MARSHALL DAY Acoustics

WATTA WELLA RENEWABLE ENERGY PROJECT
ENVIRONMENTAL NOISE ASSESSMENT

Rp 001 20200098 | 8 July 2022

6 Gipps Street
Collingwood VIC 3066
Australia
T: +613 9416 1855
ABN: 53 470 077 191
www.marshallday.com

Project:	**Watta Wella Renewable Energy Project Environmental Noise Assessment**
Prepared for:	**RES Australia Pty Ltd Suite 6.01 Level 6, 165 Walker Street North Sydney NSW 2060**
Attention:	**Nathan Kelly**
Report No.:	**Rp 001 20200098**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Final	-	Issued	8 July 2022	C. Delaire C. Guzik	B. Wilson J. Adcock C. Delaire

EXECUTIVE SUMMARY

This report presents the results of an assessment of environmental noise associated with the Watta Wella Renewable Energy Project that is proposed to be developed by RES Australia Pty Ltd.

The assessment is based on the proposed renewable energy project comprising a wind component, solar farm, battery energy storage system and related infrastructure.

The wind component assessment is based on a forty-four (44) multi-megawatt turbine layout, whilst the Environment Effects Statement (EES) referral considered a layout with 47 turbines. The assessment will be updated post-referral decision and prior to planning submission to reflect the final design.

The planning application for the renewable energy project seeks permission to develop turbines with a maximum tip height of 255 m. The actual turbine which would be used at the site would be determined at a later stage in the project, after the project has been granted planning approval. The final selection would be based on a range of design requirements including achieving compliance with the planning permit noise limits at surrounding noise sensitive locations (receivers). In advance of a final selection, the assessment considers a candidate turbine model that is representative of the size and type of turbine which could be used at the site. For this purpose, the Vestas V162-5.6MW with a nominal hub height of 166 m and rotor diameter of 162 m, has been nominated by the proponent for this assessment.

Operational noise from the proposed wind turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the Victorian Government's *Development of Wind Energy Facilities in Victoria - Policy and Planning Guidelines*, November 2021.

The operational wind turbine noise assessment considers base noise limits determined in accordance with NZS 6808, accounting for the land zoning of the area.

Manufacturer specification data provided by the proponent for the candidate turbine model has been used as the basis for the assessment. This specification provides noise emission data in accordance with the international standard referenced in NZS 6808. The noise emission data used is consistent with the range of values expected for comparable types of multi megawatt wind turbine models that are being considered for the site.

The noise emission data has been used with international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* to predict the level of noise expected to occur at neighbouring receivers. The ISO 9613-2 standard has been applied using well-established input choices and adjustments, based on research and international guidance, that are specific to wind turbine noise assessments.

The results of the noise modelling and the proposed layout provided for the Watta Wella Renewable Energy Project demonstrate that the predicted noise levels for the proposed turbine layout and candidate turbine models achieve the base (minimum) noise limits determined in accordance with NZS 6808 at all neighbouring receivers.

The noise limits determined in accordance with NZS 6808 apply to the total combined operational wind turbine noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore also considered the operational Bulgana Green Power Hub (BGPH), adjacent to the south of Watta Wella Renewable Energy Project. An assessment of the predicted noise levels for the BGPH has demonstrated that cumulative wind turbine noise levels do not affect the compliance outcomes for either of the projects.

The assessment has also considered operational noise of infrastructure associated with the renewable energy project (i.e. substation and battery energy storage system) to be located to the southeast of the site. Noise levels from the related infrastructure have been assessed in accordance with Victorian EPA Publication 1826.2 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (the Noise Protocol). The assessment demonstrates that the related

infrastructure can be designed and operated to achieve the recommended levels determined in accordance with the Noise Protocol.

The noise assessment therefore demonstrates that the proposed Watta Wella Renewable Energy Project is able to be designed and developed to achieve the Victorian policy requirements.

MARSHALL DAY Acoustics

TABLE OF CONTENTS

1.0 INTRODUCTION

RES Australia Pty Ltd (RES) is proposing to develop the Watta Wella Renewable Energy Project within the Victorian local government area of the Northern Grampians Shire Council, approximately 12 km northeast of Stawell and 18 km west of Landsborough.

The proposed renewable energy project comprises a wind component, solar farm, battery energy storage system and related infrastructure.

Throughout this report, the term 'renewable energy project' refers to both the wind turbines and the related infrastructure.

This report presents the results of an assessment of operational noise associated with the wind component, undertaken in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the *Environment Protection Regulations 2021* (the EP Regulations) and the Victorian Department of Environment, Land, Water and Planning publication *Policy and planning guidelines for development of wind energy facilities in Victoria*, November 2021 (the Victorian Wind Energy Guidelines).

Noise associated with operation of the proposed related infrastructure associated with the renewable energy project has been assessed in accordance with EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* dated May 2021 (Noise Protocol), as required by the EP Regulations.

The noise assessment presented in this report is based on:

- Operational base noise limits determined in accordance with NZS 6808 and the Noise Protocol, accounting for local land zoning;
- Predicted noise levels for the proposed Watta Wella Renewable Energy Project turbines, based on the proposed site layout and a candidate turbine model that is representative of the size and type of turbine that the planning application seeks consent for;
- Predicted noise levels from the operational Bulgana Green Power Hub, adjacent to the south of the project, to assess potential cumulative effects;
- Predicted noise levels for the proposed related infrastructure, based on empirical noise emission data; and
- A comparison of the predicted noise levels with the applicable base noise limits determined in accordance with NZS 6808 and the noise limits defined by the Noise Protocol.

Acoustic terminology used in this report is presented in Appendix A.

2.0 PROJECT DESCRIPTION

The wind component of the Watta Wella Renewable Energy Project is based on a forty-four (44) multi-megawatt turbine layout, whilst the Environment Effects Statement (EES) referral considered a layout with 47 turbines. The assessment will be updated post-referral decision and prior to planning submission to reflect the final design.

The coordinates of the proposed wind turbines are tabulated in Appendix B.

RES is seeking consent for wind turbines with a maximum tip height of 255 m. The Vestas V162-5.6MW, with a rotor diameter of 162 m and a power output of 5.6 MW, has been selected as the candidate turbine model for this assessment. Further details of the candidate turbine model are presented in Section 6.1.

A total of fifty-four (54) noise sensitive locations (referred to as *receivers* herein) located within 3 km of the proposed turbines have been considered in this noise assessment. This includes eleven (11) host landholders (referred to as *stakeholder receivers* herein).

Related infrastructure associated with the project, including a solar farm, battery energy storage system (BESS) and a substation, is also proposed to be located to the southeast of the site.

The coordinates of the receivers are tabulated in Appendix C.

A site layout plan illustrating the turbine layout, related infrastructure and receivers is provided in Appendix D.

3.0 VICTORIAN POLICY & GUIDELINES

The following publications are relevant to the assessment of operational noise from proposed wind farm developments in Victoria:

- *Environment Protection Act 2017*
- *Environment Protection Regulations 2021*
- Victorian Department of Environment, Land, Water and Planning publication *Policy and planning guidelines for development of wind energy facilities in Victoria,* November 2021
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise*
- EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol) dated May 2021.

Details of the guidance and noise criteria provided by these publications are provided below.

