is usually the threshold of hearing, namely 20 micropascals (µPa).
Sound power	Sound power is the rate of sound energy transferred from a noise source per unit of time in Joules per second (J/s) or Watts (W).
Sound power level	The sound power level is a relative quantity as it relates the sound power of a source to the threshold of human hearing (10^{-12} W). Sound power levels are expressed in dB(A), as they are referenced to sound detected by the human ear (A-weighted).
Noise nuisance	Noise nuisance means any sound which disturbs or impairs or may disturb or impair the convenience or peace of any person.
Octave bands	The octave bands refer to the frequency groups that make a sound. The sound is generally divided in to nine groups (octave bands) ranging from 32 Hertz (Hz) to 8,000 Hz. The lower frequency ranges of a sound have a vibrating character where the higher frequency of sound has the character of high-pitched sound. In viewing the total octave bands scale from 32 Hz to 8000 Hz the character of the sound can be described.

ACRONYMS AND ABBREVIATIONS

CadnaA	Computer Aided Noise Abatement
dB	Decibel
dB(A)	A-weighted sound measurement
dB(C)	C-weighted sound measurement
dB(Z)	Z-weighted sound measurement
DMRE	Department of Mineral Resources and Energy
EHS	Environmental health and Safety
ESIA	Environmental and Social Impact Assessment
ETSU	Energy Technology Support Unit
ha	Hectare
Hz	Hertz
IFC	International Finance Corporation
km	Kilometre
kV	Kilovolt
L_{A90}	Noise level exceeded for 90% of the measurement period
L_{Aeq}	Equivalent continuous sound pressure level
$L_{R,dn}$	Equivalent continuous day/night rating level
$L_{Req,d}$	Equivalent continuous rating level for day-time
$L_{Req,n}$	Equivalent continuous rating level for night-time
$L_{Req,T}$	Typical noise rating levels
m	Metre
m/s	Meters per second
MW	Megawatt
OECD	Organisation for Economic Co-operation and Development
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standards
WEF	Wind Energy Facility
WHO	World Health Organisation
WSP	WSP Group Africa (Pty) Ltd

EXECUTIVE SUMMARY

Dalmanutha Wind (Pty) Ltd proposes to establish the Dalmanutha wind energy facility (WEF) near Belfast, in the Mpumalanga Province. The proposed Project consists of two alternatives, namely Alternative 1 (a WEF consisting of up to 70 wind turbines) and Alternative 2 (a wind and solar energy facility consisting of up to 44 wind turbines). The Dalmanutha WEF forms part of the Dalmanutha Wind Energy Complex.

WSP Group Africa (Pty) Ltd (WSP) has been appointed to undertake the Environmental and Social Impact Assessment (ESIA) for the Project. Wind turbines have the potential to generate noise and as such a specialist Environmental Acoustic Impact Assessment is required as part of the ESIA process for the WEF. This report presents the findings of the Screening-Level Environmental Acoustic Impact Assessment performed. It is noted that noise impacts are anticipated from the wind turbines, however, noise from the powerlines and solar facility will be negligible and as such impacts for these have not been assessed.

The International Finance Corporation (IFC) Environmental Health and Safety (EHS) guidelines for Wind Energy were followed for this assessment, which is primarily based on the Energy Technology Support Unit's (ETSU) ETSU-R-97 report. Such guidance stipulates that a preliminary modelling exercise is executed using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines. If L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s (at a height of 10 m) during day and night times, this would be sufficient to assess the noise impact of the proposed facility, offering adequate protection of amenity at these receptors. If L_{A90} levels at any receptor location are above 35 dB(A), then impacts at these receptors may be perceived and potential turbine relocations may need to be considered. In low noise environments, the ETSU-R-97 report itself, however, stipulates that noise from wind farms should be limited to a range between 35 and 40 dB(A) (daytime). Additionally, a fixed limit of 43 dB(A) should be implemented during night-time. This should increase to 45 dB(A) (day and night) if the potential receptors have financial investments in the facility. With the Dalmanutha WEF being located within a low noise environment a combination of the IFC and ETSU methodology was followed in this assessment.

Fifty sensitive receptors (farmhouses) were identified within 2 km of the site. Based on WSP's preliminary model (following the IFC methodology), the following was determined:

Alternative 1 (70 Wind Turbines)

- Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at twenty of the 50 receptors.
- However, being a low noise environment, with reference to the ETSU daytime limit range of 35 – 40 dB(A), L_{A90} noise levels at 36 of the 50 receptor locations are below this threshold. Additionally, at night, L_{A90} levels at 49 of the 50 receptor locations are below the ETSU 43 dB(A) threshold.
- It is, however, understood that all of the receptors within the project boundary have direct interest and are vested in the Project, thus a blanket threshold value of 45 dB(A) (day and night) applies. Predicted L_{A90} noise levels at all onsite receptor locations are below this 45 dB(A) threshold. Additionally, predicted L_{A90} noise levels at all receptors outside of the project boundary (Rec 01,

Rec 05, Rec 06, Rec 09, Rec 10 – 18, Rec 24 – 25, Rec 27 – 28, Rec 38 – 41 and Rec 50) are below the ETSU 40 dB(A) threshold. As such, complaints are not anticipated as a result of the operation of the Dalmanutha WEF.

Alternative 2 (44 Wind Turbines)

- Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at 26 of the 50 receptors.
- However, being a low noise environment, with reference to the ETSU daytime limit range of 35 – 40 dB(A), L_{A90} noise levels at 41 of the 50 receptor locations are below this threshold. Additionally, at night, L_{A90} levels at 49 of the 50 receptor locations are below the ETSU 43 dB(A) threshold.
- It is, however, understood that all of the receptors within the project boundary have direct interest and are vested in the Project, thus a blanket threshold value of 45 dB(A) (day and night) applies. Predicted L_{A90} noise levels at all onsite receptor locations are below this 45 dB(A) threshold. Predicted L_{A90} noise levels at all receptors outside of the project boundary, except for Rec 17 and Rec 18 are below the ETSU 40 dB(A) threshold. As such, complaints may be anticipated at these two receptors as a result of the operation of the Dalmanutha WEF. It is recommended that the turbines in closest proximity to these receptors (WTG 09 and WTG 10) be relocated slightly southwards to drop the noise levels at these receptors below the acceptable 40 dB(A) threshold. Alternatively, financial incentives for these receptors may also need to be considered.

The resultant environmental acoustic risks associated with the construction phase of the Project are anticipated to be “low” to “very low” with general mitigation options employed. For the operational phase (Alternative 1), impacts are anticipated to be “low” as it is understood that the direct surrounding receptors are all vested in the Project. For the operational phase (Alternative 2), impacts are anticipated to be “moderate” especially at Rec 17 and Rec 18. Should the nearby turbines be relocated slightly, impacts are anticipated to become “low”. Ultimately, should no complaints from receptors arise, it is recommended that the Project (Alternative 1) be considered for authorisation.

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IMPACT ASSESSMENT METHODOLOGY

1. INTRODUCTION

Dalmanutha Wind (Pty) Ltd proposes to establish the Dalmanutha Wind Energy Complex near Belfast, in the Mpumalanga Province. The Project is being developed in the context of the Department of Mineral Resources and Energy (DMRE) Integrated Resource Plan and the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), with further potential for private off-take by nearby mining and industrial operations.

The Dalmanutha Wind Energy Complex will include the following:

- Dalmanutha Wind Energy Facility (WEF) *or* Dalmanutha Wind and Solar Energy Facility (both up to 300 MW).
- Dalmanutha West WEF (less than 20 MW).
- Common collector substation and powerline (up to 132 kV).

WSP Group Africa (Pty) Ltd (WSP) has been appointed to undertake the Environmental and Social Impact Assessment (ESIA) for the Projects. This report specifically focuses on the Dalmanutha WEF.

Wind turbines have the potential to generate noise and as such a specialist Environmental Acoustic Impact Assessment is required as part of the ESIA process for the Dalmanutha WEF. This report presents the findings of the Screening-Level Environmental Acoustic Impact Assessment performed. It is noted that noise impacts are anticipated from the wind turbines, however, noise from the powerlines and solar facility will be negligible and as such impacts for these have not been assessed.

1.1. TERMS OF REFERENCE

The terms of reference, designed to best meet the project requirements and the requirements of the Noise Specialist Protocol (contained in GNR 320 of March 2020), are summarised below:

- Execution of a preliminary modelling exercise using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines.
- If L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s (at a height of 10 m) during day and night times, this would be sufficient to assess the noise impact of the proposed facility. If L_{A90} levels at any receptor location are above 35 dB(A) then impacts at these receptors may be perceived and potential turbine relocations may need to be considered.
- Presentation of modelled results in the form of an Environmental Acoustic Impact Assessment Report (this report), as per the requirements of the Noise Specialist Protocol (contained in GNR 320 of March 2020).

1.2. DECLARATION OF INDEPENDENCE

Kirsten Collett is an air quality and acoustic consultant with a Master of Science (Atmospheric Sciences) degree obtained from the University of the Witwatersrand. She is currently employed by WSP and has worked on environmental acoustic impact assessments, monitoring and modelling for a variety of clients over the past ten years. She has provided acoustic consulting support to various client industries including petrochemical, mining and production industries among others. She is also a registered Professional Natural Scientist (Pr. Nat. Sci.) with the South African Council for Natural Scientific Professions (SACNASP). Please see **Appendix A** for a CV detailing project experience.

I hereby declare that I am fully aware of my responsibilities in terms of the National Environmental Management Act: Environmental Impact Assessment Regulations of 2014 and that I have no financial or other interest in the undertaking of the proposed activity other than the imbursement of consultant's fees.

Name:	Kirsten Collett
Company:	WSP Group Africa (Pty) Ltd
Contact Details:	+27 11 361 1372
	Kirsten.Collett@wsp.com
Signature:	

2. BACKGROUND

2.1. LOCALITY

Dalmanutha Wind (Pty) Ltd is proposing to construct the Dalmanutha WEF, near Belfast in the Mpumalanga Province. The WEF will be located ~7 km southeast of the town of Belfast (**Figure 1**). Access to the site will be via either the tarred R33 or the N4 National road which run along the western and northern boundaries of the site respectively. The site itself will extend across eighteen existing farms. The energy produced will be fed via 33kV cables to a 132 kV Independent Power Producer (IPP) substation, located adjacent to the common grid infrastructure.

2.2. TOPOGRAPHY

The surrounding landscape has a rolling hill topography which is suitable for the development of a wind project. The Project site itself is located on a flat, high-lying landscape that has the highest wind resource within the immediate area. The proposed WEF lies at an elevation of approximately 1,630 m in the northern section to 1,888 m in the southern section. A map showing the typical terrain across the area is presented in **Figure 2**.

2.3. SENSITIVE RECEPTORS

Sensitive receptors are identified as areas that may be impacted negatively due to noise associated with the proposed WEF. Examples of receptors include, but are not limited to, schools, shopping centres, hospitals, office blocks and residential areas. Being such a remotely located site, dominant receptors in the area surrounding the site include small farmsteads and farmhouses. Impacts in the context of this report will relate to inhabitants (humans and animals[1]) of such farmsteads/farmhouses. The specific sensitive receptors (farmhouses) considered in this study are presented in **Figure 3**.

[1] There is limited research on the exact impacts on animals, however, for the purpose of determining such impacts in this report, the IFC/ETSU limits are applied.