3.1 Environment Protection Act 2017

The *Environment Protection Act 2017* (the EP Act) provides the overarching legislative framework for the protection of the environment in Victoria.

The EP Act establishes a general environmental duty to minimise the risks of harm to human health or the environment from pollution or waste, including noise related amenity impacts, so far as reasonably practicable.

The EP Act also prohibits the emission of unreasonable noise from commercial and industrial trade premises. Specifically, the EP Act states that:

> *A person must not, from a place or premises that are not residential premises—*
>
> *(a) emit an unreasonable noise; or*
>
> *(b) permit an unreasonable noise to be emitted*

Under the EP Act, unreasonable noise means noise that:

> *(a) is unreasonable having regard to the following—*
>
> > *(i) its volume, intensity or duration;*
> >
> > *(ii) its character;*
> >
> > *(iii) the time, place and other circumstances in which it is emitted;*
> >
> > *(iv) how often it is emitted;*
> >
> > *(v) any prescribed factors; or*
>
> *(b) is prescribed to be unreasonable noise:*

Further information about noises that are prescribed to be unreasonable are separately defined in regulations made under the EP Act (see next section).

3.2 Environment Protection Regulations 2021

The *Environment Protection Regulations 2021* (the EP Regulations) give effect to the EP Act by establishing prescriptive requirements for a range of environmental considerations including noise.

The noise requirements are defined according to the type of noise generating activity under consideration, and include definitions such as the types of noise sensitive areas where these requirements apply and assessment time periods.

3.2.1 Wind turbine noise

Part 5.3 Division 5 of the EP Regulations nominates NZS 6808 as the relevant standard for assessing operational wind turbine noise in Victoria and introduces additional measures to demonstrate compliance post-construction.

Specifically, the EP Regulations outline the following:

- Noise agreements

  An owner or operator of a wind energy facility may enter into a written agreement with a relevant landowner to modify the noise limits which apply at the premises of the relevant landowner. These locations are referred to as ‘involved receivers’.

  If a noise agreement is made after 1 November 2021, an increased base noise limit of 45 dB L_{A90} would apply. If a noise agreement was made prior to 1 November 2021, the noise limit can be modified as specified in the noise agreement.

- Wind energy facility operators’ duties

  The duties of wind energy facility operators comprise ensuring compliance with NZS 6808 and a suite of actions to manage and monitor noise from the wind farm, as prescribed in Regulation 131C.

  Providing that the operator of a wind farm complies with the requirements of Regulation 131C, their duty with respect to the general environmental duty under the EP Act has been addressed.

In accordance with the EP Regulations, noise levels from a wind farm are prescribed to be *unreasonable* for the purposes of the EP Act, if they exceed the relevant applicable noise limits.

3.2.2 Industry noise

In relation to noise from commercial, industrial and trade premises (industry), the EP Regulations specify that the prediction, measurement, assessment or analysis of noise within a noise sensitive area must be conducted in accordance with the Noise Protocol (see Section 3.5). Noise from industry is prescribed by the EP Regulations to be unreasonable for the purposes of the EP Act if it exceeds a noise limit or alternative assessment criterion determined in accordance with the Noise Protocol.

3.3 Victorian Wind Energy Guidelines

The Victorian Department of Environment, Land, Water and Planning *Policy and planning guidelines for development of wind energy facilities in Victoria,* November 2021 (Victorian Wind Energy Guidelines) provide advice to responsible authorities, proponents and the community about suitable sites to locate wind energy facilities and to inform planning decisions about a wind energy facility proposal.

The stated purpose of the Victorian Wind Energy Guidelines is to set out:

- *a framework to provide a consistent and balanced approach to the assessment of wind energy projects across the state*
- *a set of consistent operational performance standards to inform the assessment and operation of a wind energy facility project*
- *guidance as to how planning permit application requirements might be met; and*
- *a framework for the regulation of wind turbine noise.*

Section 5 of the Victorian Wind Energy Guidelines outlines the key criteria for evaluating the planning merits of a wind energy facility. Section 5.1.2 details information relating to the amenity of areas surrounding a wind farm development, including information relating to noise levels. In particular, it provides the following guidance for the assessment of noise levels for proposed new wind farm developments:

> *A wind energy facility must comply with the noise limits in the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (the Standard).* […]
>
> *The Standard specifies a general 40 decibel limit (40 dB $L_{A90(10min)}$) for wind energy facility sound levels outdoors at noise sensitive locations, or that the sound level should not exceed the background sound level by more than five decibels (referred to as 'background sound level +5 dB'), whichever is the greater.* […]
>
> *Under Section 5.3 of the Standard, a 'high amenity noise limit' of 35 decibels may be justified in special circumstances. All wind energy facility applications must be assessed using Section 5.3 of the Standard to determine whether a high amenity noise limit is justified for specific locations, following procedures outlined in 5.3.1 of the Standard. Guidance can be found on this issue in the VCAT determination for the Cherry Tree Wind Farm[1].*

Based on the Victorian Wind Energy Guidelines, the environmental noise of proposed new wind farm developments must be assessed in accordance with NZS 6808 at noise sensitive locations, which are defined in Section 5.1.2 of the Victorian Wind Energy Guidelines as follows:

> *Noise sensitive locations are defined in [NZS 6808] as, "The location of a noise sensitive activity, associated with a habitable space or education space in a building not on a wind farm site", and include:*
>
> - *any part of land zoned predominantly for residential use*
> - *residential land uses included in the accommodation group at clause 73.03, Land use terms of the VPP and all planning schemes*
> - *education and child care uses included in the child care centre group and education centre group at clause 73.03 of the of the VPP and all planning schemes.*

1 *Cherry Tree Wind Farm v Mitchell Shire Council* (2013)

Specifically, Clause 73.03 of the Victoria Planning Provisions (VPP) defines *Accommodation* as *land used to accommodate persons* and lists the following uses:

- *Camping and caravan park*
- *Corrective institution*
- *Dependent person's unit*
- *Dwelling*
- *Group accommodation*
- *Host farm*
- *Host farm*
- *Residential aged care facility*
- *Residential building*
- *Residential village*
- *Retirement village*

Consideration must also be given to whether a high amenity noise limit is warranted to reflect special circumstances at specific locations.

3.4 NZS 6808

The New Zealand Standard NZS 6808 provides methods for the prediction, measurement, and assessment of sound from wind turbines. The following sections provide an overview of the objectives of NZS 6808 and the key elements of the standard's assessment procedures.

3.4.1 Objectives

The foreword of NZS 6808 provides guidance about the objectives of the noise criteria outlined within the standard:

> *Wind farm sound may be audible at times at noise sensitive locations, and this Standard does not set limits that provide absolute protection for residents from audible wind farm sound. Guidance is provided on noise limits that are considered reasonable for protecting sleep and amenity from wind farm sound received at noise sensitive locations.*

The *Outcome Statement* of NZS 6808 then goes on to provide information about the objective of the standard in a planning context:

> *This Standard provides suitable methods for the prediction, measurement, and assessment of sound from wind turbines. In the context of the* [New Zealand] *Resource Management Act, application of this Standard will provide reasonable protection of health and amenity at noise sensitive locations.*

Section C1.1 of the standard provides further information about the intent of the standard, which is:

> [...] *to avoid adverse noise effects on people caused by the operation of wind farms while enabling sustainable management of natural wind resources.*

Based on the objectives outlined above, NZS 6808 addresses health and amenity considerations at noise sensitive locations by specifying noise criteria which are to be used to assess wind farm noise.