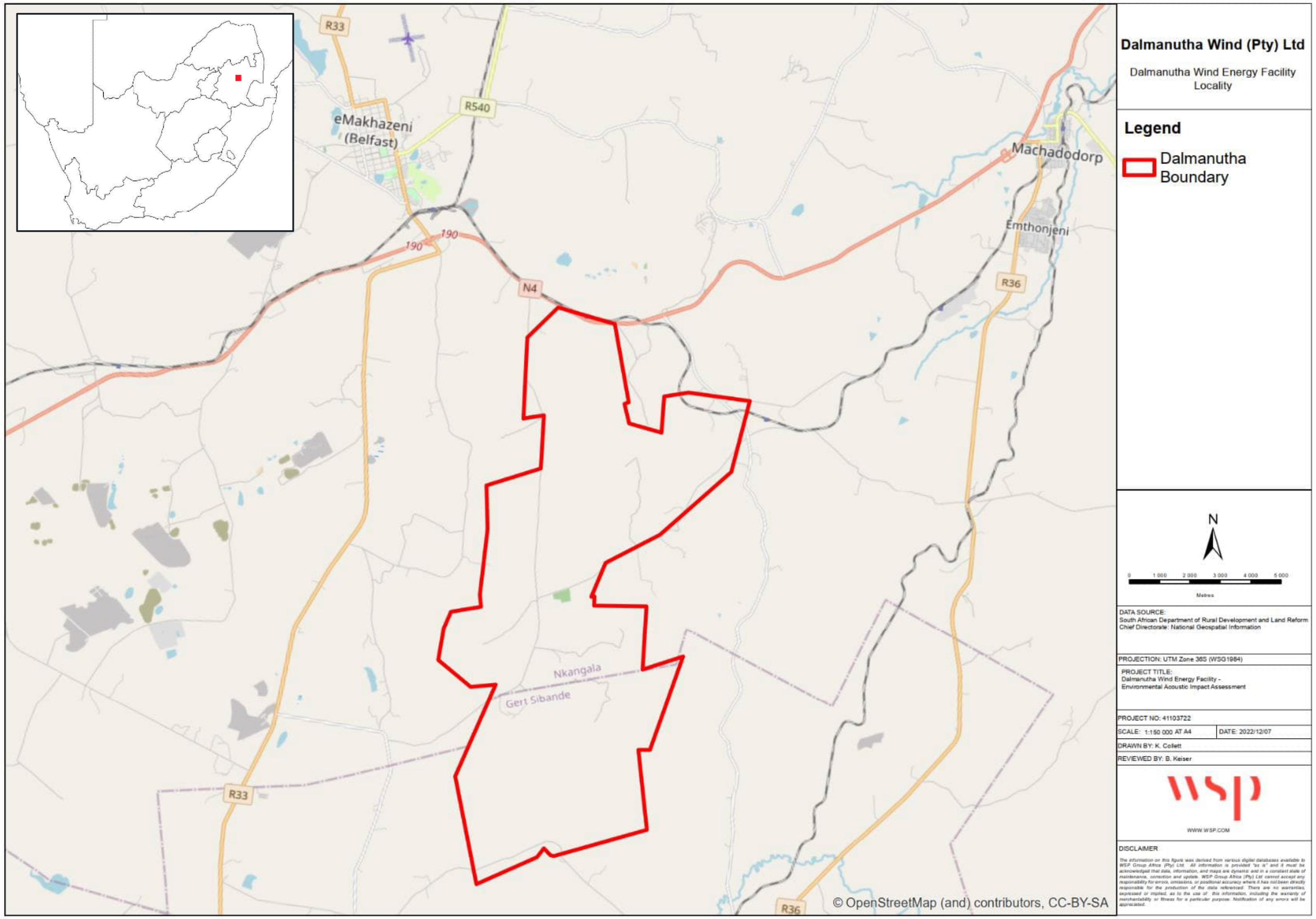

Figure 1: Location of the project site

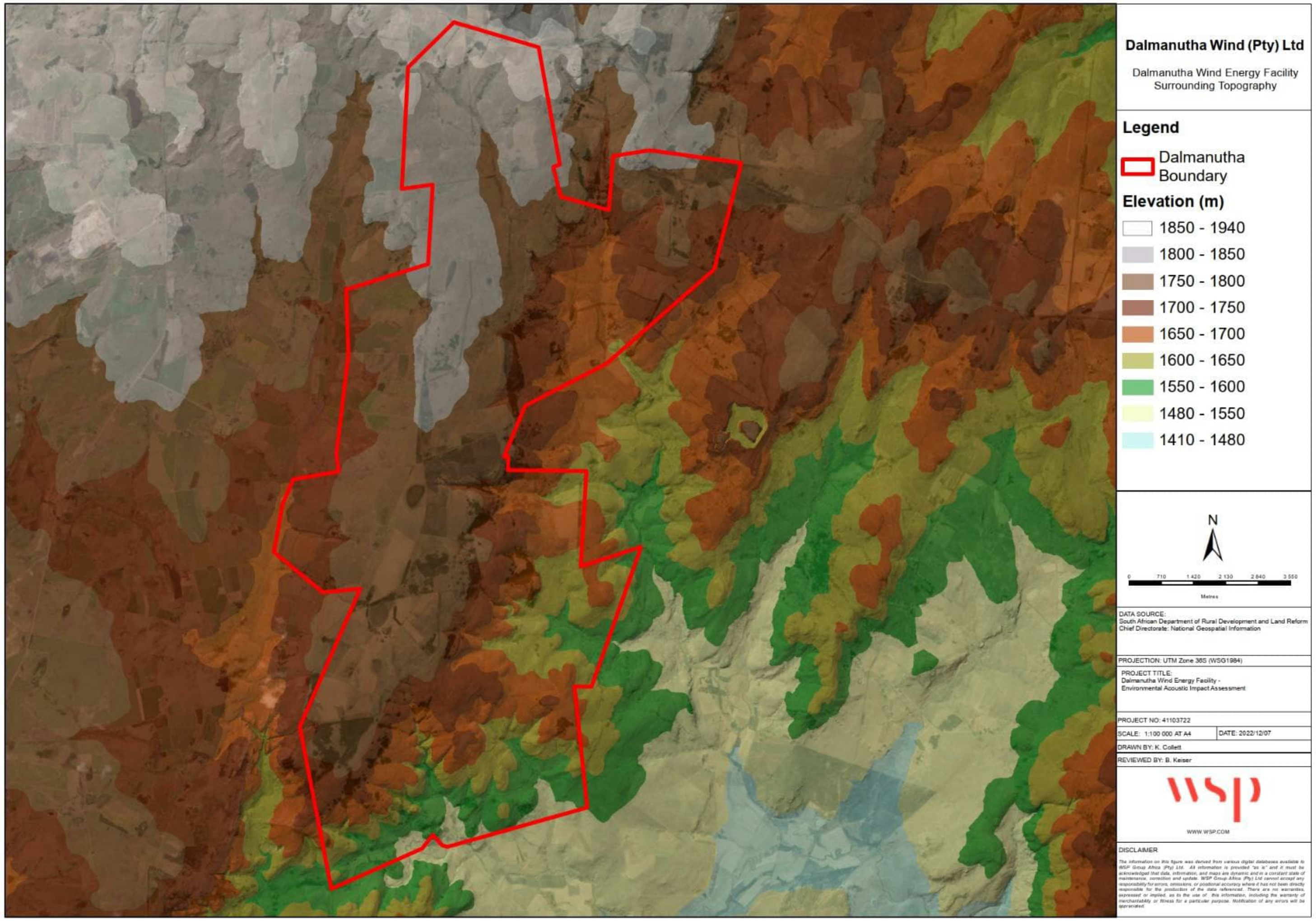

Figure 2: Terrain map

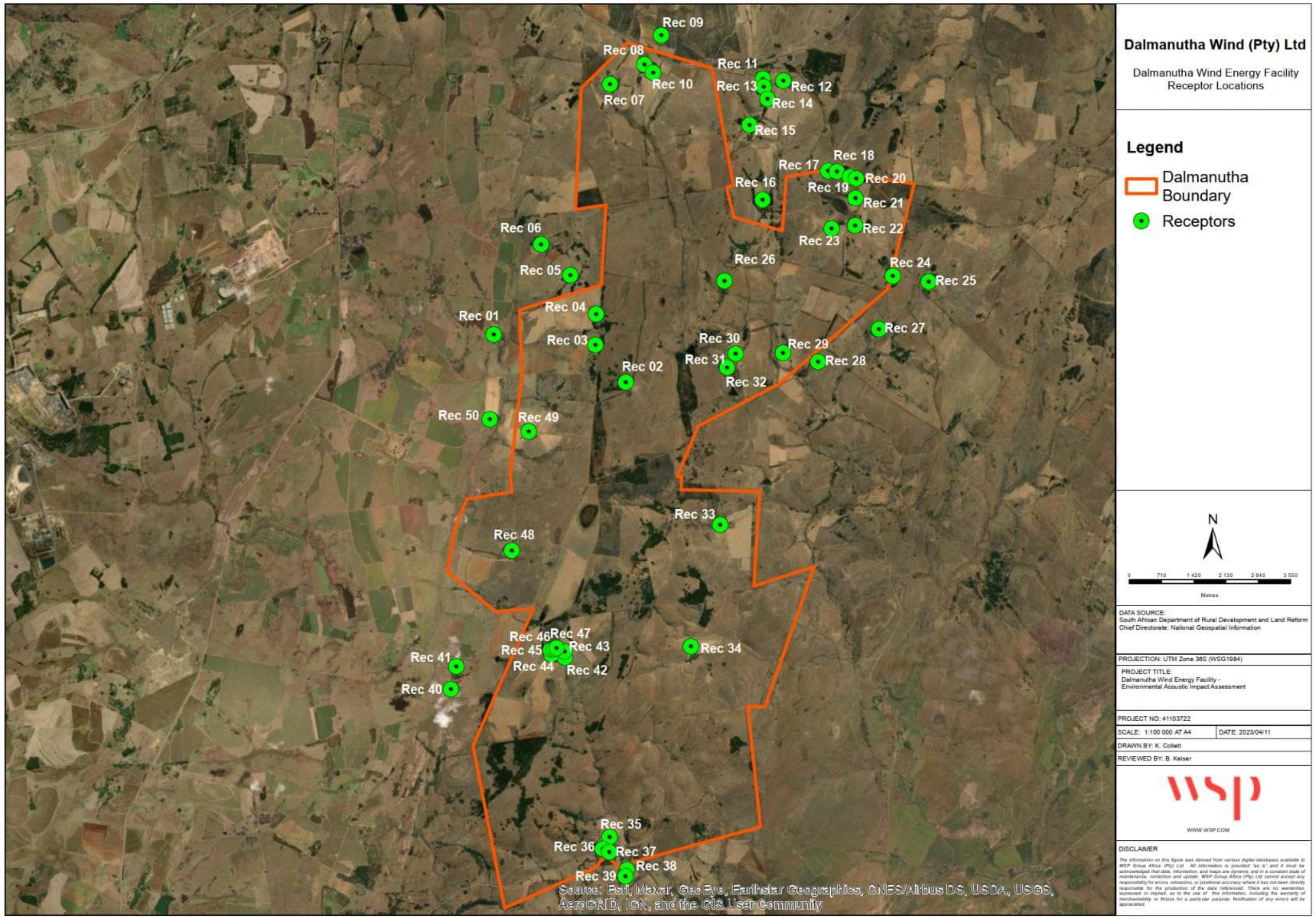

Figure 3: Location of sensitive receptors

2.4. PROJECT DESCRIPTION

2.4.1. WIND ENERGY POWER GENERATION PROCESS

Wind power is the conversion of wind energy into a useful form of energy, such as electricity, using modern and highly reliable wind turbines. Wind power is non-dispatchable, meaning that for economic operation, all of the available output must be taken when it is available.

The main components of a modern utility-scale wind turbine are illustrated in **Figure 4**. When the wind blows around the blades, the shape of the blades creates aerodynamic lift and drag. These forces are used to generate torque, which causes the blades to spin the rotor on its axis, creating mechanical power that is converted into electricity in a generator housed in the nacelle (Council of Canadian Academics, 2015).

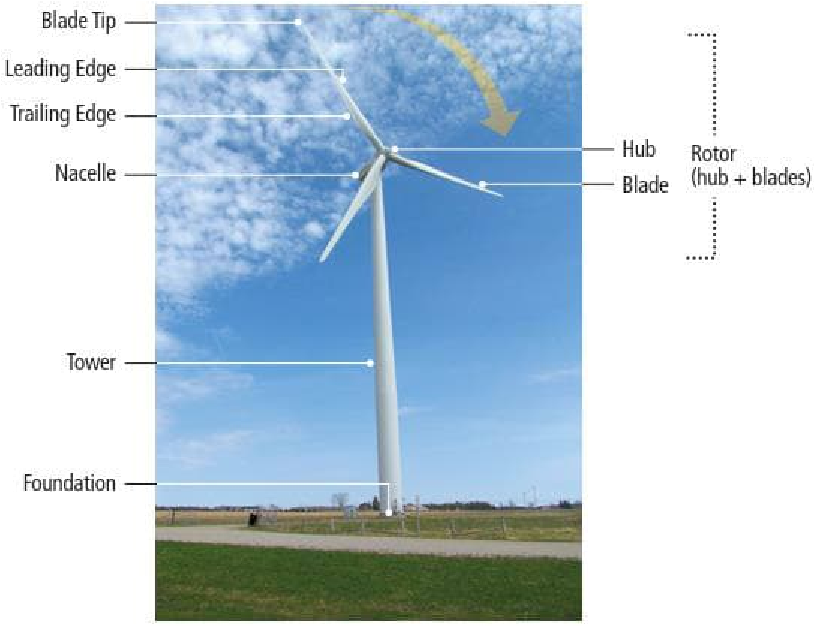

Figure 4: Components of a typical wind turbine (Council of Canadian Academics, 2015)

The electricity generated by the wind turbines is passed through a step-up transformer and then transmitted via either underground or overhead cables to a central substation, which connects the wind energy facility to a high voltage network. Wind turbines are designed to operate automatically with minimal maintenance for approximately 20-25 years.

2.4.2. PROJECT INFRASTRUCTURE

For the Project, two alternative set-ups/layouts are being considered, namely:

- Alternative 1: Dalmanutha WEF with up to 70 wind turbines
- Alternative 2: Dalmanutha wind and solar facility with up to 44 wind turbines.

The details of each of the alternatives, as applicable to the acoustic impact assessment, are outlined in **Table 1**. A map indicating the location of the wind turbines for Alternative 1 and Alternative 2 are presented in **Figure 5** and **Figure 6**, respectively. It is noted that there is minimal noise associated with the operation of a solar facility and as such only noise associated with the WEF component is assessed in this study.

Table 1: Project Summary of the Dalmanutha WEF

	Alternative 1	Alternative 2
Municipality	Emakhazeni Local Municipality of the Nkangala District Municipality	
Project Extent	9,197 ha	9,197 ha
Capacity	Up to 300 MW	Up to 300 MW
Number of Turbines	Up to 70	Up to 44
Turbine Hub Height	Up to 200 m	Up to 200 m
Rotor Diameter	Up to 200 m	Up to 200 m
Sound Power Level (at 10 m/s)	106.0 dB(A)	106.0 dB(A)

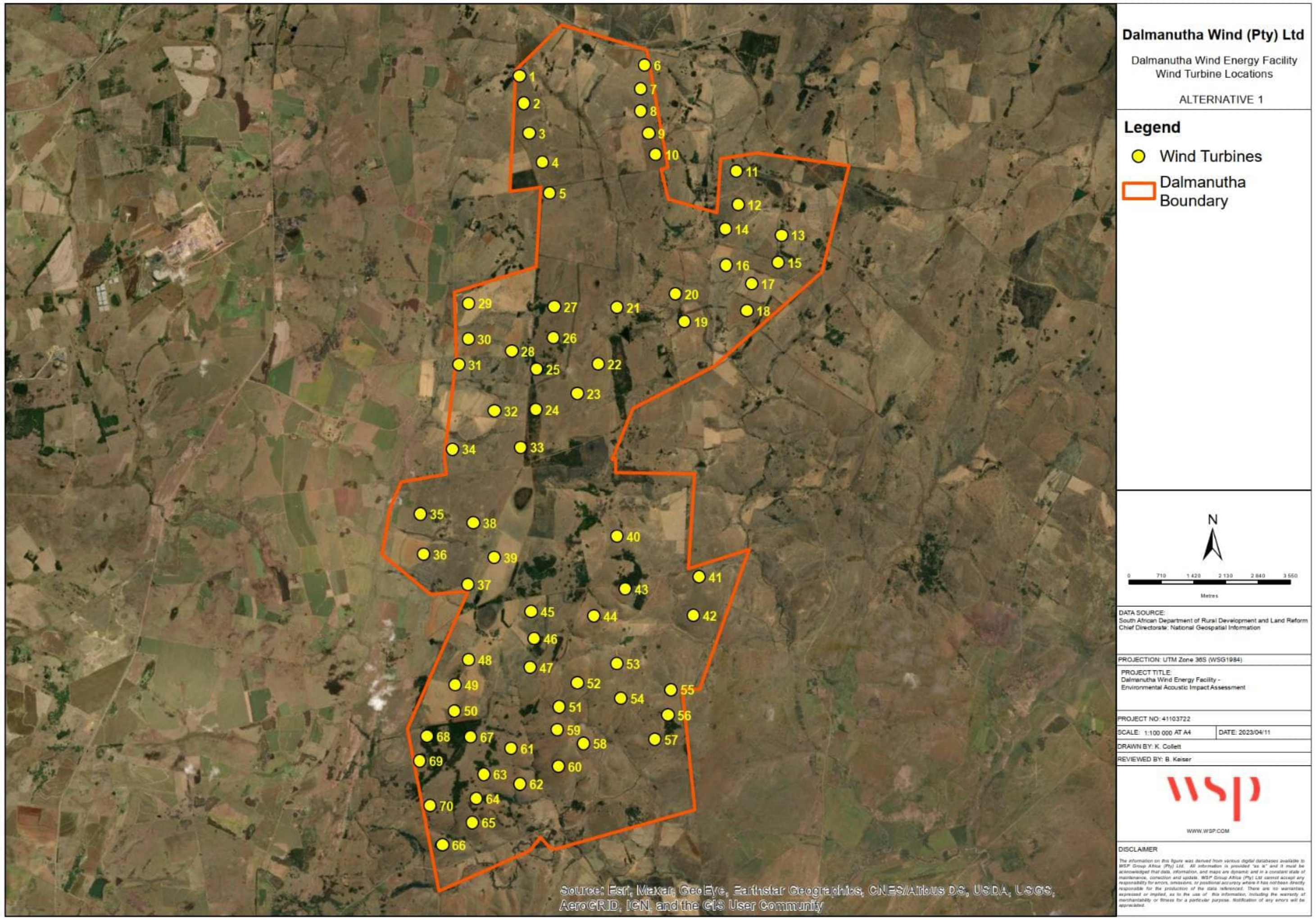

Figure 5: Layout of the proposed Dalmanutha WEF (Alternative 1)

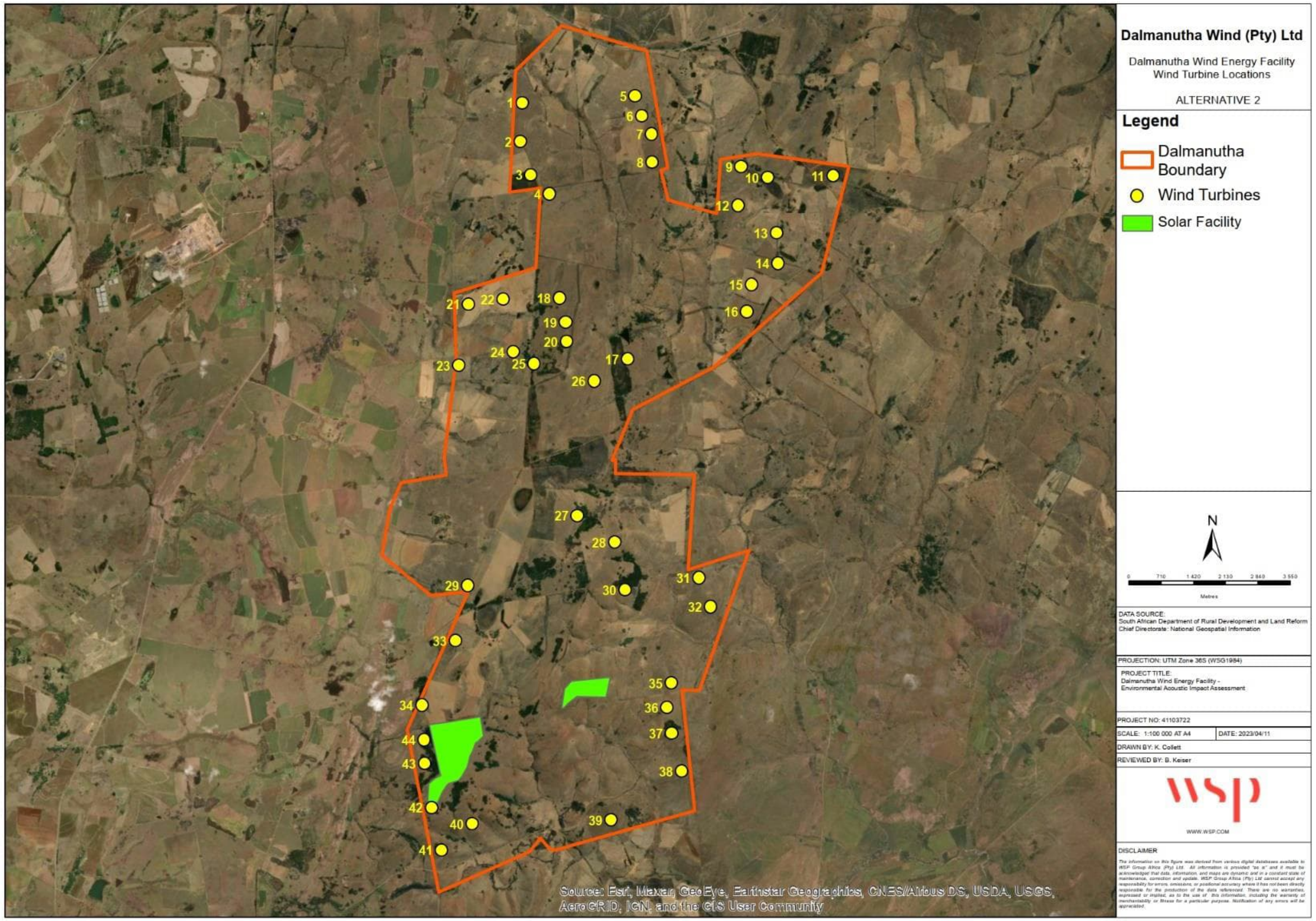

Figure 6: Layout of the proposed Dalmanutha WEF (Alternative 2)

2.5. WIND TURBINES AND NOISE

Noise from wind turbines can be classified into two categories, namely mechanical noise generated from the turbine's mechanical components and aerodynamic noise, produced by flow of air over the turbine blades.