3.4.2 Noise sensitive locations

The provisions of NZS 6808 are intended to protect noise sensitive locations (also generally referred to as *receivers* herein) that existed before the development of a wind farm. Noise sensitive locations are defined by the Standard as:

> *The location of a noise sensitive activity, associated with a habitable space or education space in a building not on the wind farm site. Noise sensitive locations include:*
>
> *(a) Any part of land zoned predominantly for residential use in a district plan;*
>
> *(b) Any point within the notional boundary of buildings containing spaces defined in (c) to (f);*
>
> *(c) Any habitable space in a residential building including rest homes or groups of buildings for the elderly or people with disabilities …*
>
> *(d) Teaching areas and sleeping rooms in educational institutions …*
>
> *(e) Teaching areas and sleeping rooms in buildings for licensed kindergartens, childcare, and day-care centres; and*
>
> *(f) Temporary accommodation including in hotels, motels, hostels, halls of residence, boarding houses, and guest houses.*
>
> *In some instances holiday cabins and camping grounds might be considered as noise sensitive locations. Matters to be considered include whether it is an established activity with existing rights.*

For the purposes of an assessment according to the Standard, the notional boundary is defined as:

> *A line 20 metres from any side of a dwelling or other building used for a noise sensitive activity or the legal boundary where this is closer to such a building.*

NZS 6808 was prepared to provide methods of assessment in the statutory context of New Zealand. Specifically, NZS 6808 notes that in the context of the New Zealand Resource Management Act, application of the Standard will provide reasonable protection of health and amenity at noise sensitive locations. This is an important point of context, as the New Zealand Resource Act states:

> *(3)(a)(ii): A consent authority must not, when considering an application, have regard to any effect on a person who has given written approval to the application.*

Based on the above definitions and statutory context, noise predictions are normally prepared for stakeholder receivers irrespective of whether they are inside or outside of the project boundary. However, the noise limits specified in the Standard are not applied to these locations on account of their participation with the project.

3.4.3 Noise limit

Section 5.2 *Noise limit* of NZS 6808 defines acceptable noise limits as follows:

> *As a guide to the limits of acceptability at a noise sensitive location, at any wind speed wind farm sound levels ($L_{A90(10\,min)}$) should not exceed the background sound level by more than 5 dB, or a level of 40 dB $L_{A90(10\,min)}$, whichever is the greater.*

This arrangement of limits requires the noise associated with a wind farm to be restricted to a permissible margin above background noise, except in instances when both the background and source noise levels are low. In this respect, the criteria indicate that it is not necessary to continue to adhere to a margin above background when the background noise levels are below the range of 30-35 dB.

The criteria specified in NZS 6808 apply to the combined noise level of all wind farms influencing the environment at a receiver. Specifically, section 5.6.1 states:

> *The noise limits* […]*should apply to the cumulative sound level of all wind farms affecting any noise sensitive location.*

3.4.4 High amenity

Section 5.3.1 of NZS 6808 states that the base noise limit of 40 dB L_{A90} detailed in Section 3.4.3 above is "*appropriate for protection of sleep, health, and amenity of residents at most noise sensitive locations*.". It goes on to note that the application of a high amenity noise limit may require additional consideration:

> […] *In special circumstances at some noise sensitive locations a more stringent noise limit may be justified to afford a greater degree of protection of amenity during evening and night-time. A high amenity noise limit should be considered where a plan promotes a higher degree of protection of amenity related to the sound environment of a particular area, for example where evening and night-time noise limits in the plan for general sound sources are more stringent than 40 dB* $L_{Aeq(15\ min)}$ *or 40 dBA* L_{10}*. A high amenity noise limit should not be applied in any location where background sound levels, assessed in accordance with section 7, are already affected by other specific sources, such as road traffic sound.*

The definition of the high amenity noise limit provided in NZS 6808 is specific to New Zealand planning legislation and guidelines. A degree of interpretation is therefore required when determining how to apply the concept of high amenity in Victoria.

In accordance with Section 5.3 of NZS 6808, if a high amenity noise limit is justified, wind farm noise levels (L_{A90}) during evening and nigh-time periods should not exceed the background noise level (L_{A90}) by more than 5 dB or 35 dB L_{A90}, whichever is the greater. The standard recommends that this reduced noise limit would typically apply for wind speeds below 6 m/s at hub height. A high amenity noise limit is not applicable during the daytime period.

The method for assessing the applicability of the high amenity noise limit, detailed in NZS 6808, is a two-step approach as follows:

1. Determination of whether the planning guidance for the area warrants consideration of a high amenity noise limit.

   First and foremost, for a high amenity noise limit to be considered, the land zoning of a receiver location must promote a higher degree of acoustic amenity.

2. Evaluation of whether a high amenity noise limit is justified.

   Following the guidance presented in C5.3.1, if the planning guidance for the area warrants consideration of a high amenity noise limit, and the receiver location is located within the 35 dB L_{A90} noise contour, then a calculation should be undertaken to determine whether background noise levels are sufficiently low.

3.4.5 Special audible characteristics

Section 5.4.2 of NZS 6808 requires the following:

> *Wind turbine sound levels with special audible characteristics (such as tonality, impulsiveness and amplitude modulation) shall be adjusted by arithmetically adding up to +6dB to the measured level at the noise sensitive location.*

Notwithstanding this, the standard requires that wind farms be designed with no special audible characteristics at nearby residential properties while concurrently noting in Section 5.4.1 that:

> […] *as special audible characteristics cannot always be predicted, consideration shall be given to whether there are any special audible characteristics of the wind farm sound when comparing measured levels with noise limits.*

NZS 6808 emphasises assessment of special audible characteristics during the post-construction measurement phase of a project. An indication of the potential for tonality to be a characteristic of the noise emission from the assessed turbine model is sometimes available from tonality audibility assessments conducted as part of manufacturer turbine noise emission testing. However, this data is frequently not available at the planning stage of an assessment.

3.5 Noise Protocol

EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol) sets noise limits that apply to commercial, industrial and trade premises and entertainment venues in Victoria. Compliance with the noise limits is mandatory under the EP Act.

The proposed transformer station is considered a 'commercial, industrial and trade premises' under the EP Act.

The Noise Protocol prescribes noise limits and the procedures to be used for an assessment of compliance.

The noise limits apply at a 'noise sensitive area', which is defined in Section 4 of the EP Regulations as being *within 10 metres of the outside of the external walls* of buildings including dwellings, hotels, schools and campgrounds.

The procedures for setting noise limits are defined separately for urban and rural areas. However, in both cases, the noise limits are defined by considering the land zoning in the area and the noise environment of the receiver. The noise limits are defined separately for day, evening and night periods.

In contrast to NZS 6808 and Part 5.3 Division 5 of the EP Regulations, the Noise Protocol does not differentiate between involved and non-involved receivers.

The measurement and analysis procedures outlined in the Noise Protocol include adjustments which are to be applied to noise that is characterised by audible tones, impulses or intermittency. Further details of the noise limits applicable to this project are provided in Section 7.1 of this report.