2.5.1. MECHANICAL NOISE

The mechanical noise generated by a wind turbine is predominantly tonal (dominated by a narrow range of frequencies), but may also be broadband in character, displaying a wide range of frequencies (Council of Canadian Academics, 2015). Such noise is produced by the physical movement of the following components:

- Gearbox
- Generator
- Yaw drives
- Cooling fans
- Auxiliary equipment.

Over time, appropriate design and manufacturing have reduced the mechanical noise produced from wind turbines. As such, the aerodynamic noise from the blades has become the dominant source of noise for modern turbines, however, low frequency tones associated with mechanical sources are audible for some turbines (Hau, 2006; Manwell *et al*., 2009; Oerlemans, 2011).

2.5.2. AERODYNAMIC NOISE

Aerodynamic noise is typically broadband in nature and is generated by the interaction between air flow and different parts of the turbine blades. These interactions depend on the speed and turbulence of the wind; the shape of the blade; the angle between the blade and relative wind velocity flowing over the blade; and the distance from the hub. The noise levels produced are relative to the velocity of the air flow, with higher rotor speeds resulting in higher noise levels. Specifically, parts of the blade closer to the tips move faster than those closer to the hub, resulting in faster relative air velocities and create higher aerodynamic noise levels. As such, most of the aerodynamic noise is produced near (but not at) the blade tips. This is partly why turbines with longer blades have a higher sound power level (Oerlemans, 2011).

Aerodynamic noise from wind turbines also has a strong directional component, projecting primarily downward, upward, or even perpendicular depending on the dominant mechanism (Oerlemans, 2011). As such, noise levels measured at a particular location can vary depending on the direction, speed and turbulence of the prevailing wind. Furthermore, as the rotor turns, the orientation of each blade changes in relation to a stationary receiver. As such, the noise levels at the receiver will vary as the blades rotate, resulting in periodic regular changes in noise levels over time (Renewable UK, 2013).

As wind speed increases, the aerodynamic noise of the turbines also increases. At low speeds the noise created is generally low and increases to a maximum at a certain speed (around 10 m/s) where it either remains constant or can even slightly decrease.

2.5.3. LOW FREQUENCY NOISE AND INFRASOUND

In addition to the noise discussed above, wind turbines also produce some steady, deep, low frequency sounds (between 1 – 100 Hz), particularly under turbulent wind conditions. Sound waves below 20 Hz are called infrasound. These infrasound levels are only audible at very high sound pressure levels. Older wind turbines that had downwind rotors created noticeable amounts of infrasound. Levels produced by modern-day, up-wind style turbines are below the hearing threshold for most people (Jakobsen, 2005).

The human ear is substantially less sensitive to sound at very low or very high frequencies. For most people, a very low pitch sound (20 Hz) must have a sound pressure level of 70 dB to be audible. Levels of infrasound near modern commercial wind turbines are far below this level and are generally not perceptible to people (Leventhall, 2006).

Low frequency sound, like all other sound, decreases as it travels away from the source. Siting wind turbines further away from sensitive receptors will therefore decrease the risk of infrasound. It is, however, important to note that in flat terrain, low frequency sound can travel more effectively than high frequency sound. Most environmental sound measurements and noise regulations are based on the A-weighed decibel scale (dB(A)), which under-weights low frequency sounds in order to mimic the human ear. Thus, noise limits based on the dB(A) levels do not fully regulate infrasound. The dB(C) scale offers an alternative of measuring sound that provides more weight to lower frequencies (Jakobsen, 2005; Bolin *et al*., 2011).

SANS 10103 proposes a methodology to identify whether low frequency noise could be an issue. The method suggests that if the difference between L_{Aeq} and L_{Ceq} is greater than 10 dB, then a predominant low frequency component may be present. However, in all cases the existing acoustic energy in low frequencies associated with wind must be considered.

2.5.4. SUBSTATION AND TRANSFORMER NOISE

In addition to the noise from wind turbines, wind farms require a substation and transformers, which produce a characteristic “hum” or “crackle” noise. Utility companies have experience with building and siting such sources to minimise their impact. Substation-related noise is relatively easy to mitigate should this be required, based on the use of acoustic shielding and careful planning regarding placement away from sensitive receptors. As such, noise associated with this source is not considered in this assessment.

2.6. EXISTING NOISE CLIMATE

The existing noise climate surrounding the Dalmanutha WEF is predominantly rural with very low baseline noise levels anticipated. Noise sources may include birds, insects, livestock and the activities of resident farmers. Vehicular influences may include traffic on local roads and the nearby N4 National Road and R33 Regional Road.

3. ACOUSTIC FUNDAMENTALS

3.1. PRINCIPLES

Sound is defined as any pressure variation (in air, water or other medium) that the human ear can detect. Noise is defined as "unwanted sound". Noise can lead to health impacts and can negatively affect people's quality of life. Hearing impairment is typically defined as a decrease in the threshold of hearing. Severe hearing deficits may be accompanied by tinnitus (ringing in the ears). Noise-induced hearing impairment occurs predominantly in the higher frequency range of 3,000 to 6,000 Hertz (Hz), with the largest effect at 4,000 Hz. With increasing L_{Aeq} and increasing exposure time, noise-induced hearing impairment occurs even at frequencies as low as 2,000 Hz. However, hearing impairment is not expected to occur at L_{Aeq} levels of 75 dB(A) or below, even for prolonged occupational noise exposure.

Speech intelligibility is adversely affected by noise. Most of the acoustical energy of speech is in the frequency range of 100 to 6,000 Hz, with the most important cue-bearing energy being between 300 and 3,000 Hz. Speech interference is basically a masking process in which simultaneous interfering noise renders speech incapable of being understood. Environmental noise may also mask other acoustical signals that are important for daily life such as doorbells, telephone signals, alarm clocks, music, fire alarms and other warning signals.

Sleep disturbance is a major effect of environmental noise. It may cause primary effects during sleep and secondary effects that can be assessed the day after night-time noise exposure. Uninterrupted sleep is a prerequisite for good physiological and mental functioning and the primary effects of sleep disturbance are: (a) difficulty in falling asleep; and (b) awakenings and alterations of sleep stages or depth. The difference between the sound levels of a noise event and background sound levels, rather than the absolute noise level, may determine the reaction probability.

The annoyance due to a given noise source is subjective from person to person and is also dependent upon many non-acoustic factors such as the prominence of the source, its importance to the listener's economy (wellbeing), and his or her personal opinion of the source. Increased exposure to noise can have negative effects on individuals, both physiological (influence on communication, productivity and even impaired hearing) and psychological effects (stress, frustration and disturbed sleep). As such, noise impacts need to be understood to mean one or a combination of negative physical, physiological or psychological responses experienced by individuals, whether consciously or unconsciously, caused by exposure to noise.

More technically, noise impacts are defined as the capacity of noise to induce annoyance depending upon its physical characteristics, including the sound pressure level, spectral characteristics and variations of these properties with time. During daytime, individuals may be annoyed at L_{Aeq} levels below 55 dB(A), while very few individuals are moderately annoyed at L_{Aeq} levels below 50 dB(A). Sound levels during the evening and night should be 5 to 10 dB(A) lower than during the day (World Health Organisation, 1999).

Table 2: Typical noise levels

Sound Pressure Level (dB(A))	Typical Source	Subjective Evaluation
130	threshold of pain	intolerable
120 110	heavy rock concert grinding on steel	extremely noisy
100 90	loud car horn at 3 m construction site with pneumatic hammering	very noisy
80 70	kerbside of busy street loud radio or television	loud
60 50	department store general office	moderate to quiet
40 30	inside private office inside bedroom	quiet to very quiet
20	unoccupied recording studio	almost silent

3.2. NOISE PROPAGATION

Sound is a pressure wave that diminishes with distance from source. Depending on the nature of the noise source, sound propagates at different rates. The three most common categories of noise are point sources (specified single point of noise generation), line sources (multiple linear noise generating points, such as a road) and area sources (specified single area of noise generation). The most important factors affecting noise propagation are:

- The type of source (point, line or area).
- Obstacles such as barriers and buildings.
- Distance from source.
- Atmospheric absorption.
- Ground absorption.
- Reflections.

Research has shown that doubling the distance from a noise source results in a proportional decline in noise level. Sound propagation in air can be compared to ripples on a pond. The ripples spread out uniformly in all directions, decreasing in amplitude as they move further from the source. An acoustically hard site exists where sound travels away from the source over a generally flat, hard surface such as water, concrete, or hard-packed soil. These are examples of reflective ground, where the ground cover provides little or no attenuation. The standard attenuation rate for hard site conditions is 6 dB(A) per doubling of distance for point sources. Thus, if you are at a position one meter from the source and move one meter further away from the source, the sound pressure level will drop by 6 dB(A), moving to 4 meters, the drop will be a further 6 dB(A), and so on. When ground cover or normal unpacked earth (i.e., a soft site) exists between the source and receptor, the ground becomes absorptive to sound energy. Absorptive ground results in an additional noise reduction of approximately 1.5 dB(A) per doubling of distance.

This methodology is only applicable when there are no reflecting or screening objects in the sound path. When an obstacle is in the sound path, part of the sound may be reflected, and part absorbed, and the remainder may be transmitted through the object. How much sound is reflected, absorbed and/or transmitted depends on many factors, including the properties of the object. When receptor locations are not in the line of sight of the noise source, there may be up to 20 dB(A) attenuation for broadband noise, with a further 10 to 15 dB(A) attenuation when inside the average residence and the windows are open.

3.3. CHARACTERISTICS OF NOISE

The human ear simultaneously receives sound (normal un-weighted sound or Z-weighting dB(Z)) at many frequencies (octave bands) at different amplitudes. The ear then adjusts its sensitivity based on the amplitude of the sound observed. This focuses the sound and makes it audible by adjusting the amplitude of the low, middle and high frequencies. To measure how a person experiences sound, an electronic weighting adjusted to the Z-weighted sound was developed, including three different weighting curves, namely:

- A-weighting - This measurement is often noted as dB(A) and this weighting curve attempts to make the noise level meter respond closely to the characteristics of a human ear. It adjusts the frequencies at low and high frequencies. Various national and international standards relate to measurements recorded in the A-weighting of sound pressure levels.
- B-weighting - is similar to A-weighting but with less attenuation. The B-weighting is very seldom, if ever, used. The B-weighting follows the C-weighted trend.
- C-weighting - is intended to represent how the ear perceives sound at high decibel levels. C-weighted measurements are reported as dB(C).
- Z-weighting - this refers to linear, un-weighted noise levels.

The weighting is employed by arithmetically adding a table of values (**Table 3**), listed by octave bands, to the measured linear sound pressure levels for each specific octave band. The resulting octave band measurements are logarithmically added to provide a single weighted value describing the sound, based on the applied weighting curve (**Figure 7**). Thus, if the A-weighted curve was applied to the sound, the noise level is noted as dB(A).

Table 3: Frequency weighting table for the different weighting curves

Frequency (Hz)	32 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz
A-weighting	-39.4	-26.2	-16.1	-8.6	-3.2	0	1.2	1	1.1
B-weighting	-17.1	-9.3	-4.2	-1.3	-0.3	0	-0.1	-0.7	-2.9
C-weighting	-3	-0.8	-0.2	0	0	0	-0.2	-0.8	-3
Z-weighting	0	0	0	0	0	0	0	0	0

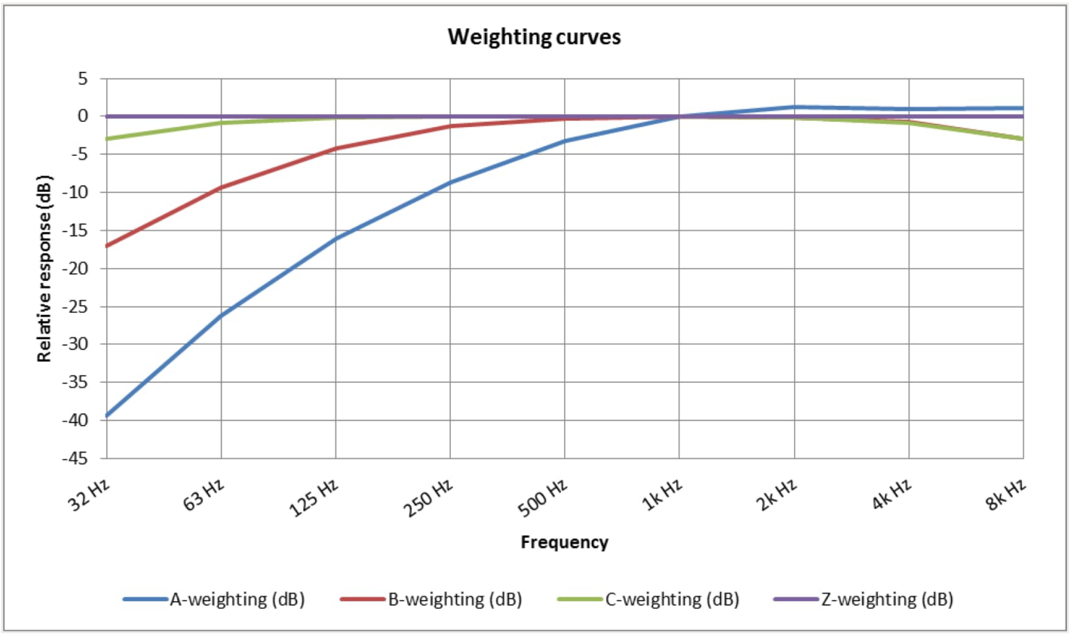

Figure 7: Weighting curves

4. LEGISLATIVE FRAMEWORK

4.1. SOUTH AFRICAN LEGISLATION

4.1.1. SOUTH AFRICAN NOISE CONTROL REGULATIONS

In South Africa, environmental noise control has been in place for three decades, beginning in the 1980s with codes of practice issued by the South African National Standards (formerly the South African Bureau of Standards, SABS) to address noise pollution in various sectors of the country. Under the previous generation of environmental legislation, specifically the Environmental Conservation Act 73 of 1989 (ECA), provisions were made to control noise from a national level in the form of the Noise Control Regulations (GNR 154 of January 1992). In later years, the ECA was replaced by the National Environmental Management Act 107 of 1998 (NEMA) as amended. The National Environmental Management: Air Quality Act 39 of 2004 (NEMAQA) was published in line with NEMA and contains noise control provisions under Section 34:

> *"(1) The minister may prescribe essential national standards –*
>
> > *(a) for the control of noise, either in general or by specific machinery or activities or in specified places or areas; or*
> >
> > *(b) for determining –*
> >
> > > *(i) a definition of noise; and*
> > >
> > > *(ii) the maximum levels of noise.*
>
> *(2) When controlling noise, the provincial and local spheres of government are bound by any prescribed national standards."*

Under NEMAQA, the Noise Control Regulations were updated and are to be applied to all provinces in South Africa. The Noise Control Regulations give all the responsibilities of enforcement to the Local Provincial Authority, where location specific by-laws can be created and applied to the locations with approval of Provincial Government. Where province-specific regulations have not been promulgated, acoustic impact assessments must follow the Noise Control Regulations. These regulations define the following:

- Ambient Sound Level: the reading on an integrating impulse sound level meter taken at a measuring point in the absence of any alleged disturbing noise at the end of a total period of at least 10 minutes, after such meter had been put into operation.
- Zone Sound Level: a derived dB(A) value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area.
- Disturbing Noise: a noise level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dB(A) or more.

With the above definitions in mind, regulation 4 of the Noise Control Regulations stipulate that no person shall make, produce or cause a disturbing noise, or allow it to be made, produced or caused by any person, machine, device or apparatus or any combination thereof.

Furthermore, NEMAQA prescribes that the Minister must publish maximum allowable noise levels for different districts and National noise standards. These have not yet been accomplished and as a result all monitoring and assessments are done in accordance with the SANS 10103:2008 and 10328:2008 as discussed in the sections that follow.

4.1.2. SOUTH AFRICAN NATIONAL STANDARDS (SANS)

The SANS 10328:2008 (*Methods for Environmental Noise Impact Assessments*) presently inform environmental acoustic impact assessments in South Africa. This standard defines that the purpose of an Environmental Acoustic Impact Assessment is to determine and quantify the acoustical impact of, or on, a proposed development. It also stipulates the methods used to assess impacts as well as the minimum requirements to be investigated and included in the Environmental Acoustic Impact Assessment report as part of the EIA. These minimum requirements include:

1) The purpose of the investigation.
2) A brief description of the planned development or the changes that are being considered.
3) A brief description of the existing environment including, where relevant, the topography, surface conditions and meteorological conditions during measurements.
4) The identified noise sources together with their respective sound pressure levels or sound power levels (or both) and, where applicable, the operating cycles, the nature of sound emission, the spectral composition and the directional characteristics.
5) The identified noise sources that were not taken into account and the reasons as to why they were not investigated.
6) The identified noise-sensitive developments and the noise impact on them.
7) Where applicable, any assumptions, with references, made with regard to any calculations or determination of source and propagation characteristics.
8) An explanation, either by 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.
9) 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.

10) The location of measuring or calculating points in a sketch or on a map.

11) Quantification of the noise impact with, where relevant, reference to the literature consulted and the assumptions made.

12) Alternatives that were considered and the results of those that were investigated.

13) A list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation.

14) 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.

15) Conclusions that were reached.

16) Proposed recommendations.

17) 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.

18) 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.

The SANS 10103:2008 document (*The measurement and rating of environmental noise with respect to speech communication*) provides methods and guidelines to assess working and living environments with respect to acoustic comfort as well as respect to possible annoyance by noise. As applicable to this assessment, SANS 10103 provides guideline typical rating levels for noise in different districts. These rating levels are presented in **Table 4**.

Table 4: Typical rating levels for noise in districts (adapted from SANS 10103:2008)

Type of District	Classification	Equivalent Continuous Rating level for Noise ($L_{Req,T}$) (dB(A)) Outdoors	
		Daytime ($L_{Req,d}$)	Night-time ($L_{Req,n}$)
a) Rural	A	45	35
b) Suburban (with little road traffic)	B	50	40
c) Urban	C	55	45
d) Urban (with one or more of the following: workshops, business premises and main roads)	D	60	50
e) Central Business Districts	E	65	55
f) Industrial District	F	70	60

As stipulated in SANS 10103:2008, noise can pose as an annoyance to a community if the increase in average noise levels exceeds the ambient noise by a certain degree. These specified increases together with the relevant estimated community responses are presented in **Table 5**.

Table 5: Categories of community/group response (adapted from SANS 10103:2008)

Excess ($\Delta L_{Req,T}$)[a] dB(A)	Estimated Community or Group Response	
	Category	Description
0 – 10	Little	Sporadic Complaints
5 – 15	Medium	Widespread Complaints
10 – 20	Strong	Threats of community/group action
>15	Very Strong	Vigorous community/group action

Overlapping ranges for the excess values are given because a spread in the community reaction might be anticipated.

[a] $\Delta L_{Req,T}$ should be calculated from the appropriate of the following:

1) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS $L_{Req,T}$ of the residual noise (determined in the absence of the specific noise under investigation);

2) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the maximum rating level of the ambient noise given in Table 1 of the code;

3) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the typical rating level for the applicable district as determined from Table 2 of the code; or

4) $L_{Req,T}$ = Expected increase in $L_{Req,T}$ of ambient noise in the area because of the proposed development under investigation.

4.2. WORLD HEALTH ORGANISATION GUIDELINES FOR COMMUNITY NOISE

The World Health Organisation (WHO) together with the Organisation for Economic Co-operation and Development (OECD) are the main international bodies that have collected data and developed assessments on the effects of exposure to environmental noise. This has provided the following summary of thresholds for noise nuisance in terms of the outdoor day-time equivalent continuous A-weighted sound pressure level (L_{Aeq}) in residential districts:

- At 55 - 60 dB(A) noise creates annoyance.
- At 60 - 65 dB(A) annoyance increases considerably.
- Above 65 dB(A) constrained behaviour patterns, symptomatic of serious damage caused by noise

The WHO therefore recommends a maximum outdoor daytime (07:00 – 22:00) L_{Aeq} of 55 dB(A) in residential areas and schools in order to prevent significant interference with normal activities. It further recommends a maximum night-time (22:00 – 07:00) L_{Aeq} of 45 dB(A) outside dwellings. No distinction is made as to whether the noise originates from road traffic, from industry, or any other noise source.

The WHO guideline for industrial noise is set at 70 dB(A) over a period of 24 hours. Anything above this level would cause hearing impairment, however, a peak noise level of 110 dB(A) is allowable on a fast response measurement.

4.3. INTERNATIONAL FINANCE CORPORATION GUIDELINES

From the International Finance Corporation (IFC) Environmental, Health and Safety (EHS) Guidelines, the impacts of noise beyond the property boundary of a facility are addressed in section 1.7 (IFC, 2007). The noise guidelines stipulated by the IFC are grouped into two categories, namely "Residential; institutional; educational" and "Industrial; commercial" (**Table 6**). Such guidelines are in-line with the WHO guidelines as discussed above and are as such applicable to this assessment. Noise impacts should not exceed these levels or result in a maximum increase in background noise levels of 3 dB(A) at the nearest off site receptor location.

Table 6: IFC Environmental Noise Level Guidelines

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

The guideline also states that highly intrusive noise, such as noise from aircraft flyovers and passing trains should not be included when establishing background noise levels.

4.4. THE ASSESSMENT AND RATING OF NOISE FROM WIND FARMS (ETSU)

The ETSU-R-97 report describes the framework for the measurement of noise associated with wind farms and provides indicative noise levels that offer a reasonable degree of protection to communities surrounding wind farm developments, without placing unreasonable restrictions on the wind farm developers. The assessment was developed by a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry. The key findings identified in the assessment include:

- Absolute noise limits applied at all wind speeds are not suited to wind farms. Limits set relative to background noise are more appropriate.
- The L_{A90} descriptor is much more accurate when monitoring and assessing wind turbine noise.
- Limits should be set on noise over a range of wind speeds up to 12 m/s when measured at 10 m height.
- The effects of other wind energy facilities in a specific area should be added to the effect of the proposed wind energy facility in order to determine the cumulative effect.
- Increases in noise levels as a result of a wind energy facility should be restricted to 5 dB(A) above the current ambient noise level at a specified receptor location.
- Noise from wind farms should be limited to a range between 35 and 40 dB(A) (daytime) in a low noise environment. A fixed limit of 43 dB(A) should be implemented during night-time. This should increase to 45 dB(A) (day and night) if the potential receptors have financial investments in the facility.
- For turbines spaced further apart, if noise is limited to an L_{A90} of 35 dB(A) at wind speeds up to 10 m/s (at 10 m height), then this condition alone offers sufficient protection of amenity and background noise surveys would not be necessary.

5. METHODOLOGY

The IFC EHS guidelines for Wind Energy were followed for this assessment, which is primarily based on the ETSU-R-97 report. Such guidance stipulates that a preliminary modelling exercise should be carried out using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines.

The CadnaA (Computer Aided Noise Abatement) acoustic model was used to calculate noise levels at specific receivers (sensitive receptors). The CadnaA software provides an integrated environment for noise predictions under varying scenarios and calculates the cumulative effects of various sources. The model uses ground elevations in the calculation of the noise levels in a grid and uses standard meteorological parameters that have an effect on the propagation of noise. CadnaA has been utilised in many countries across the globe for the modelling of environmental noise and town planning. It is comprehensive software for three-dimensional calculations, presentation, assessment and prediction of environmental noise emitted from industrial plants, parking lots, roads, railway schemes or entire towns and urbanized areas.

The IFC EHS guidance then indicates that if the model results indicate L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s (at a height of 10 m) during day and night times, this would be sufficient to assess the noise impact of the proposed facility, offering adequate protection of amenity at these receptors. If L_{A90} levels at any receptor location are above 35 dB(A), then impacts at these receptors may be perceived and potential turbine relocations should be considered.

In low noise environments, the ETSU-R-97 report itself, however, stipulates that noise from wind farms should be limited to a range between 35 and 40 dB(A) (daytime). Additionally, a fixed limit of 43 dB(A) should be implemented during night-time. This should increase to 45 dB(A) (day and night) if the potential receptors have financial investments in the facility.

With the Dalmanutha WEF being located within a low noise environment a combination of the IFC and ETSU methodology was followed in this assessment.

6. ASSUMPTIONS AND LIMITATIONS

In this Environmental Acoustic Impact Assessment, various assumptions were made and limitations experienced that may impact on the results obtained. These include:

- The turbine specifications provided are assumed to be representative of what will be installed in reality.
- The turbine locations provided are assumed to be an accurate representation of where these will be located in reality. It is, however, noted that the assessed layouts are not final and are still subject to minor changes.
- Identification of sensitive receptors is based on a desktop assessment and it is assumed that all key receptors have been included.

7. RESULTS

7.1. CONSTRUCTION PHASE

Unlike general industry, construction activities are not always stationary and in one location. Construction activities at the proposed site will include civil works (including surveying), reinforced concrete works, masonry works, façade works, floor works, general construction activities including mechanical, electrical, and plumbing installation works. Due to the erratic and transient nature of such construction activities as well as the fact that detailed construction phase plans have not yet been developed for the proposed Project, noise impacts from the construction phase of the facility could not be quantified.

During the construction phase of the facility various noise sources will be present onsite including earth-moving equipment (trucks, cranes, scrapers and loaders), compressors and generators, pumps, rotary drills, concrete mixers and materials handling activities among others. All of these sources will generate substantial amounts of noise and may impact on neighbouring sensitive receptors. As such, mitigation interventions are advised during the construction phase. These mitigation recommendations are detailed in the section that follows.

7.1.1. MITIGATION RECOMMENDATIONS

To minimise the acoustic impacts from the construction phase of the proposed Project, various mitigation techniques can be employed. These options include both management and technical options:

- Planning construction activities in consultation with landowners/land occupiers so that activities with the greatest potential to generate noise are planned during periods of the day that will result in least disturbance. Information regarding construction activities should be provided to identified and nearby receptors likely to be affected. Such information includes:
  - Proposed working times.
  - Anticipated duration of activities.
  - Explanations on activities to take place and reasons for activities.
  - Contact details of a responsible person on site should complaints arise.
- When working near a potential sensitive receptor, limit the number of simultaneous activities to a minimum as far as possible.
- Using noise control devices, such as temporary noise barriers and deflectors for high impact activities, and exhaust muffling devices for combustion engines.
- Selecting equipment with the lowest possible sound power levels whilst still being suitable for the specific task.
- Ensuring equipment is well-maintained to avoid additional noise generation.

7.2. OPERATIONAL PHASE

7.2.1. ALTERNATIVE 1

Table 7 presents the predicted noise levels from 70 turbines (with a hub height of 200 m and sound power level of 106.0 dB(A)). The preliminary model was run taking the surrounding terrain into account. Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at twenty of the 50 receptors. This indicates that noise from the turbines could create a nuisance or impact at those locations above this threshold.

However, being a low noise environment, with reference to the ETSU daytime limit range of 35 – 40 dB(A), L_{A90} noise levels at 36 of the 50 receptor locations are below this threshold. Additionally, at night, L_{A90} levels at 49 of the 50 receptor locations are below the ETSU 43 dB(A) threshold. It is, however, understood that all of the receptors within the project boundary have direct interest and are vested in the Project, thus a blanket threshold value of 45 dB(A) (day and night) applies. Predicted L_{A90} noise levels at all onsite receptor locations are below this 45 dB(A) threshold. Additionally, predicted L_{A90} noise levels at all receptors outside of the project boundary (Rec 01, Rec 05, Rec 06, Rec 09, Rec 10 – 18, Rec 24 – 25, Rec 27 – 28, Rec 38 – 41 and Rec 50) are below the ETSU 40 dB(A) threshold. As such, complaints are not anticipated as a result of the operation of the Dalmanutha WEF.

Table 7: Predicted noise levels at sensitive receptors – Alternative 1

ID	Description	Predicted L_{Aeq} noise level	Predicted L_{A90} noise level	L_{A90} below 35 dB(A) (IFC)	L_{A90} below 40 dB(A) (ETSU)	L_{A90} below 45 dB(A) (ETSU)*
Rec 01	Farmhouse	38.6	36.6	No	Yes	**N/A
Rec 02	Farmhouse	45.5	43.5	No	No	Yes
Rec 03	Farmhouse	44.8	42.8	No	No	Yes
Rec 04	Farmhouse	42.1	40.1	No	No	Yes
Rec 05	Farmhouse	35.5	33.5	Yes	Yes	**N/A
Rec 06	Farmhouse	31.3	29.3	Yes	Yes	**N/A
Rec 07	Farmhouse	41.1	39.1	No	Yes	Yes
Rec 08	Farmhouse	36.0	34.0	Yes	Yes	Yes
Rec 09	Farmhouse	31.8	29.8	Yes	Yes	**N/A
Rec 10	Farmhouse	36.9	34.9	Yes	Yes	Yes
Rec 11	Farmhouse	36.3	34.3	Yes	Yes	**N/A
Rec 12	Farmhouse	31.6	29.6	Yes	Yes	**N/A

ID	Description	Predicted L_{Aeq} noise level	Predicted L_{A90} noise level	L_{A90} below 35 dB(A) (IFC)	L_{A90} below 40 dB(A) (ETSU)	L_{A90} below 45 dB(A) (ETSU)*
Rec 13	Farmhouse	36.7	34.7	Yes	Yes	**N/A
Rec 14	Farmhouse	36.9	34.9	Yes	Yes	**N/A
Rec 15	Farmhouse	40.8	38.8	No	Yes	**N/A
Rec 16	Farmhouse	40.5	38.5	No	Yes	**N/A
Rec 17	Farmhouse	39.4	37.4	No	Yes	**N/A
Rec 18	Farmhouse	38.0	36.0	No	Yes	**N/A
Rec 19	Farmhouse	36.1	34.1	Yes	Yes	Yes
Rec 20	Farmhouse	35.3	33.3	Yes	Yes	Yes
Rec 21	Farmhouse	38.0	36.0	No	Yes	Yes
Rec 22	Farmhouse	41.6	39.6	No	Yes	Yes
Rec 23	Farmhouse	43.7	41.7	No	No	Yes
Rec 24	Farmhouse	36.9	34.9	Yes	Yes	**N/A
Rec 25	Farmhouse	30.3	28.3	Yes	Yes	**N/A
Rec 26	Farmhouse	39.7	37.7	No	Yes	Yes
Rec 27	Farmhouse	36.1	34.1	Yes	Yes	**N/A
Rec 28	Farmhouse	39.5	37.5	No	Yes	**N/A
Rec 29	Farmhouse	40.9	38.9	No	Yes	Yes
Rec 30	Farmhouse	43.5	41.5	No	No	Yes
Rec 31	Farmhouse	39.6	37.6	No	Yes	Yes
Rec 32	Farmhouse	39.4	37.4	No	Yes	Yes
Rec 33	Farmhouse	35.4	33.4	Yes	Yes	Yes
Rec 34	Farmhouse	42.3	40.3	No	No	Yes
Rec 35	Farmhouse	39.2	37.2	No	Yes	Yes
Rec 36	Farmhouse	37.9	35.9	No	Yes	Yes
Rec 37	Farmhouse	36.6	34.6	Yes	Yes	Yes

ID	Description	Predicted L_{Aeq} noise level	Predicted L_{A90} noise level	L_{A90} below 35 dB(A) (IFC)	L_{A90} below 40 dB(A) (ETSU)	L_{A90} below 45 dB(A) (ETSU)*
Rec 38	Farmhouse	30.6	28.6	Yes	Yes	**N/A
Rec 39	Farmhouse	27.3	25.3	Yes	Yes	**N/A
Rec 40	Farmhouse	34.4	32.4	Yes	Yes	**N/A
Rec 41	Farmhouse	32.9	30.9	Yes	Yes	**N/A
Rec 42	Farmhouse	43.2	41.2	No	No	Yes
Rec 43	Farmhouse	42.8	40.8	No	No	Yes
Rec 44	Farmhouse	42.7	40.7	No	No	Yes
Rec 45	Farmhouse	42.2	40.2	No	No	Yes
Rec 46	Farmhouse	42.2	40.2	No	No	Yes
Rec 47	Farmhouse	42.2	40.2	No	No	Yes
Rec 48	Farmhouse	43.8	41.8	No	No	Yes
Rec 49	Farmhouse	42.2	40.2	No	No	Yes
Rec 50	Farmhouse	37.3	35.3	No	Yes	**N/A

Note: L_{A90} calculation based on guidance from the ETSU-R-97 report.
* L_{A90} below 45 dB(A) if potential receptors have financial investment in the facility.
** These receptors are outside of the project boundary and therefore do not have any financial incentives in the project.