4.0 ASSESSMENT METHOD

4.1 Overview

Based on the policies and guidelines outlined in Section 3.0, assessing the operational noise levels of a proposed wind farm (including the turbines and the related infrastructure) involves:

- assessing background noise levels at noise sensitive locations around the project;
- assessing the land zoning of the project site and surrounding areas;
- establishing suitable noise criteria accounting for background noise levels and land zoning;
- predicting the level of noise expected to occur as a result of the proposed turbines and related infrastructure; and
- assessing whether the development can achieve the requirements of Victorian policy and guidelines by comparing the predicted noise levels to the noise criteria; and
- recommending reasonably practicable measures to minimise the risk of noise impact.

4.2 Background noise levels

Background noise level information is used to inform the setting of limits for both the related infrastructure and the wind turbine components of a wind farm project. However, in rural areas where wind farms are typically developed, the background noise level data is most relevant to the assessment of the wind turbines. This is due to the need to consider the changes in background noise levels and wind turbine noise levels for different wind conditions.

In accordance with the Victorian Wind Energy Guidelines and NZS 6808, background noise level information is used for setting noise limits for the wind turbine component of a wind farm project.

The procedures for determining background noise levels are defined in NZS 6808. The first step in assessing background noise levels involves determining whether background noise measurements are warranted. For this purpose, Section 7.1.4 of the standard provides the following guidance:

> *Background sound level measurements and subsequent analysis to define the relative noise limits should be carried out where wind farm sound levels of 35 dB $L_{A90(10\ min)}$ or higher are predicted for noise sensitive locations, when the wind turbines are at 95% rated power. If there are no noise sensitive locations within the 35 dB $L_{A90(10\ min)}$ predicted wind farm sound level contour then background sound level measurements are not required.*

The initial stage of a background noise monitoring program in accordance with NZS 6808 therefore comprises:

- Preliminary wind turbine noise predictions to identify all receivers where predicted noise levels are higher than 35 dB L_{A90}
- Identification of selected receivers where background noise monitoring should be undertaken prior to development of the wind farm, if required.

If required, the surveys involve measurements of background noise levels at receivers, and simultaneous measurement of wind speeds at the site of the proposed wind farm. The survey typically extends over a period of several weeks to enable a range of wind speeds and directions to be measured.

The results of the survey are then analysed to determine the trend between the background noise levels and site wind speeds at the proposed hub height of the turbines. This trend defines the value of the background noise for the different wind speeds in which the turbines will operate. At the wind speeds when the background noise level is above 35 dB L_{A90} (or 30 dB L_{A90} in special circumstances where high amenity limits apply), the background noise levels are used to set the noise limits for the wind farm.

4.3 Noise predictions

Operational noise levels from the renewable energy project (wind turbines and related infrastructure) are predicted using:

- Noise emission data for the wind turbines and related infrastructure
- A 3D digital model of the site and the surrounding environment
- International standards used for the calculation of environmental sound propagation.

The method selected to predict noise levels is International Standard ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). The prediction method is consistent with the guidance provided by NZS 6808 and has been shown to provide a reliable method of predicting the typical upper levels of the wind turbine noise expected to occur in practice.

The method is generally applied in a comparable manner to both wind turbine and transformer station noise levels. For example, for both types of sources, equivalent ground and atmospheric conditions are used for the calculations. However, when applied to wind turbine noise, additional and specific input choices apply, as detailed below.

Key elements of the noise prediction method are summarised in Table 1. Further discussion of the method and the calculation choices is provided in Appendix G.

Table 1: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.2
Method	International Standard ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (the UK Institute of Acoustics guidance). The adjustments are applied within the SoundPLAN modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below and are discussed in Appendix G.

Detail	Description
Source characterisation	Each source of operational noise is modelled as a point source of sound. The total sound of the component of the renewable energy project being modelled (i.e. the wind turbines or the related infrastructure) is then calculated on the basis of simultaneous operation of all elements (e.g. all wind turbines) and summing the contribution of each. To model the turbine components of the renewable energy project, the following specific procedures are noted: • Calculations of turbine to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the turbine. • Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each turbine. Further discussion of terrain screening effects is provided below.
Terrain data	10 m resolution elevation data, provided by the proponent
Terrain effects (turbine-specific procedures)	Adjustments for the effects of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix G. • Valley effects: + 3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the turbine and calculation point is 50 % greater than would occur if the ground were flat. • Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the turbine and the calculation point. The value of the screening effect is limited to a maximum value of 2 dB. For reference purposes, the ground elevations at the turbine and receivers are tabled in Appendix B and Appendix C respectively. The topography of the site is depicted in the elevation map provided in Appendix E.
Ground conditions	Ground factor of G = 0.5 on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix G. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10 ^{o}C and relative humidity 70 % These represent conditions which result in relatively low levels of atmospheric sound absorption. The calculations are based on sound speed profiles[2] which increase the propagation of sound from each turbine to each receiver location, whether as a result of thermal inversions or wind directed toward each calculation point.

[2] The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

Detail	Description
Receiver heights	1.5 m above ground level It is noted that the UK Institute of Acoustics guidance refers to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which results in lower noise levels. However, importantly, predictions in Australia do not generally subtract a margin recommended by the UK Institute of Acoustics guidance to account for differences between L_{Aeq} and L_{A90} noise levels (this is consistent with NZS 6808 which indicates that predicted L_{Aeq} levels should be taken as the predicted L_{A90} sound level of the wind turbines). The magnitude of these differences is comparable and therefore balance each other out to provide similar predicted noise levels.

5.0 EXISTING NOISE ENVIRONMENT

The results of preliminary noise modelling of the site indicated only one receiver where predicted noise levels were higher than 35 dB L_{A90}, and this receiver (376) is a stakeholder. Therefore, in accordance with NZS 6808, background noise monitoring is not required to be undertaken.

However, RES elected to commission a survey of background noise levels at a broader range of locations than was strictly required by NZS 6808. The objective of the noise monitoring was to obtain data that would assist with providing context to the predicted noise levels of the proposed wind farm. Accordingly, monitoring was undertaken between 15 July to 20 September 2021 at four (4) locations.

The noise monitoring, analysis procedures and results are detailed in the Background Noise Report[3].

The data presented in Table 2 and Table 3 and summarises the background noise levels determined in accordance with NZS 6808 for the all-time and night-time periods respective.

The data in these tables is provided for the key wind speeds relevant to the assessment of wind farm noise. The results for all surveyed wind speeds are illustrated in the graphical data provided for each receiver in the appendices of the Background Noise Report.

Table 2: Background noise levels, dB L_{A90} - All-time period

Location	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
376*	28.0	28.6	29.4	30.2	31.1	32.0	33.0	34.1	35.1	36.2	37.2	38.3	39.3
422	30.6	31.5	32.4	33.2	34.0	34.7	35.3	36.0	36.6	37.1	37.6	38.1	38.5
404	29.2	29.4	29.8	30.3	30.8	31.5	32.2	33.0	33.8	34.6	35.5	36.4	37.3
412	26.3	27.3	28.2	29.2	30.2	31.2	32.2	33.1	33.9	34.7	35.4	35.9	36.3

Note 1: 166 m above ground level at 672316 E, 5904979 N (MGA 94 Zone 54)

* Involved receiver

Table 3: Background noise levels, dB L_{A90} - Night period

Location	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
376*	25.1	25.7	26.3	27.0	27.8	28.6	29.5	30.5	31.5	32.7	33.9	35.1	36.5
422	29.2	29.6	29.9	30.2	30.5	30.9	31.3	31.7	32.2	32.7	33.4	34.1	34.9
404	28.5	28.1	27.8	27.7	27.7	27.9	28.2	28.7	29.4	30.2	31.2	32.3	33.7
412	23.6	24.9	26.0	27.0	27.8	28.6	29.3	30.0	30.6	31.1	31.6	32.1	32.6

Note 1: 166 m above ground level at 672316 E, 5904979 N (MGA 94 Zone 54)

* Involved receiver

3 MDA Report Rp 002 02Draft 20200098 *Watta Wella Renewable Energy Project - Background noise monitoring*, dated 14 June 2022

6.0 WIND TURBINE ASSESSMENT

6.1 Noise limits

6.1.1 High amenity

In accordance with NZS 6808, an assessment is required for all receivers located within the predicted 35 dB L_{A90} contour to determine whether a high amenity noise limit may be justified. As detailed in Section 3.4.4, this is based on a two-step approach comprising:

1. A land zoning review to determine whether the planning guidance for the area warrants consideration of a high amenity noise limit. If it does, then the second step should be considered;
2. A review of the relationship between the background noise levels and predicted noise levels, using the calculation set out in clause C5.3.1.

Based on the predicted noise level contours presented subsequently in Section 6.4, and the zoning map for the area presented in Appendix F, the area within the predicted 35 dB L_{A90} contour is identified as Farming Zone. In addition, as discussed in Section 5.0, all non-involved receivers are located outside the predicted 35 dB L_{A90} contour.

Following guidance from the VCAT determination for the Cherry Tree Wind Farm, as required by the Victorian Wind Energy Guidelines, the areas within the Farming Zone do not warrant consideration of the high amenity noise limit.

Based on the above, the high amenity noise limit is not justified for the proposed Watta Wella Renewable Energy Project.

6.1.2 Stakeholder receivers

The definition of noise sensitive locations in NZS 6808 specifically excludes dwellings located within a wind farm site boundary. The discussion earlier in this report in Section 3.4.2, also provides details of the statutory context of NZS 6808 and indicates the method is not intended to be applied to noise sensitive locations outside the site boundary where a noise agreement exists between the occupants and the proponent of the development.

However, consistent with the Victorian Wind Energy Guidelines, Regulation 131B of the EP Regulations specifies a noise limit for involved receivers of 45 dB L_{A90} or background noise (L_{A90}) + 5 dB, whichever is the greater, where a noise agreement between the owner or operator of a wind energy facility and a landowner is made on or after 1 November 2021.

Where an agreement is in place, RES has set a limit of 45 dB or background + 5dB, whichever is higher for participating landowners.

6.1.3 Applicable noise limits

Accounting for the conclusions of the assessment of high amenity detailed in the previous section, the applicable noise limits are detailed in Table 4.

Table 4: Applicable noise limits, dB L_{A90}

Receiver status	Noise limit
Non-involved	40 dB or background L_{A90} + 5 dB, whichever is the greater
Involved	45 dB or background L_{A90} + 5 dB, whichever is the greater

Applicable noise limits based on the background noise levels presented in Section 5.0 are summarised in Table 5 and Table 6.

Table 5: All-hours period operational wind farm noise limits, dB L_{A90} – All-time period

Location	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
376*	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
422	40.0	40.0	40.0	40.0	40.0	40.0	40.3	41.0	41.6	42.1	42.6	43.1	43.5
404	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.5	41.4	42.3
412	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.4	40.9	41.3

Note 1: 166 m above ground level at 672316 E, 5904979 N (MGA 94 Zone 54)

* Involved receiver

Table 6: All-hours period operational wind farm noise limits, dB L_{A90} – Night period

Location	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
376*	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
422	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
404	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
412	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0

Note 1: 166 m above ground level at 672316 E, 5904979 N (MGA 94 Zone 54)

* Involved receiver

6.2 Wind turbine model

The final turbine model for the site would be selected after a tender process to procure the supply of turbines. The final selection would be based on a range of design requirements including achieving compliance with the planning permit noise limits at surrounding receivers.

Accordingly, to assess the proposed wind turbines at this stage in the project, it is necessary to consider a candidate turbine model that is representative of the size and type of turbines being considered. The purpose of the candidate turbine is to assess the viability of achieving compliance with the applicable noise limits, based on noise emission levels that are typical of the size of turbines being considered for the site.

For this assessment, the proponent has nominated the Vestas V162-5.6MW as the candidate turbine model.

This model is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the turbines being regulated by control systems which vary the pitch of the turbine blades (the angular orientation of the blade relative to its axis).

This assessment has been based on the turbine using unconstrained generation modes (i.e. no noise reduced operating modes) and with blade serrations. Blade serrations are now routinely used to reduce wind turbine noise emissions, and it is understood that their use is now the market standard for turbines being offered in the Australian market.

Details of the assessed candidate wind turbine are provided in Table 7.

Table 7: Selected candidate wind turbine model

Detail	V162-5.6MW
Make	Vestas
Rotor diameter	162 m
Hub height	166 m
Operating mode	Mode 0[1]
Rated power	5.6 MW
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	12 m/s
Cut-out wind speed (hub height)	24 m/s

1 It is our understanding that 'Mode 0' is a manufacturer designation which indicates an unconstrained mode of operation to achieve a power output of 5.6 MW (i.e. without noise curtailment)

The hub height detailed above is suitable for noise assessment purposes. It is our understanding that the final hub height of the selected wind turbine model may differ slightly. However, the magnitude of the potential change is expected to be minor and inconsequential with respect to predicted noise levels.

The final hub height will be used for the pre-construction noise assessment once the turbine layout has been finalised and the final turbine model selected.

6.3 Wind turbine noise emissions

6.3.1 Sound power levels

The noise emissions of the wind turbines are described in terms of the sound power level for different wind speeds. The sound *power* level is a measure of the total sound energy produced by each turbine and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the turbine.

Sound power level data for the candidate turbine models, including sound frequency characteristics, has been sourced from the Vestas document No. 0079-5298_01 *V162-5.6MW - Third octave noise emission*, dated 23 January 2019.

Based on the data sourced from the manufacturer's specification, the noise modelling undertaken for this assessment involved conversion of third octave band level to octave band levels (where applicable), and adjustment by addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The overall A-weighted sound power levels (including the +1 dB addition) as a function of hub height wind speed are presented in Table 8 with the octave band values presented in Table 9. These represent the total noise emissions of the turbine for each sound mode, including the secondary contribution of ancillary plant associated with each turbine (e.g. cooling fans).

Table 8: Sound power levels versus hub height wind speed, dB L_{WA}

	Hub height wind speed m/s								
Turbine	4	5	6	7	8	9	10	11	≥12
V162-5.6MW	94.7	95.3	98.3	101.2	103.9	105.0	105.0	105.0	105.0

Table 9: Octave band sound power levels, dB L_{WA}

	Octave band centre frequency, Hz									
Turbine	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**Total**
V162-5.6MW [1]	76.0	86.4	93.8	98.3	100.1	99.0	94.9	88.2	78.5	105.0

[1] Based on one-third octave band levels at 12 m/s

These sound power levels are also illustrated in Appendix I.