7.2.2. ALTERNATIVE 2

Table 8 presents the predicted noise levels from 44 turbines (with a hub height of 200 m and sound power level of 106.0 dB(A)). The preliminary model was run taking the surrounding terrain into account. Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at 26 of the 50 receptors. This indicates that noise from the turbines could create a nuisance or impact at those locations above this threshold.

However, being a low noise environment, with reference to the ETSU daytime limit range of 35 – 40 dB(A), L_{A90} noise levels at 41 of the 50 receptor locations are below this threshold. Additionally, at night, L_{A90} levels at 49 of the 50 receptor locations are below the ETSU 43 dB(A) threshold. It is, however, understood that all of the receptors within the project boundary have direct interest and are vested in the Project, thus a blanket threshold value of 45 dB(A) (day and night) applies. Predicted L_{A90} noise levels at all onsite receptor locations are below this 45 dB(A) threshold. Predicted L_{A90} noise levels at all receptors outside of the project boundary, except for Rec 17 and Rec 18 are below the ETSU 40 dB(A) threshold. As such, complaints may be anticipated at these two receptors as a result of the operation of the Dalmanutha WEF. It is therefore recommended that the turbines in closest proximity to these receptors (WTG 09 and WTG 10) be relocated slightly southwards to drop the noise levels at these receptors below the acceptable 40 dB(A) threshold. Alternatively, financial incentives for these receptors may also need to be considered.

Table 8: Predicted noise levels at sensitive receptors – Alternative 2

ID	Description	Predicted L_{Aeq} noise level	Predicted L_{A90} noise level	L_{A90} below 35 dB(A) (IFC)	L_{A90} below 40 dB(A) (ETSU)	L_{A90} below 45 dB(A) (ETSU)*
Rec 01	Farmhouse	37.3	35.3	No	Yes	**N/A
Rec 02	Farmhouse	45.1	43.1	No	No	Yes
Rec 03	Farmhouse	44.8	42.8	No	No	Yes
Rec 04	Farmhouse	43.9	41.9	No	No	Yes
Rec 05	Farmhouse	38.8	36.8	No	Yes	**N/A
Rec 06	Farmhouse	34.5	32.5	Yes	Yes	**N/A
Rec 07	Farmhouse	35.9	33.9	Yes	Yes	Yes
Rec 08	Farmhouse	31.6	29.6	Yes	Yes	Yes
Rec 09	Farmhouse	27	25.0	Yes	Yes	**N/A
Rec 10	Farmhouse	33.9	31.9	Yes	Yes	Yes
Rec 11	Farmhouse	33.2	31.2	Yes	Yes	**N/A
Rec 12	Farmhouse	26.8	24.8	Yes	Yes	**N/A
Rec 13	Farmhouse	34	32.0	Yes	Yes	**N/A
Rec 14	Farmhouse	33	31.0	Yes	Yes	**N/A
Rec 15	Farmhouse	40.1	38.1	No	Yes	**N/A
Rec 16	Farmhouse	39.8	37.8	No	Yes	**N/A
Rec 17	Farmhouse	43.8	41.8	No	No	**N/A
Rec 18	Farmhouse	43.1	41.1	No	No	**N/A
Rec 19	Farmhouse	42.5	40.5	No	No	Yes
Rec 20	Farmhouse	41.7	39.7	No	Yes	Yes
Rec 21	Farmhouse	43.4	41.4	No	No	Yes

ID	Description	Predicted L_{Aeq} noise level	Predicted L_{A90} noise level	L_{A90} below 35 dB(A) (IFC)	L_{A90} below 40 dB(A) (ETSU)	L_{A90} below 45 dB(A) (ETSU)*
Rec 22	Farmhouse	42.9	40.9	No	No	Yes
Rec 23	Farmhouse	44.5	42.5	No	No	Yes
Rec 24	Farmhouse	37.1	35.1	No	Yes	**N/A
Rec 25	Farmhouse	27.3	25.3	Yes	Yes	**N/A
Rec 26	Farmhouse	0.0	0.0	Yes	Yes	Yes
Rec 27	Farmhouse	36.0	34.0	Yes	Yes	**N/A
Rec 28	Farmhouse	38.7	36.7	No	Yes	**N/A
Rec 29	Farmhouse	37.2	35.2	No	Yes	Yes
Rec 30	Farmhouse	35.5	33.5	Yes	Yes	Yes
Rec 31	Farmhouse	37.6	35.6	No	Yes	Yes
Rec 32	Farmhouse	37.6	35.6	No	Yes	Yes
Rec 33	Farmhouse	35.6	33.6	Yes	Yes	Yes
Rec 34	Farmhouse	38.1	36.1	No	Yes	Yes
Rec 35	Farmhouse	32.7	30.7	Yes	Yes	Yes
Rec 36	Farmhouse	32.7	30.7	Yes	Yes	Yes
Rec 37	Farmhouse	32.5	30.5	Yes	Yes	Yes
Rec 38	Farmhouse	31.3	29.3	Yes	Yes	**N/A
Rec 39	Farmhouse	30.4	28.4	Yes	Yes	**N/A
Rec 40	Farmhouse	35.6	33.6	Yes	Yes	**N/A
Rec 41	Farmhouse	33.6	31.6	Yes	Yes	**N/A
Rec 42	Farmhouse	36.3	34.3	Yes	Yes	Yes
Rec 43	Farmhouse	36.6	34.6	Yes	Yes	Yes
Rec 44	Farmhouse	39.3	37.3	No	Yes	Yes
Rec 45	Farmhouse	39.6	37.6	No	Yes	Yes
Rec 46	Farmhouse	38.8	36.8	No	Yes	Yes

ID	Description	Predicted L_{Aeq} noise level	Predicted L_{A90} noise level	L_{A90} below 35 dB(A) (IFC)	L_{A90} below 40 dB(A) (ETSU)	L_{A90} below 45 dB(A) (ETSU)*
Rec 47	Farmhouse	38.2	36.2	No	Yes	Yes
Rec 48	Farmhouse	32.1	30.1	Yes	Yes	Yes
Rec 49	Farmhouse	35.3	33.3	Yes	Yes	Yes
Rec 50	Farmhouse	33.2	31.2	Yes	Yes	**N/A

Note: L_{A90} calculation based on guidance from the ETSU-R-97 report.
* L_{A90} below 45 dB(A) if potential receptors have financial investment in the facility.
** These receptors are outside of the project boundary and therefore do not have any financial incentives in the project.

7.2.3. CUMULATIVE ASSESSMENT

The proposed Dalmanutha WEF is located adjacent to the proposed Dalmanutha West WEF, with no other operational WEFs identified in the area. Common receptors shared between the Dalmanutha and Dalmanutha West WEFs are Rec 01, Rec 49 and Rec 50. Based on the close proximity of these receptors to the wind turbines at the Dalmanutha West WEF, cumulative noise impacts at these two locations may be noted.

It is also understood that a Prospecting Right Application for coal has been lodged by Elispec Mining (DMRE Ref No. MP 30/5/1/1/2/17337 PR) for a portion of the northern part of the proposed Dalmanutha WEF. It is noted that a wind facility would have significantly less impact on the noise climate of the area than the proposed mining activities, should the prospecting right be granted and later converted to a mining right.

7.2.4. MITIGATION RECOMMENDATIONS

From the preliminary modelling it is evident that noise levels for Alternative 2 at Rec 17 and Rec 18 will be slightly elevated and re-location of the nearby turbines should be considered. Alternatively, mitigation measures could be employed, namely (IFC, 2015):

— Operating turbines in reduced noise mode should any complaints be received.
— Selecting turbines with lower noise level specifications.
— Building walls/appropriate noise barriers around potentially affected buildings.
— Limiting turbine operations above the wind speed at which turbine noise becomes unacceptable in the project-specific circumstances.
— Relocating these two receptors or offering them financial incentives.

8. ASSESSMENT OF IMPACTS

The purpose of this Environmental Acoustic Impact Assessment is to identify the potential impacts and associated risks posed by the operation of the proposed Dalmanutha WEF on the noise climate of the area. The outcomes of the impact assessment will provide a basis to identify the key risk drivers and make informed decisions on the way forward in order to ensure that these risks do not result in unacceptable social or environmental risk.

All impacts of the operation of the proposed project were evaluated using a risk matrix, which is a semi-quantitative risk assessment methodology. This system derives an environmental impact level on the basis of the extent, reversibility, duration and probability of occurrence. The overall risk level is determined using professional judgement based on a clear understanding of the nature of the impact, potential mitigatory measures that can be implemented and changes in risk profile as a result of implementation of these mitigatory measures. A full description of the risk rating methodology is presented in **Appendix B**. Key localised acoustic impacts associated with the project include:

- Construction phase impacts of noise on sensitive receptors.
- Operational phase impacts of noise on sensitive receptors.

Outcomes of the Environmental Acoustic Impact Assessment are contained within **Table 9** outlining the impact of each parameter and the resulting risk level. It is noted that such an impact assessment is based on the ETSU limits for receptors with a financial interest in the Project, hence the assessment is slightly less stringent than the IFC methodology.

Table 9: Impact assessment of risks associated with the Dalmanutha WEF

	Without Mitigation							With Mitigation						
Description	Magnitude	Extent	Reversibility	Duration	Probability of Occurrence	Significance	Risk Level	Magnitude	Extent	Reversibility	Duration	Significance	Probability of Occurrence	Risk Level
Construction phase impacts of noise on sensitive receptors (*both Alternatives*)	3	2	1	1	3	21	**Low**	2	2	1	1	2	12	**Very Low**

Description	Without Mitigation							With Mitigation						
	Magnitude	Extent	Reversibility	Duration	Probability of Occurrence	Significance	Risk Level	Magnitude	Extent	Reversibility	Duration	Significance	Probability of Occurrence	Risk Level
Operational phase impacts of noise on sensitive receptors (*Alternative 1*)	2	1	1	4	3	24	**Low**	2	1	1	4	2	16	**Low**
Operational phase impacts of noise on sensitive receptors (*Alternative 2*)	2	2	1	4	4	36	**Moderate**	2	2	1	4	2	18	**Low**

9. CONCLUSIONS

WSP has been appointed to undertake the ESIA for the for the proposed Dalmanutha WEF. Wind turbines have the potential to generate noise and as such a specialist Environmental Acoustic Impact Assessment is required as part of the ESIA process for the WEF.

Based on the IFC EHS Guidelines for Wind Energy a preliminary modelling exercise was executed using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines. If L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s (at a height of 10 m) during day and night times, this would be sufficient to assess the noise impact of the proposed facility, offering adequate protection of amenity at these receptors. If L_{A90} levels at any receptor location are above 35 dB(A), then impacts at these receptors may be perceived and potential turbine relocations may need to be considered. In low noise environments, the ETSU-R-97 report itself, however, stipulates that noise from wind farms should be limited to a range between 35 and 40 dB(A) (daytime). Additionally, a fixed limit of 43 dB(A) should be implemented during night-time. This should increase to 45 dB(A) (day and night) if the potential receptors have financial investments in the facility. With the Dalmanutha WEF being located within a low noise environment a combination of the IFC and ETSU methodology was followed in this assessment.

Fifty sensitive receptors (farmhouses) were identified within 2 km of the site. Based on WSP's preliminary model (following the IFC methodology), the following was determined:

Alternative 1 (70 Wind Turbines)

- Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at twenty of the 50 receptors.
- However, being a low noise environment, with reference to the ETSU daytime limit range of 35 – 40 dB(A), L_{A90} noise levels at 36 of the 50 receptor locations are below this threshold. Additionally, at night, L_{A90} levels at 49 of the 50 receptor locations are below the ETSU 43 dB(A) threshold.
- It is, however, understood that all of the receptors within the project boundary have direct interest and are vested in the Project, thus a blanket threshold value of 45 dB(A) (day and night) applies. Predicted L_{A90} noise levels at all onsite receptor locations are below this 45 dB(A) threshold. Additionally, predicted L_{A90} noise levels at all receptors outside of the project boundary (Rec 01, Rec 05, Rec 06, Rec 09, Rec 10 – 18, Rec 24 – 25, Rec 27 – 28, Rec 38 – 41 and Rec 50) are below the ETSU 40 dB(A) threshold. As such, complaints are not anticipated as a result of the operation of the Dalmanutha WEF.

Alternative 2 (44 Wind Turbines)

- Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at 26 of the 50 receptors.
- However, being a low noise environment, with reference to the ETSU daytime limit range of 35 – 40 dB(A), L_{A90} noise levels at 41 of the 50 receptor locations are below this

threshold. Additionally, at night, L_{A90} levels at 49 of the 50 receptor locations are below the ETSU 43 dB(A) threshold.

- It is, however, understood that all of the receptors within the project boundary have direct interest and are vested in the Project, thus a blanket threshold value of 45 dB(A) (day and night) applies. Predicted L_{A90} noise levels at all onsite receptor locations are below this 45 dB(A) threshold. Predicted L_{A90} noise levels at all receptors outside of the project boundary, except for Rec 17 and Rec 18 are below the ETSU 40 dB(A) threshold. As such, complaints may be anticipated at these two receptors as a result of the operation of the Dalmanutha WEF. It is recommended that the turbines in closest proximity to these receptors (WTG 09 and WTG 10) be relocated slightly southwards to drop the noise levels at these receptors below the acceptable 40 dB(A) threshold. Alternatively, financial incentives for these receptors may also need to be considered.

The resultant environmental acoustic risks associated with the construction phase of the Project are anticipated to be “low” to “very low” with general mitigation options employed. For the operational phase (Alternative 1), impacts are anticipated to be “low” as it is understood that the direct surrounding receptors are all vested in the Project. For the operational phase (Alternative 2), impacts are anticipated to be “moderate” especially at Rec 17 and Rec 18. Should the nearby turbines be relocated slightly, impacts are anticipated to become “low”. Ultimately, should no complaints from receptors arise, it is recommended that the Project (Alternative 1) can be considered for authorisation.

10. REFERENCES

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Appendix A

CURRICULUM VITAE

Kirsten Collett

Earth & Environment, Air Quality & Acoustics – Environment & Energy, Principal Consultant

CAREER SUMMARY

Kirsten is a Principal Air Quality and Acoustic Consultant with a Master of Science (Atmospheric Sciences) degree obtained from the University of the Witwatersrand. She is currently employed at the Johannesburg branch of WSP and has worked on various air quality and acoustic impact assessments; air quality management plans; air quality and acoustic monitoring projects; and air quality and acoustic modelling projects for a variety of clients over the past eleven years. She has provided consulting support to various client industries including petrochemical, mining, metallurgical, manufacturing and local government bodies among others. She is also a registered Professional Natural Scientist (Pr.Nat.Sci.) with the South African Council for Natural Scientific Professions (SACNASP).

Countries of work experience gained include South Africa, Botswana, Mozambique, Madagascar, Somalia, Ethiopia, Serbia, Qatar and Kuwait.