Review of available sound power data for a range of turbine models has shown that there isn't a clear relationship between turbine size or power output and the noise emission characteristics of a given turbine model. In practice, the overall noise emissions of a turbine are dependent on a range of factors, including the turbine size and power output, and other important factors such as the blade design and rotational speed of the turbine. Therefore, while turbine sizes and power ratings of contemporary turbines have increased, the noise emissions of the turbines are comparable to, or lower than, previous generations of turbines as a result of design improvements (notably, measures to reduce the speed of rotation of the turbines, and enhanced blade design features such as serrations for noise control).

6.3.2 Special Audible Characteristics

Special audible characteristics relate to potential tonality, amplitude modulation and impulsiveness of a turbine.

Information concerning potential tonality is often limited at the planning stage of a project, and test data for tonality is presently unavailable for the selected candidate turbine model. However, the occurrence of tonality in the noise of contemporary multi-megawatt turbine designs is unusual. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical.

Amplitude modulation and impulsiveness are not able to be predicted, however the evidence of operational wind farms in Australia indicates that their occurrence is limited and atypical.

Given the above, adjustments for special audible characteristics have not been applied to the predicted noise levels presented in this assessment. Notwithstanding this, the subject of special audible characteristics would be addressed in subsequent assessment stages for the project, following approval of the wind farm, and again following construction of the wind farm.

6.4 Predicted noise levels

This section of the report presents the predicted noise levels of the wind turbine component of the Watta Wella Renewable Energy Project at surrounding receivers.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. However, in the case of wind farm layout design, significant layout modifications may only give rise to fractional changes in the predicted noise level. This is a result of the relatively large number of sources influencing the total predicted noise level, as well as the typical separating distances between the turbine locations and surrounding assessment positions. It is therefore necessary to consider the predicted noise levels at a finer resolution than can be perceived or measured in practice. It is for this reason that the levels presented in this section are reported to one decimal place.

Noise levels from the proposed Watta Wella Renewable Energy Project have been predicted using the sound power level data detailed in Section 6.3.1 for the selected candidate turbine model and are summarised in Table 10 for for the wind speeds which result in the highest predicted noise levels (hub height wind speed ≥12 m/s). Results are presented for receivers where the highest predicted noise levels are greater than or equal to 30 dB L_{A90}.

The locations of the predicted 35 dB and 40 dB L_{A90} noise contours are illustrated in Figure 1, for the wind speed which results in the highest predicted noise levels.

Predicted noise levels for each integer wind speed are tabulated in Appendix H for all considered receivers, including receivers where the highest predicted noise level is below 30 dB L_{A90}.

Table 10: Highest predicted noise level at receivers with predicted levels over 30 dB L_{A90}

Receiver	Predicted level, dB L_{A90}
113	30.0
127 (S)	30.4
337	31.0
339	31.9
343	30.6
344	32.1
346	31.7
348	30.6
350	31.5
351	30.5
367	31.3
369	32.7
376 (S)	37.8
404	34.1
412	31.4
413	31.1
422	32.7
423 (S)	33.1
426	31.5
431	30.2
432	32.4
433	30.1
442	30.8
472 (S)	30.2
478 (S)	31.0
484 (S)	33.1
485 (S)	32.5
486 (S)	32.5
487 (S)	32.2

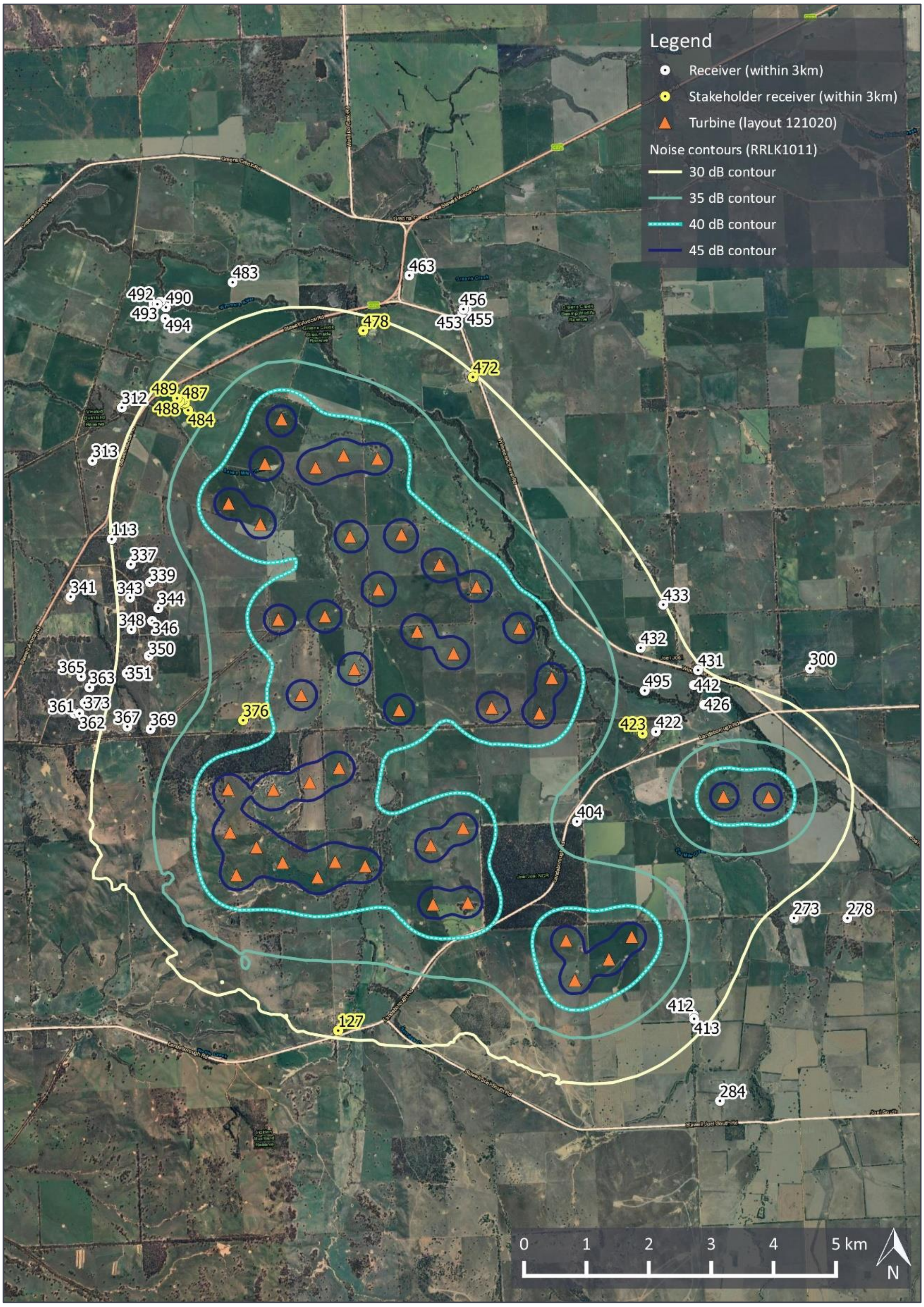
Receiver	Predicted level, dB L_{A90}
488 (S)	32.1
489 (S)	31.8
495	32.8

(S) Stakeholder receiver

The following can be concluded from the predicted noise levels detailed in Table 10:

- Compliance with the applicable base noise limit of 40 dB L_{A90} by at least 5.9 dB at non-involved receivers
- Compliance with the applicable base noise limit of 45 dB L_{A90} by at least 7.2 dB at involved receivers.

Figure 1: Highest predicted noise level contours, dB L_{A90}



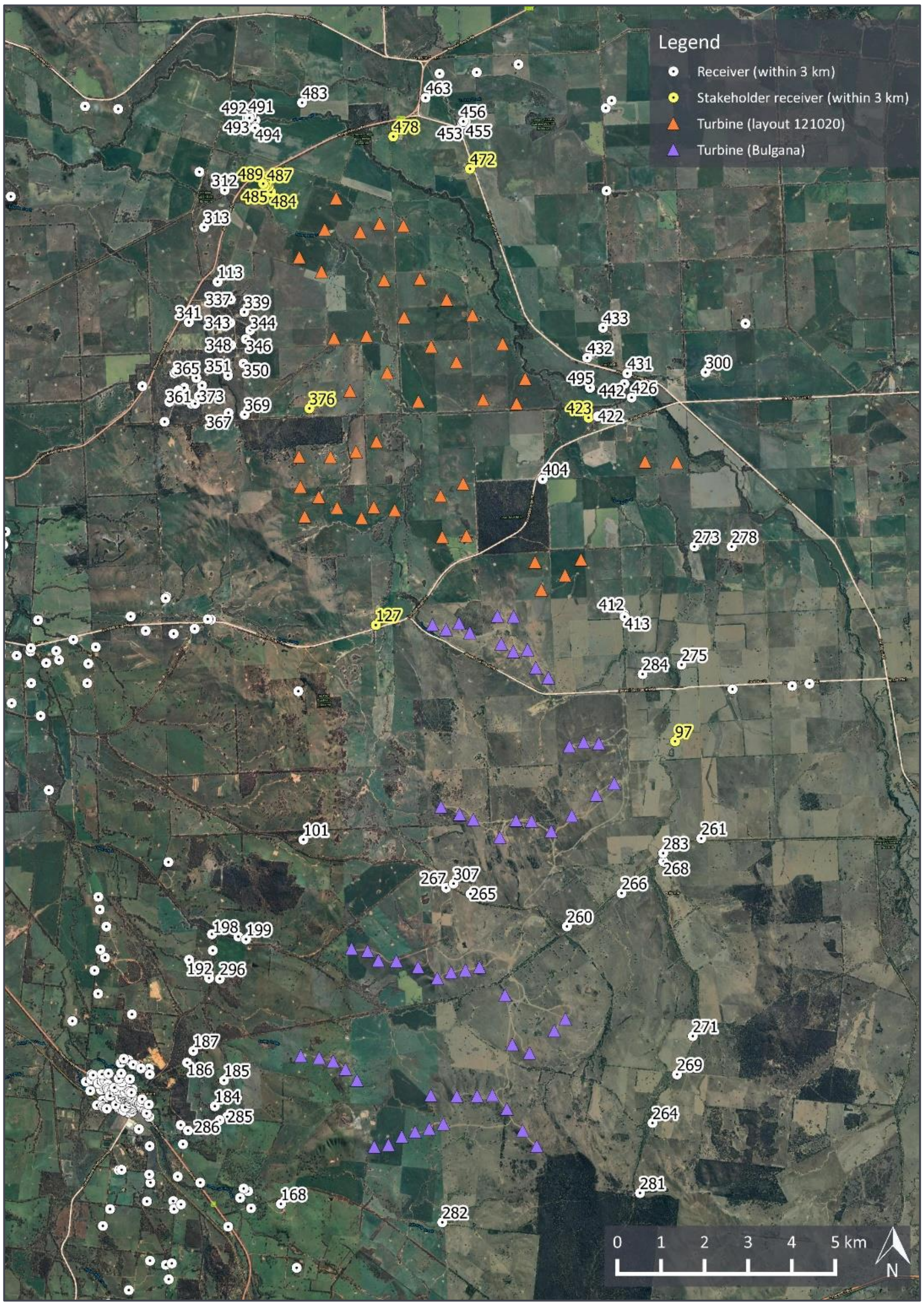
6.5 Cumulative assessment

The noise limits determined in accordance with NZS 6808 apply to the total combined operational wind turbine noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore considered other approved and operational wind farm projects in the surrounding area.

The Bulgana Green Power Hub (BGPH) has been identified adjacent to the south of the proposed Watta Wella Renewable Energy Project for the review of potential cumulative noise considerations. We are not aware of any other permitted or operational wind farm projects within 10 km of the proposed renewable energy project.

A site plan showing the location of the BGPH in relation to the Watta Wella Renewable Energy Project is provided in Figure 2.

Figure 2: Bulgana Green Power Hub and Watta Wella Renewable Energy Project



The BGPH, began operating mid-2021, comprises fifty-six (56) SG3.4-132 wind turbines with a hub height[4] of 114 m. The coordinates of the turbines were provided by RES on 22 November 2020.

Sound power level data for the SG3.4-132 turbine model, including sound frequency characteristics, has been sourced from the Siemens Gamesa Renewable Energy document No. GD287601-en *General Characteristics Manual - SG3.4-132 3.465MW noise spectrum*, dated 17 December 2019.

The predicted cumulative wind turbine noise of the two projects is illustrated as noise contours in Figure 3 for the wind speeds which give rise to the highest noise emissions from each site respectively. These noise contours demonstrate cumulative wind turbine noise levels are predicted below the minimum applicable limit of 40 dB L_{A90} at all receivers, and therefore no change in the predicted compliance outcomes.

Further receiver-specific information on cumulative noise levels is provided in Table 11 for the receivers that are located nearest to both projects (specifically, those receivers that are within 3 km of turbines of both projects). As per the noise contours, the predicted noise level data is provided for the wind speeds which give rise to the highest noise emissions from each site respectively.

Table 11: Cumulative assessment

	Predicted noise level, dB L_{A90}			Change in compliance outcome due to cumulative effects
Receiver	Watta Wella only	BGPH only	Cumulative	
127 (S)	30.4	35.4	36.6	No
284	26.0	34.6	35.2	No
412	31.4	33.4	35.5	No
413	31.1	33.5	35.5	No