11 years with WSP

Area of Expertise

Air Quality Impact Assessments

Air Quality Management

Ambient Air Quality and Acoustic Monitoring

Environmental Acoustic Impact Assessments

13 years of experience

Language

English - Fluent

EDUCATION

Master of Science, Atmospheric Sciences, University of Witwatersrand, Johannesburg, South Africa	2009
Bachelor of Science (Honours) Geography and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa	2006
Bachelor of Science, Geography and Environmental Studies, University of Witwatersrand, Johannesburg, South Africa	2005

ADDITIONAL TRAINING

CadnaA - Acoustics Training	2022
Snake Awareness Training	2016
Business-focussed Project Management	2013

PROFESSIONAL MEMBERSHIPS

SACNASP – South African Council for Natural Scientific Professions	2016
NACA – National Association for Clean Air	2016

Kirsten Collett

Earth & Environment, Air Quality & Acoustics – Environment & Energy, Principal Consultant

SASAS – South African Society for Atmospheric Sciences	2022

PROFESSIONAL HISTORY

WSP Group Africa (Pty) Ltd	2011 – present
Climatology Research Group (University of the Witwatersrand)	2009 – 2011

PROFESSIONAL EXPERIENCE

Air Quality Impact Assessments (AQIAs)

Transnet Port Terminals - Saldanha, AQIA for a Proposed Expansion to an Iron Ore Loading Terminal, Saldanha, Western Cape, South Africa
2020 – 2022
Project Manager and Lead Consultant
WSP was contracted to undertake an air quality impact assessment in the form of an atmospheric impact report (AIR) to determine the impacts of a proposed increase in iron ore storage and handling capacity at the Saldanha Port. The project was part of an Atmospheric Emission Licence (AEL) variation application, with an AIR specifically requested by the authorities. The project included a baseline assessment, compilation of a comprehensive emissions inventory and dispersion modelling using the CALPUFF dispersion model to assess the impacts of emissions on the surrounding communities. The project also included the AEL component, with authority liaison, advertisement placement and submission of the AEL variation application on the South African Atmospheric Emission Licencing and Inventory Portal (SAAELIP).

Cast Products South Africa, AQIA for a Section 22A AEL Renewal for a Foundry, Boksburg, Gauteng, South Africa
2022
Project Manager and Lead Consultant
WSP was contracted to undertake an air quality impact assessment in the form of an atmospheric impact report (AIR) for the Boksburg Foundry. The Client failed to renew their current AEL timeously and as such a Section 22A rectification process was triggered. As part of the Section 22A process, an AIR was specifically requested by the authorities. The project included a baseline assessment, compilation of a comprehensive emissions inventory and dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on the surrounding communities. The project also included the AEL component, with authority liaison, advertisement placement and submission of the AEL renewal application on the South African Atmospheric Emission Licencing and Inventory Portal (SAAELIP).

Orion Engineered Carbons, AQIA for a Bulk Liquid Cargo Facility, Port of Gqeberha, Eastern Cape, South Africa
2020 – 2021
Project Manager and Lead Consultant
WSP was appointed to conduct an AQIA in the form of an Atmospheric Impact Report as part of the licencing of the operational tanks at the port. This formed part of a Noxious Use Permit application, as per the Port Elizabeth Zoning Scheme. The assessment consisted of quantification of emissions from the tanks using the US EPA's Tanks 4.0.9 model as well as dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on any surrounding receptors.

Platinum Cement Industries, AQIA for a Proposed Cement Grinding Processing Facility, Umbogintwini, KwaZulu-Natal, South Africa
2020 – 2021
Project Manager and Lead Consultant
WSP was appointed to conduct an AQIA in the form of an Atmospheric Impact Report as part of an Atmospheric Emission Licence (AEL) application for a proposed cement grinding processing facility. The

assessment consisted of the compilation of a comprehensive emissions inventory to account for emissions from the facility as well as dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on any surrounding receptors.

Protea Chemicals, AQIA for a Revised Production Rate for a Chemical Producer, Cape Town, Western Cape, South Africa
2020
Project Manager and Lead Consultant
WSP was appointed to conduct an AQIA in the form of an Atmospheric Impact Report as part of an Atmospheric Emission Licence (AEL) amendment application for a production rate change at the facility. The assessment consisted of the compilation of a comprehensive emissions inventory to account for emissions from the facility as well as dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on any surrounding receptors.

WSP Middle East, AQIA for a Proposed Independent Power Project, Qatar
2020
Project Manager and Lead Consultant
WSP was contracted to undertake a screening-level air quality impact assessment to determine the suitability of the proposed stack heights in dispersing emission away from sensitive receptors. The project included a baseline assessment, emissions inventory, dispersion modelling using SCREEN3 and comparison of the predicted concentrations against the Qatar ambient air quality standards.

Transnet Port Terminals - Saldanha, AQIA for a Proposed Expansion to an Iron Ore Loading Port, Saldanha, Western Cape, South Africa
2019
Project Manager and Lead Consultant
WSP was contracted to undertake an air quality impact assessment to determine the impacts of a proposed increase in iron ore storage and handling capacity at the Saldanha Port. The project included a baseline assessment, compilation of a comprehensive emissions inventory and dispersion modelling using the CALPUFF dispersion model to assess the impacts of emissions on the surrounding communities.

Anglo American Coal SA, AQIA for a proposed coal stockpile at an underground mine, Ogies, Mpumalanga, South Africa
2018
Project Manager and Lead Consultant
WSP was appointed to conduct an Air Pollution Assessment in the form of an Atmospheric Impact Report for a proposed coal stockpile at the underground section of the Zibulo Colliery. The assessment consisted of the compilation of a comprehensive emissions inventory to account for emissions from the proposed stockpile as well as dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on any surrounding receptors.

WSP Middle East, AQIA for a Proposed Waste to Energy Facility, Kuwait
2017 – 2018
Project Manager and Lead Consultant
WSP was contracted to undertake an air quality impact assessment to determine the impacts of a proposed waste to energy facility in Kuwait. The project included assessment of baseline monitoring data (conducted by a local partner), a baseline assessment, emissions inventory, dispersion modelling using CALPUFF and comparison of the predicted concentrations against the Kuwait and International ambient air quality guidelines/standards. A preliminary screening assessment was undertaken using SCREEN3 to determine the monitoring locations for the baseline monitoring campaign.

The Dow Chemical Company (Rohm and Haas) - Advanced Materials, AQIA for a Chemical Manufacturer, New Germany, KwaZulu-Natal, South Africa
2015
Project Manager and Lead Consultant
WSP was appointed to conduct an Air Pollution Assessment in the form of an Atmospheric Impact Report for the proposed Polyol Blending Plant at the Dow Advanced Materials site in New Germany. The assessment consisted of the compilation of a comprehensive emissions inventory to account for emissions from both the existing and proposed operations as well as dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on the surrounding communities.

South32 Aluminium SA Limited, AQIA for Remediation of a Smelter, Richards Bay, KwaZulu-Natal, South Africa
2015 – 2016
Lead Consultant
WSP was contracted to undertake an air quality impact assessment to determine the impacts of remediating the legacy landfill sites at the Bayside Aluminium Smelter in Richards Bay. Kirsten was responsible for the development of a comprehensive emissions inventory; and determination of the impact of the proposed project on the surrounding communities using the AERMOD dispersion modelling software.

South32 Aluminium SA Limited, AQIA for a Smelter Decommissioning, Richards Bay, KwaZulu-Natal, South Africa
2014 – 2015
Lead Consultant
WSP was contracted to undertake a screening-level air quality impact assessment for the decommissioning of the Bayside Aluminium Smelter in Richards Bay. Kirsten was responsible for the development of a comprehensive emissions inventory; and determination of the impact of the proposed project on the surrounding communities using the AERSCREEN Tier 1 dispersion modelling software.

First in Spec Biofuels Ltd, AQIA for a Biodiesel Plant, Coega IDZ, Eastern Cape, South Africa
2011 – 2015
Lead Consultant
As part of a larger Environmental Impact Assessment for a proposed biodiesel production plant in Coega, WSP was commissioned to conduct a specialist air quality impact assessment for the facility. Kirsten was responsible for compiling the air quality impact assessment which was initially a screening-level assessment and later upgraded to a Tier 2 full air quality impact assessment. The project involved a baseline review of the area; baseline meteorological and pollutant data analysis; emission inventory compilation; dispersion modelling; reporting; and atmospheric emission licence (AEL) compilation.

Atha-Africa Ventures (Pty) Ltd, AQIA for a Proposed Mine, Wakkerstroom, Mpumalanga, South Africa
2012 – 2014
Lead Consultant
WSP was commissioned to undertake an air quality impact assessment for a proposed underground coal mine near Wakkerstroom, Mpumalanga as part of a comprehensive environmental and social impact assessment for the mine. Kirsten was responsible for conducting the air quality assessment. The assessment comprised on-site ambient air quality monitoring in order to assess the existing air quality in the region as well as dispersion modelling (using the ADMS (v5) software) to determine the predicted impacts that the proposed mine will have on the existing air quality.

Apollo Tyres South Africa (Pty) Ltd, AQIA for a Tyre Manufacturer, Durban, KwaZulu-Natal, South Africa
2012 – 2013
Consultant
WSP was commissioned to perform an air quality impact assessment for a tyre manufacturer to determine the changes in emissions should they replace their existing heavy fuel oil fired boiler with two coal fired boiler equipped with bag filters. Kirsten was responsible for conducting this screening-level air quality assessment through a baseline review of the site; emissions inventory compilation; and determination of the impact of the boiler emissions on the surrounding communities using the SCREEN3 screening-level dispersion modelling software.

Ferrochrome Furnaces (Pty) Ltd, AQIA for Ferrochrome Production Facility, Rustenburg, North West, South Africa
2012

Lead Consultant
WSP was commissioned to perform an air quality impact assessment of a proposed ferrochrome production facility in Zinniaville, Rustenburg as part of a larger environmental impact assessment. Kirsten was responsible for conducting the air quality assessment through a baseline review of the site; compilation of a detailed site-specific emissions inventory; determination of the impact of the proposed facility on the surrounding communities using the ADMS dispersion modelling software; and compilation of the atmospheric emission licence (AEL) application.

SIVEST SA (Pty) Ltd, AQIA for a Fuel Depot Recommissioning, Western Cape, South Africa
2012
Consultant
WSP was commissioned as part of a broader environmental impact assessment, to conduct an air quality impact assessment of the recommissioning of the Total Paarden Island fuel storage and distribution terminal near Cape Town. The air quality impact assessment investigated emissions generated as a result of both the construction phase and operational phase of the facility. Kirsten was responsible for the assessment which comprised a baseline review of the site; compilation of a detailed site-specific emissions inventory; estimation of emissions generated from each of the onsite storage tanks through the use of the TANKS 4.0.9 model; and determination of the impact of the proposed facility on the surrounding communities using the SCREEN3 dispersion modelling software.

Noble Resources Ltd, AQIA for a Proposed Oilseeds Processing Plant, Standerton, Mpumalanga, South Africa
2011-2012
Consultant
Noble Resources proposed to construct an oilseeds processing plant in Standerton and required an air quality assessment to determine what impacts the activity would have in the region. Kirsten performed this assessment through a baseline assessment of the site; development of a comprehensive emissions inventory; and determination of the proposed impacts through the use of a Tier 2 atmospheric dispersion model (ADMS)

City of Johannesburg, Ambient Air Quality Assessment during Car Free Day, Johannesburg, South Africa
2007 – 2008
Consultant
This project monitored vehicular emissions from a mobile monitoring station placed alongside the M1 highway in Johannesburg. This was done to evaluate the effectiveness of car free day and to assess whether there was a reduction in emissions on the day. Kirsten was involved in the assessment, analysis and reporting in this specific project.

Air Quality Management

Weir Minerals, Atmospheric Emission Licence (AEL) Audit, Annual Reporting and NAEIS submission for a Foundry, Isando, Gauteng
2021
Project Manager and Lead Consultant
WSP was appointed to undertake an audit of the facility's current AEL to assess the accuracy of what was represented in the AEL as well as to evaluate compliance with the conditions stipulated in the AEL. Additionally, the scope of work included compilation of their Annual Report as well as reporting of emissions onto the National Atmospheric Emissions Inventory System (NAEIS). Kirsten was responsible for conducting the audit, compiling the audit report and annual report and submitting all information onto NAEIS.

Sasol Satellite Operations Ekandustria, Atmospheric Emission Licence (AEL) Audit for an Explosives Manufacturer, Ekandustria, Mpumalanga, South Africa
2020
Project Manager and Lead Consultant

WSP was appointed to undertake an audit of the facility's current AEL to assess the accuracy of what was represented in the AEL as well as to evaluate compliance with the conditions stipulated in the AEL. Kirsten was responsible for conducting the audit and compiling the audit report.

Anglo American Coal SA, Isibonelo Colliery Air Quality Management Plan, Mpumalanga, South Africa
2019 – 2020
Project Manager and Lead Consultant
Anglo American Coal SA requested the compilation of an Air Quality Management Plan (AQMP) for the Isibonelo Colliery in the Mpumalanga province. The AQMP was aimed at improving air quality at the colliery through the identification of main sources of emissions and recommendations to reduce emissions from these sources. Kirsten was responsible for the compilation of the AQMP which was performed through a baseline assessment of activities at the colliery; identification of key emission sources; compilation of a detailed site specific emissions inventory; determination of the impact of emissions from the colliery on surrounding communities using the AERMOD dispersion modelling software; review of current management and mitigation techniques at the colliery; and development of strategies to minimise any impacts of emissions from the colliery going forward.

Transnet Port Terminals Saldanha Bay, Atmospheric Emission Licence (AEL) Audit for a Manganese Multipurpose Terminal, Saldanha, Western Cape, South Africa
2019
Lead Consultant
WSP was contracted to undertake an audit of the current provisional AEL (PAEL) for the terminal and assist with conversion of the PAEL to a final AEL. The project included a site visit and audit, Client and Authority liaison and assistance with submission of the AEL on the South African Atmospheric Emission Licencing and Inventory Portal (SAAELIP).

Anglo American Coal SA, Mafube Colliery Integrated Air Quality Management Plan, Mpumalanga, South Africa
2015 – 2016
Project Manager and Lead Consultant
WSP was appointed for the compilation of an integrated Air Quality Management Plan (AQMP) for the Mafube Colliery in the Mpumalanga province. The AQMP was aimed at improving air quality at the colliery through the identification of main sources of emissions and recommendations to reduce emissions from these sources. Kirsten was responsible for the compilation of the AQMP which was performed through a baseline assessment of activities at the colliery; identification of key emission sources; compilation of a detailed site specific emissions inventory; determination of the impact of emissions from the colliery on surrounding communities using the AERMOD dispersion modelling software; review of current management and mitigation techniques at the colliery; and development of strategies to minimise any impacts of emissions from the colliery going forward.

Sonae Novobord (Pty) Ltd, Air Quality Management Reports, White River, Mpumalanga, South Africa
2011 – 2015
Consultant
WSP has been continuously monitoring formaldehyde, suspended particulate matter (PM_{10}) and dust deposition (fallout) concentrations in and around the Sonae Novobord White River plant since 2008. Kirsten was responsible for analysing and assessing the ambient monitoring data and drafting the air quality management reports.

Anglo American Coal SA, Combined Integrated Air Quality Management Plan for the Greenside, Kleinkoppje and Landau Collieries, Mpumalanga, South Africa
2013 – 2014
Lead Consultant
Anglo American Coal SA requested the compilation of a combined integrated Air Quality Management Plan (AQMP) for the Greenside, Kleinkoppje and Landau Collieries in the Mpumalanga province. The AQMP was

aimed at becoming a management tool for the collieries going forward Kirsten was responsible for the compilation of the combined AQMP which was performed through a baseline assessment of activities at each colliery; identification of key emission sources; compilation of a detailed site specific emissions inventory for each colliery; determination of the impact of emissions from each colliery (as well as the combined impact) on surrounding communities using the CALPUFF dispersion modelling software; review of current management and mitigation techniques at each colliery; and development of strategies to minimise any impacts of emissions going forward.

Columbus Stainless (Pty) Ltd, Fugitive Dust Suppression Plan for a Steel Producer, Middelburg, Mpumalanga, South Africa
2013
Lead Consultant
WSP was commissioned to compile a fugitive dust suppression plan in order to assess the fugitive dust emanating from a stainless-steel plant in Middelburg. Kirsten was responsible for compiling the fugitive dust suppression plan through on-site dust fallout monitoring; analysis of all historical particulate matter, dust fallout and meteorological data for the site; identification of key emission sources; and provision of mitigation and management measures to limit the impact of fugitive dust going forward.

Anglo American Coal SA, Greenside Colliery Integrated Air Quality Management Plan, Mpumalanga, South Africa
2012 – 2013
Lead Consultant
Anglo American Coal SA requested the compilation of an integrated Air Quality Management Plan (AQMP) for the Greenside Colliery in the Mpumalanga province. The AQMP was aimed at improving air quality at the colliery through the identification of main sources of emissions and recommendations to reduce emissions from these sources. Kirsten was responsible for the compilation of the AQMP which was performed through a baseline assessment of activities at the colliery; identification of key emission sources; compilation of a detailed site specific emissions inventory; determination of the impact of emissions from the colliery on surrounding communities using the ADMS dispersion modelling software; review of current management and mitigation techniques at the colliery; and development of strategies to minimise any impacts of emissions from the colliery going forward.

Anglo American Coal SA, Landau Colliery Integrated Air Quality Management Plan, Mpumalanga, South Africa
2012
Lead Consultant
Anglo American Coal SA requested the compilation of an integrated Air Quality Management Plan (AQMP) for the Landau Colliery in the Mpumalanga province. The AQMP was aimed at improving air quality at the colliery through the identification of main sources of emissions and recommendations to reduce emissions from these sources. Kirsten was responsible for the compilation of the AQMP which was performed through a baseline assessment of activities at the colliery; identification of key emission sources; compilation of a detailed site specific emissions inventory; determination of the impact of emissions from the colliery on surrounding communities using the ADMS dispersion modelling software; review of current management and mitigation techniques at the colliery; and development of strategies to minimise any impacts of emissions from the colliery going forward.

Sonae Novobord (Pty) Ltd, Strategic Overview of Air Quality Conditions at the Sonae Novobord Plant, White River, Mpumalanga, South Africa
2008 – 2011
Consultant
WSP has been monitoring various air quality aspects in and around the Sonae Novobord White River plant since 2008. Concentrations of formaldehyde, suspended particulate matter (PM_{10}) and dust deposition (fallout) have been continually monitored in terms of the requirements of the NEMA Section 24G Environmental Management Plan. Kirsten was involved in performing a strategic assessment of conditions at the plant, to

ascertain whether the air quality has improved over time and whether the conditions set out in the Record of Decision and the Air Quality Management Plan are being met.

Ambient Monitoring

Anglo American Coal SA, Dust Fallout and Particulate Matter Monitoring for nine Collieries, Mpumalanga, South Africa
2016 – 2022
Project Manager
WSP was appointed to manage Anglo American Coal SA's air quality monitoring requirements at nine of their collieries. The contract includes dust fallout monitoring at all nine collieries, while continuous particulate matter (PM_{10} and $PM_{2.5}$) monitoring is conducted at seven collieries using mobile custom-designed solar system trailers. Kirsten was responsible for project management and quality control for the project.

Foskor (Pty) Ltd, Dust Fallout and Particulate Matter Monitoring for a Phosphate Mine, Phalaborwa, Limpopo, South Africa
2016 – 2019
Project Manager
WSP was commissioned to manage and maintain a dust monitoring network for Foskor Phalaborwa's phosphate rock operations in the Limpopo Province. The monitoring network comprises 37 dust fallout samplers, and a real-time particulate matter (PM_{10}) monitor. Kirsten was responsible for project management and quality control for the project.

Total South Africa (Pty) Ltd, Leak Detection and Repair Programs for Ten Fuel Depots, South Africa
2016 – 2017
Project Manager
WSP was appointed to conduct leak detection and repair programs at ten of Total South Africa's bulk fuel storage depots as part of their atmospheric emission licence conditions. Kirsten was responsible for project management, data analysis and reporting for the project.

Eskom Holdings SOC Limited, Dust Fallout Monitoring for Kendal Power Station, Kendal, Mpumalanga, South Africa
2016
Project Manager
WSP was commissioned to monitor dust fallout at the Kendal Power Station in Mpumalanga for a six month period. Kirsten was responsible for project management, data analysis and reporting for the project.

Evraz Highveld Steel and Vanadium Corporation Ltd, Dust Fallout Monitoring for a Steel Facility, Mpumalanga, South Africa
2012 – 2015
Project Manager
As part of Evraz Highveld Steel's on-going monitoring program for the assessment of dust generated by the steelworks and associated activities, WSP was commissioned to conduct dust fallout monitoring both on and off site. Monitoring has been performed over time at the site on a monthly basis in accordance with the ASTM D1739 reference method. Kirsten was responsible for data analysis, interpretation and reporting during the 2012 monitoring period. Most recently, Kirsten was responsible for project management during the 2014 and 2015 campaign.

Evraz Highveld Steel & Vanadium Corporation Ltd, Particulate Matter Monitoring for a Steel Facility, Mpumalanga, South Africa
2014 – 2015
Project Manager
WSP was commissioned to monitor particulate matter concentrations at three locations in and around the Evraz Highveld Steel facility using E-sampler monitoring equipment. Kirsten was responsible for project management and reporting for the project.

Eskom Holdings SOC Limited, Dust Fallout Monitoring for Majuba Power Station, Volksrust, Mpumalanga, South Africa
2013 – 2015
Project Manager
WSP was commissioned to monitor dust fallout at the Majuba Power Station in Mpumalanga for a two-year period. Kirsten was responsible for project management, data analysis and reporting for the project.

Tubular Holdings (Pty) Ltd, Dust Fallout Monitoring, Kendal, Mpumalanga, South Africa
2013 – 2014
Project Manager
WSP was commissioned to monitor dust fallout and meteorological conditions at the Tubular Holdings workers' living quarters near Kendal, Mpumalanga. The project was initiated to determine the source of dust at this location. Kirsten was responsible for project management; data analysis; and reporting for the project.

Atlantis Foundries (Pty) Ltd, Dust Monitoring Program for a Foundry, Atlantis, Western Cape, South Africa
2011
Data Analyst
WSP was commissioned to provide specialist air quality support and monitoring services to Atlantis Foundries (Pty) Ltd, situated within Atlantis near Cape Town. The project included: dust deposition monitoring, the compilation of an Atmospheric Emission Licence (AEL) for the facility and the development of site-specific dust mitigation and management strategies. Kirsten was involved in assisting with data analysis and interpretation of the results obtained from the monthly monitoring campaigns at the site.

Sasol New Energy Holding (Pty) Ltd, Air Quality Monitoring for a Proposed Power Plant, Ressano Garcia, Mozambique
2011
Field Consultant
WSP was commissioned by Sasol New Energy Holding (Pty) Ltd to undertake an integrated environmental and social impact assessment (ESIA) and bankable environmental, social and health impact assessment (ESHIA) for the proposed gas engine power plant that is to be constructed in Ressano Garcia, Mozambique. As part of this assessment, a specialist air quality study was conducted to assess what impacts the proposed plant may have on air quality in the region. Kirsten was responsible in assisting with the set-up of passive monitoring equipment, dust buckets and a meteorological station at the site.

Eskom Holdings SOC Limited, European Integrated Project on Aerosol, Cloud, Climate and Air Quality Interactions, Mpumalanga, South Africa
2007 – 2010
Technical Consultant
This was an international aerosol project focusing on four developing countries, namely South Africa, India, Brazil and China. It was initiated to provide a comparative set of aerosol emission data between the four countries. Kirsten was involved in the setup and maintenance of the monitoring instrumentation at the South African site. For this, Kirsten was also involved in an aerosol training course in Hyytiälä, Finland as well as technical training in Leipzig, Germany for the SMPS (Scanning Mobility Particle Sizer) instrument.

Eskom Holdings SOC Limited, Ambient Air Monitoring at the Point of Highest Impact Resulting from Kriel and Matla Power Stations, Mpumalanga, South Africa
2009
Consultant
This study was conducted on the Mpumalanga Highveld in order to increase our understanding of the sources and diurnal variations of various atmospheric species as well as the effects of local meteorology on the concentration of these species. The study included ambient monitoring using a mobile monitoring station. Kirsten was involved in the data analysis, statistical manipulation and reporting.

Acoustics

ENERTRAG South Africa, Environmental Acoustic Screening Assessment for two Proposed Wind Energy Facilities, Camden, Mpumalanga, South Africa
2021 – 2022
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic screening assessment for two proposed wind energy facilities near Camden in Mpumalanga. Kirsten was responsible for conducting the assessments which

determined the potential acoustic impacts of the proposed projects based on the methodology prescribed by the International Finance Corporation Environmental Health and Safety (IFC EHS) Guidelines.

ENERTRAG South Africa, Environmental Acoustic Impact Assessment for a Proposed Green Hydrogen and Ammonia Facility, Camden, Mpumalanga, South Africa
2021 – 2022
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic Impact assessment for the proposed Camden I Green Hydrogen and Ammonia Facility. Kirsten was responsible for conducting the assessment which included a baseline assessment; development of a comprehensive acoustic inventory; and determination of the impact of the proposed project on the surrounding sensitive receptors using attenuation-over-distance acoustic calculations.

Crossboundary Energy, Environmental Acoustic Screening Assessment for a Proposed Wind Energy Facility, Port Dauphine, Madagascar
2021 – 2022
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic screening assessment for a proposed wind energy facility in Madagascar. Kirsten was responsible for conducting the assessment which determined the potential acoustic impacts of the proposed project based on the methodology prescribed by the International Finance Corporation Environmental Health and Safety (IFC EHS) Guidelines.

DP World, Environmental Acoustic Impact Assessment for the Port of Berbera Phase 2 Expansion, Somaliland, Somalia
2021 – 2022
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for the proposed Phase 2 expansion to the Port of Berbera. An acoustic inventory was developed to identify all potential sources of noise associated with the construction and operational phases of the Phase 2 expansion project. The construction phase impacts were assessed through attenuation-over-distance acoustic calculations, whilst acoustic impacts of the proposed port operations were assessed using the Computer Aided Noise Abatement (CadnaA) acoustic model.

Loci Environmental, Environmental Acoustic Impact Assessment for a Proposed Manganese Mine, Kanye, Botswana
2021 – 2022
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for a proposed manganese mine in Botswana. Kirsten was responsible for conducting the assessment which included a baseline assessment; development of a comprehensive acoustic inventory; and determination of the impact of the proposed project on the surrounding sensitive receptors using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software.

Die Oesterreichische Entwicklungsbank Ag And Metito Utilities Ltd, Environmental Acoustic Impact Assessment for a Proposed Wastewater Treatment Plant, Zrenjanin, Serbia
2021
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for the development of a proposed wastewater treatment plant (WWTP). To assess the existing noise climate in the area surrounding the proposed site, ambient noise monitoring was conducted at four receptor locations. An acoustic inventory was developed to identify all potential sources of noise associated with the construction and operational phases of the WWTP. The acoustic impacts of the operation of the proposed WWTP were then assessed using the Computer Aided Noise Abatement (CadnaA) acoustic model, while construction phase impacts were assessed through attenuation-over-distance acoustic calculations.

DNG Energy Ltd, Environmental Acoustic Impact Assessment for a Proposed Gas to Power Project, Komatipoort, Mpumalanga, South Africa
2021
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for the development of the proposed Khensani Gas to Power Project. To assess the existing noise climate in the area surrounding the proposed site, ambient noise monitoring was conducted at five receptor locations. An acoustic inventory was developed to identify all potential sources of noise associated with the operational phase of the project. The acoustic impacts of the operation of the proposed facility during both an unmitigated and mitigated scenario were then assessed using the Computer Aided Noise Abatement (CadnaA) acoustic model.

Platinum Cement Industries, Environmental Acoustic Impact Assessment for a Proposed Cement Grinding Processing Facility, Umbogintwini, KwaZulu-Natal, South Africa
2020 – 2021
Project Manager and Lead Consultant
WSP was appointed to conduct a screening-level environmental acoustic impact assessment for a proposed cement grinding processing facility. Kirsten was responsible for conducting the assessment which included a baseline assessment; development of a comprehensive acoustic inventory; and determination of the impact of the proposed project on the surrounding sensitive receptors using attenuation-over-distance acoustic calculations.

AngloGold Ashanti, Environmental Acoustic Impact Assessment for the expansion to a tailings storage facility, Northwest, South Africa
2017 – 2020
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for the proposed extension of the Kareerand Tailings Storage Facility. Kirsten was responsible for conducting the assessment which included baseline acoustic monitoring; development of a comprehensive acoustic inventory for both the construction and operational phases of the project; and determination of the impact of the proposed project on the surrounding sensitive receptors using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software.

BioTherm Energy, Environmental Acoustic Impact Assessment for three wind energy facilities, Northern and Western Cape, South Africa
2016 – 2019 and 2021 – 2022
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for three proposed wind energy facilities located between Sutherland and Matjiesfontein in the Northern and Western Cape provinces. Kirsten was responsible for conducting the assessments which included baseline acoustic monitoring; development of a comprehensive acoustic inventory for both the construction and operational phases of the project; and determination of the impact of the proposed wind energy facilities on the surrounding sensitive receptors (farmhouses) using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software. Various updates and expansions to the above-mentioned projects were then further assessed during 2021/2022.

Sappi Southern Africa Limited, Environmental Acoustic Impact Assessment for the proposed expansion to a paper mill, KwaZulu-Natal, South Africa
2018
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for the proposed expansion to the Sappi Saiccor Mill, near Umkomaas. Kirsten was responsible for conducting the assessment which included baseline acoustic monitoring; development of a comprehensive acoustic inventory for the proposed expansion activities; and determination of the impact of the proposed expansion on the surrounding sensitive receptors through the use of attenuation-over-distance acoustic calculations.

Sappi Southern Africa Limited, Environmental Acoustic Impact Assessment for a proposed timber handling facility, Umkomaas, KwaZulu-Natal, South Africa
2017
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for a proposed timber handling facility near Umkomaas. Kirsten was responsible for conducting the assessment which included

baseline acoustic monitoring; development of a comprehensive acoustic inventory; and determination of the impact of the proposed facility on the surrounding sensitive receptors (specifically, a newly proposed retirement village) using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software.

Loci Environmental, Environmental Acoustic Impact Assessment for the proposed rehabilitation of the Sekoma-Morwamosu road section, Botswana
2017
Project Manager and Lead Consultant
WSP was appointed to undertake an environmental acoustic impact assessment for the proposed rehabilitation of a section of road within the southern part of Botswana. Kirsten was responsible for conducting the assessment. Current operational noise levels in the vicinity of the road section where determined using an acoustic modelling platform, with current (2017) traffic count data as input. The acoustic impacts of the proposed rehabilitation were determined using attenuation-over-distance calculations (construction phase) and acoustic modelling (operational phase). Changes in noise levels at specific receptor locations were then assessed for each phase and the resultant community responses were evaluated.

City of Cape Town, Environmental Acoustic Impact Assessment for the Redevelopment of the Athlone Power Station, Cape Town, Western Cape, South Africa
2016 – 2017
Lead Consultant
WSP was contracted to undertake an environmental acoustic impact assessment for redevelopment of the Athlone Power Station site to determine the noise impacts of a) the surrounding activities on the redevelopment site; and b) the proposed site activities on the surrounding communities. Kirsten was responsible for conducting the assessment which included baseline acoustic monitoring; development of a comprehensive noise source inventory; and determination of the impact of the current noise climate on the Athlone site as well as the impact of the proposed redevelopment activities on the surrounding communities.

Central Termica Da Ressano Garcia, Environmental Acoustic Monitoring for a Gas Engine Power Plant, Ressano Garcia, Mozambique
2016
Project Manager
WSP was commissioned to undertake acoustic monitoring at the Central Termica De Ressano Garcia gas engine power plant site in order to assess the noise associated with the operation of the plant. Kirsten was responsible for project management, technical input and reporting for this project.

Anglo American Coal SA, Community Environmental Acoustic Monitoring Survey, Vereeniging, Gauteng, South Africa
2016
Project Manager
WSP was appointed to conduct community-based noise monitoring in a region adjacent to the New Vaal Colliery in order to assess the acoustic impacts of the colliery on the surrounding communities. Kirsten was responsible for project management, data analysis and reporting for the project.

Anglo American Platinum Limited, Screening Level Environmental Acoustic Impact Assessment for a New Ventilation Shaft, Rustenburg, Northwest, South Africa
2016
Lead Consultant
WSP was appointed to investigate the acoustic impacts associated with the construction and operation of an additional ventilation shaft at the Siphumelele 1 Mine near Rustenburg. Kirsten was responsible for conducting the assessment through baseline acoustic monitoring and acoustic propagation calculations.

Industrial Development Corporation of SA (Pty) Ltd, Environmental Acoustic Impact Assessment for a Proposed Paper Mill, Frankfort, Free State, South Africa
2013 – 2015
Lead Consultant
WSP was contracted to undertake an environmental acoustic impact assessment for a proposed paper mill in Frankfort in the Free State Province. Kirsten was responsible for conducting the assessment which included baseline acoustic monitoring; development of a comprehensive noise source inventory; and determination of the impact of the proposed project on the surrounding communities using the Computer Aided Noise Abatement (CadnaA) acoustic model.

South32 Aluminium SA Limited, Environmental Acoustic Impact Assessment for the Decommissioning of a Smelter, Richards Bay, KwaZulu-Natal, South Africa
2014 – 2015
Lead Consultant
WSP was contracted to undertake a screening-level environmental acoustic impact assessment for the decommissioning of the Bayside Aluminium Smelter in Richards Bay. Kirsten was responsible for conducting the assessment which included the development of a comprehensive noise source inventory; and determination of the impact of the proposed project on the surrounding communities using noise propagation calculations.

Sasol New Energy Holding (Pty) Ltd, Environmental Acoustic Monitoring for a Gas Engine Power Plant, Ressano Garcia, Mozambique, Africa
2014 – 2015
Project Manager and Lead Consultant
WSP was commissioned by Sasol New Energy Holding (Pty) Ltd to undertake acoustic monitoring at the Central Termica De Ressano Garcia gas engine power plant site in order to assess the noise associated with the construction and operational phases of the plant. Kirsten was responsible for technical input, acoustic data analysis and reporting for this project.

Sonae Novobord (Pty) Ltd, Environmental Noise Survey for a Wood Producer, White River, Mpumalanga, South Africa
2012 – 2015
Consultant
WSP has been conducting environmental noise monitoring at the Sonae Novobord White River plant since 2009. The project includes day and night-time monitoring in accordance with the SANS 10103:2008 methodology, data analysis, compliance assessment and reporting. Kirsten was involved in the data analysis, interpretation and reporting for the project.

Atha-Africa Ventures (Pty) Ltd, Environmental Acoustic Impact Assessment for a Proposed Mine, Wakkerstroom, Mpumalanga, South Africa
2012 – 2014
Lead Consultant
WSP Environmental was commissioned to undertake an environmental acoustic impact assessment for a proposed underground coal mine near Wakkerstroom, Mpumalanga as part of a comprehensive environmental and social impact assessment for the mine. Kirsten was responsible for conducting the environmental acoustic assessment. The assessment comprised on-site environmental noise monitoring in order to obtain a baseline noise climate for the region as well as acoustic modelling to determine the predicted impacts that the proposed mine will have on the existing noise climate. An inventory of all noise sources during the construction and operational phases was compiled with associated sound power levels for each source. These sources were then input into the Computer Aided Noise Abatement (CadnaA) acoustic model. Results were compared with the monitored (existing) noise levels as well as the SANS day and night-time guidelines to assess compliance.

Sonae Novobord (Pty) Ltd, Environmental Noise Survey for a Wood Producer, Panbult, Mpumalanga, South Africa
2013
Project Manager
WSP was commissioned to do a once-off environmental acoustic compliance monitoring survey at the Sonae Novobord Panbult site in Mpumalanga. Kirsten was responsible for project management and reporting for the project.

Kirsten Collett

Earth & Environment, Air Quality & Acoustics – Environment & Energy, Principal Consultant

Rustenburg Platinum Mines Limited, Environmental Noise Impact Assessment for the Amandelbult Mine, Limpopo, South Africa
2013
Lead Consultant
As part of an environmental impact assessment, WSP was commissioned to conduct an environmental noise assessment for the sinking of a new shaft at the Tumela mine in the Limpopo Province. Kirsten conducted this environmental noise impact assessment through a baseline review of the site; compilation of a detailed site-specific noise inventory; determination of the impact of the proposed project on the surrounding communities using the CadnaA acoustic model; interpretation of modelled results; compliance assessment; and reporting.

Shell and BP South Africa Petroleum Refineries (SAPREF), Environmental Noise Impact Assessment for SAPREF Cleaner Fuels Phase Two, Durban, KwaZulu-Natal, South Africa
2013
Lead Consultant
WSP was contracted to perform the environmental noise impact assessment of the Cleaner Fuels Phase Two Project for the SAPREF Refinery in South Durban. The project investigated the noise associated with undertaking the required modifications to the refinery in order to meet the pending fuel specifications published by the South African Department of Energy. Kirsten was responsible for analysis and interpretation of on-site acoustic monitoring; compilation of a detailed site-specific noise inventory; determination of the impact of the proposed project on the surrounding communities through the use of the CadnaA acoustic model; interpretation of modelled results; compliance assessment; and reporting.

Assmang Black Rock Mine Operations, Environmental Monitoring Assessment for a Manganese Mine, Hotazel, Northern Cape, South Africa
2012 – 2013
Consultant
WSP was commissioned to conduct environmental monitoring for their underground manganese mining venture at Black Rock in the Northern Cape Province. The environmental monitoring consisted of both environmental noise monitoring and particulate monitoring. Vehicle noise and emissions testing was also performed on various Assmang owned vehicles onsite. Kirsten was responsible for analysis of all monitored data, interpretation, compliance assessment and reporting.

AngloGold Ashanti (Pty) Ltd, Environmental Noise Surveys, Vaal River and West Wits Operations, Northwest, South Africa
2012
Consultant
WSP was commissioned by Anglo Gold Ashanti to perform environmental noise surveys of their Vaal River and West Wits mining operations in the Northwest Province, as part of their commitment to minimise negative impacts on the environment. The project included day and night-time monitoring in accordance with the SANS 10103:2008 methodology, data analysis, compliance assessment and reporting. Kirsten was responsible for assisting with data analysis, interpretation and reporting.

Sasol New Energy Holding (Pty) Ltd, Environmental Acoustic Impact Assessment for a proposed Power Plant, Ressano Garcia, Mozambique
2011
Field Consultant
WSP was commissioned by Sasol New Energy Holding (Pty) Ltd to undertake an integrated environmental and social impact assessment (ESIA) and bankable environmental, social and health impact assessment (ESHIA) for the proposed gas engine power plant that is to be constructed in Ressano Garcia, Mozambique. As part of this assessment, a specialist environmental acoustic study was conducted to assess what impacts the proposed plant may have on the noise climate of the region. Kirsten was responsible in assisting with on-site acoustic monitoring for the project.

Kirsten Collett

Earth & Environment, Air Quality & Acoustics – Environment & Energy, Principal Consultant

MSC Thesis

The Atmospheric Nitrogen Budget over the South African Highveld, Mpumalanga, South Africa
2007 – 2009
This project was Kirsten's MSc thesis and was performed in collaboration with Eskom. The project aimed to assess the atmospheric nitrogen cycle in the industrialised Highveld region. The project investigated the various atmospheric nitrogen compounds on the South African Highveld and looked at the dominant sources, the transport and conversion of the species in the atmosphere and in what form they are deposited to the ground. From this it was confirmed that the majority of emitted nitrogen remains in the atmosphere, confirming the trends depicted by satellite technology. Client: Eskom Holdings SOC Limited.

Honours Project

NOx or Not: Nitrogen Oxide Levels over the South African Highveld, Mpumalanga, South Africa
2006
This was Kirsten's honours project and was performed in collaboration with Eskom. This project aimed to validate the nitrogen dioxide hotspot over the South African Highveld as identified by satellite technology. The prevalent sources of nitrogen dioxide were investigated as well as the diurnal and seasonal distributions. Client: Eskom Holdings SOC Limited.

AWARDS

2009 - MSc Distinction

2008 - Best presentation for paper entitled "The Atmospheric Nitrogen Budget over the South African Highveld".
National Association for Clean Air (NACA) conference

PUBLICATIONS AND PRESENTATIONS

Publications

Collett, K.S., Piketh, S.J. and Ross, K.E. "An assessment of the atmospheric nitrogen budget on the South African Highveld." South African Journal of Science, 2010, pp. #106, 5/6, Article# 220.

Laakso, L., Vakkari, V., Laakso, H., Virkkula, A., Kulmala, M., Beukes, J.P., van Zyl, P.G., Pienaar, J.J., Chiloane, K., Gilardoni, S., Vignati, E., Wiedensohler, A., Tuch, T., Birmili, W., Piketh, S., Collett, K., Fourie, G.D., Komppula, M., Lihavainen, H., de Leeuw, G. and Kerminen, V.-M. "South African EUCAARI – measurements: a site with high atmospheric variability, "Atmospheric Chemistry and Physics Discussion. Month 2010, 10, 30691 – 30729.

Ross, K., Broccardo, S., Heue, K-P., Collett (nee Ferguson), K. and Piketh, S. "Nitrogen oxides on the South African Highveld." Clean Air Journal, Month 2007. 16, 2, 6 – 15.

Presentations

Collett, Kirsten. "The Atmospheric Nitrogen Budget over the South African Highveld." National Association for Clean Air Conference, Nelspruit, Mpumalanga, 2009.

Appendix B

IMPACT ASSESSMENT METHODOLOGY

The assessment of impacts and mitigation evaluates the likely extent and significance of the potential impacts on identified receptors and resources against defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise or compensate for any adverse environmental impacts, to enhance positive impacts, and to report the significance of residual impacts that occur following mitigation.

The key objectives of the risk assessment methodology are to identify any additional potential environmental issues and associated impacts likely to arise from the proposed project, and to propose a significance ranking. Issues / aspects will be reviewed and ranked against a series of significance criteria to identify and record interactions between activities and aspects, and resources and receptors to provide a detailed discussion of impacts. The assessment considers direct[2], indirect[3], secondary[4] as well as cumulative[5] impacts.

A standard risk assessment methodology is used for the ranking of the identified environmental impacts pre-and post-mitigation (i.e. residual impact). The significance of environmental aspects is determined and ranked by considering the criteria[6] presented in **Figure B-1**.

Table B-1 - Impact Assessment Criteria and Scoring System

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Magnitude (M) The degree of alteration of the affected environmental receptor	Very low: No impact on processes	Low: Slight impact on processes	Medium: Processes continue but in a modified way	High: Processes temporarily cease	Very High: Permanent cessation of processes
Impact Extent (E) The geographical extent of the impact on a given environmental receptor	Site: Site only	Local: Inside activity area	Regional: Outside activity area	National: National scope or level	International: Across borders or boundaries
Impact Reversibility (R) The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change	Reversible: Recovery without rehabilitation		Recoverable: Recovery with rehabilitation		Irreversible: Not possible despite action
Impact Duration (D) The length of permanence of the impact on the environmental receptor	Immediate: On impact	Short term: 0-5 years	Medium term: 5-15 years	Long term: Project life	Permanent: Indefinite

[2] Impacts that arise directly from activities that form an integral part of the Project.
[3] Impacts that arise indirectly from activities not explicitly forming part of the Project.
[4] Secondary or induced impacts caused by a change in the Project environment.
[5] Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.
[6] The definitions given are for guidance only, and not all the definitions will apply to all the environmental receptors and resources being assessed. Impact significance was assessed with and without mitigation measures in place.

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Probability of Occurrence (P) The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation	Improbable	Low Probability	Probable	Highly Probability	Definite
Significance (S) is determined by combining the above criteria in the following formula:	$[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$				
IMPACT SIGNIFICANCE RATING					
Total Score	**4 to 15**	**16 to 30**	**31 to 60**	**61 to 80**	**81 to 100**
Environmental Significance Rating (Negative (-))	**Very low**	**Low**	**Moderate**	**High**	**Very High**
Environmental Significance Rating (Positive (+))	**Very low**	**Low**	**Moderate**	**High**	**Very High**

10.1.1. IMPACT MITIGATION

The impact significance without mitigation measures will be assessed with the design controls in place. Impacts without mitigation measures in place are not representative of the proposed development's actual extent of impact and are included to facilitate understanding of how and why mitigation measures were identified. The residual impact is what remains following the application of mitigation and management measures and is thus the final level of impact associated with the development. Residual impacts also serve as the focus of management and monitoring activities during Project implementation to verify that actual impacts are the same as those predicted in this report.

The mitigation measures chosen are based on the mitigation sequence/hierarchy which allows for consideration of five (5) different levels, which include avoid/prevent, minimise, rehabilitate/restore, offset and no-go in that order. The idea is that when project impacts are considered, the first option should be to avoid or prevent the impacts from occurring in the first place if possible, however, this is not always feasible. If this is not attainable, the impacts can be allowed, however they must be minimised as far as possible by considering reducing the footprint of the development for example so that little damage is encountered. If impacts are unavoidable, the next goal is to rehabilitate or restore the areas impacted back to their original form after project completion. Offsets are then considered if all the other measures described above fail to remedy high/significant residual negative impacts. If no offsets can be achieved on a potential impact, which results in full destruction of any ecosystem for example, the no-go option is considered so that another activity or location is considered in place of the original plan.

The mitigation sequence/hierarchy is shown in **Figure B-1** below.

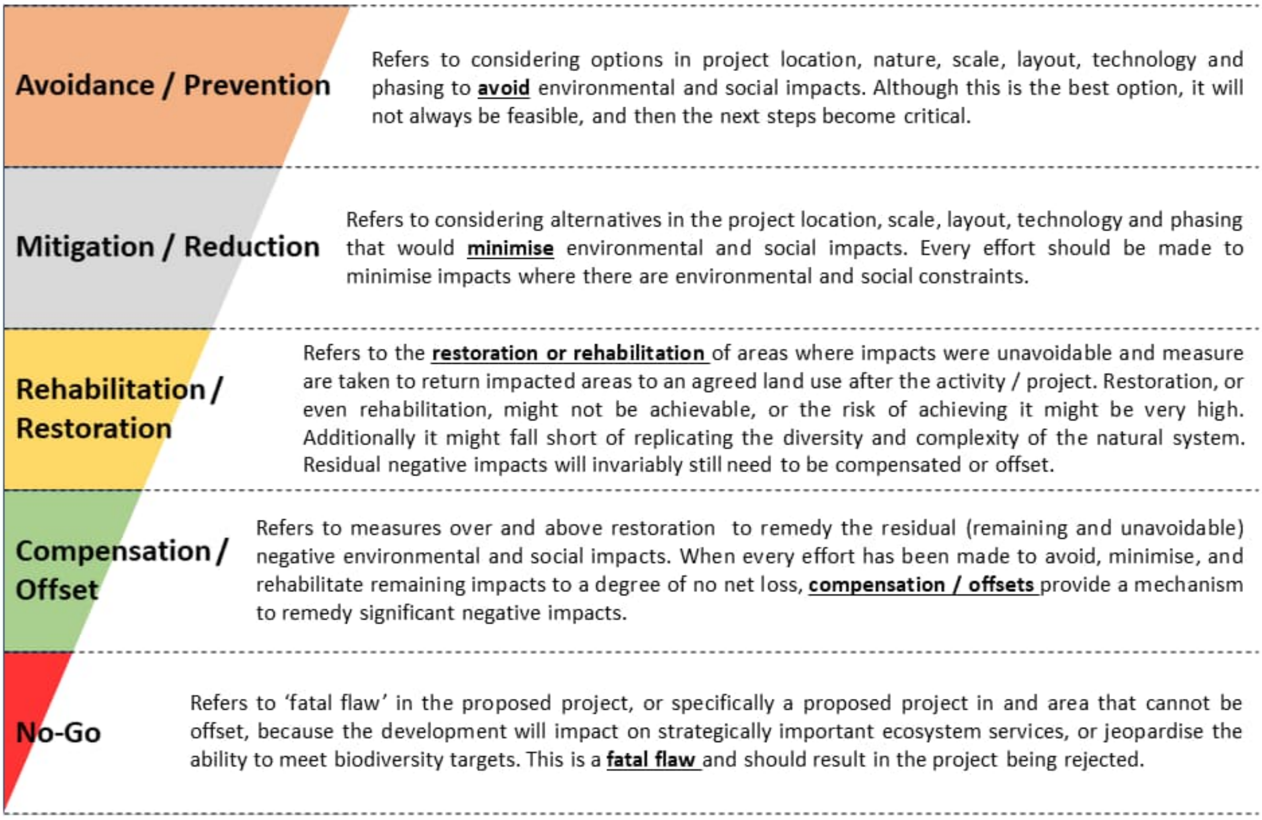

Figure B-1 - Mitigation Sequence/Hierarchy

Building 1, Maxwell Office Park
Magwa Crescent West, Waterfall City
Midrand, 1685
South Africa

wsp.com