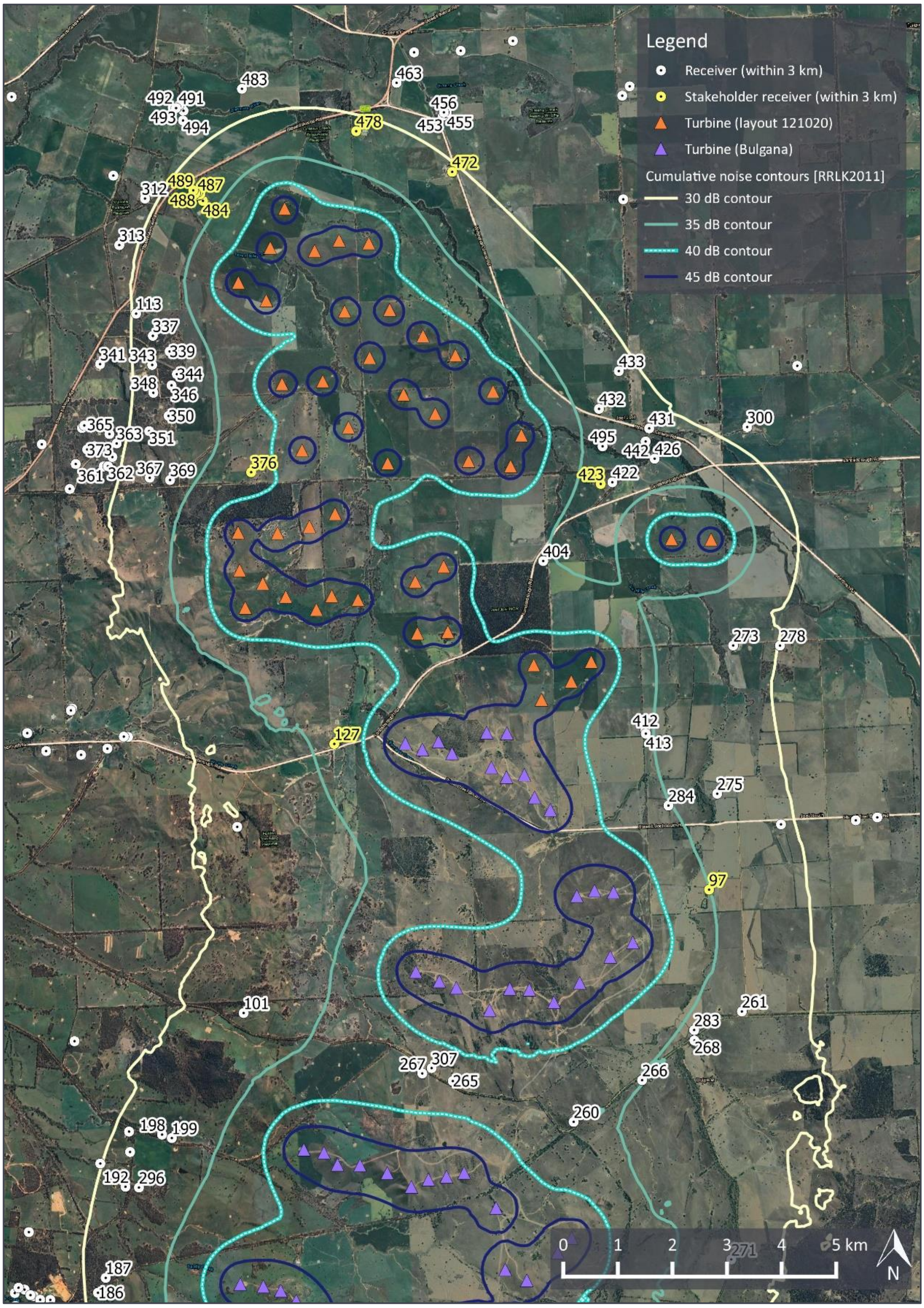
Consistent with the data illustrated in Figure 3, the results in Table 11 demonstrate that the compliance outcome for both the Watta Wella Renewable Energy Project or the BGPH would not be affected by the noise contribution from the other project.

As a further point of context to the predictions, it is noted that the turbine noise levels from each project, including the contours, are predicted on the basis of downwind propagation from each turbine; in most instances where cumulative noise is considered, a noise sensitive receiver cannot be simultaneously downwind of all wind turbines of adjoining projects. The predictions are therefore conservative for the purpose of considering cumulative noise levels.

The predicted noise levels therefore demonstrate that cumulative wind farm noise is not a material consideration for Watta Wella Renewable Energy Project and the BGPH. Specifically, the noise contribution of the BGPH is sufficiently low to be inconsequential to the noise assessment for the Watta Wella Renewable Energy Project. The predicted noise contribution of the Watta Wella Renewable Energy Project would also not affect the compliance outcomes at the receivers in the vicinity of the BGPH.

4 https://bulganagreenpowerhub.com.au/#:~:text=114m%20tall

Figure 3: Cumulative noise contours for the Watta Wella Renewable Energy Project and Bulgana Green Power Hub



7.0 RELATED INFRASTRUCTURE NOISE ASSESSMENT

This section presents an assessment of the proposed battery energy storage system (BESS) and substation (referred to herein as related infrastructure) to be installed to the southeast of the site.

7.1 Noise limits

The procedure for determining the noise limits according to the Noise Protocol depends on whether the noise source or the receivers are located in a rural or major urban area.

The procedures for rural areas, applicable for the subject site, are based on determining the zone levels according to the land zoning of the area in which the noise source and receivers are located. These zone levels are then adjusted, where appropriate, for a range of factors.

The zone levels are determined on the basis of the transformer station and surrounding residential receivers both being located on land designated as Farming Zone (FZ) (see land zoning map in Appendix F).

Considering that the land zoning is continuous between the transformer station and the receivers, a distance adjustment is not applicable.

Adjustments for ‘background relevant areas’ are not warranted in this instance, as the background noise levels during the relevant assessment conditions for the transformer station (i.e. low wind speeds) are expected to be relatively low; adjustments for background noise levels are therefore not warranted in this instance.

Based on the above and considering that the transformer station would be defined in the Victorian Planning Provisions as a *utility*, the noise limits applicable at the nearest receivers, are summarised in Table 12.

Table 12: Noise Protocol time periods and recommended levels, L_{eff}[5] dB

Period	Day of week	Start time	End time	Recommended level
Day	Monday-Friday	0700hrs	1800hrs	45
	Saturday	0700hrs	1300hrs	
Evening	Monday-Friday	1800hrs	2200hrs	38
	Saturday	1300hrs	2200hrs	
	Sunday, Public holidays	0700hrs	2200hrs	
Night	Monday-Sunday	2200hrs	0700hrs	34

As the transformer station is proposed to operate 24 hours a day and 7 days a week, meeting the applicable night-time noise limit of 34 dB L_{eff}, infers meeting the noise limits during all other time periods.

[5] L_{eff} is the effective noise level of commercial or industrial noise determined in accordance with SEPP N-1. This is the L_{Aeq} noise level over a half-hour period, adjusted for the character of the noise. Adjustments are made for tonality, intermittency and impulsiveness.

7.2 Related infrastructure noise emissions

The BESS is proposed to have a capacity of 50 MW / 50 MWh.

Equipment details proposed for the BESS are not known at this stage however total equipment noise levels from other similar projects indicate sound power levels of 85-90 dB L_{WA} for each 1 MW container unit.

The transformers and any associated cooling equipment will be the main sources of noise located within the substation.

At this stage in the project, specific details of the transformer make and model are yet to be determined. However, to provide a basis for assessing the proposed substation, RES advised that the substation is proposed to comprise two (2) transformers rated at 200 MVA each.

In lieu of measured sound power level data for a specific transformer selection, reference has been made to Australian Standard AS 60076-10:2009 *Power transformers – Part 10: Determination of sound levels* (AS 60076-10:2009) which provides a method for estimating transformer sound power levels. Specifically, Figure ZA1 from AS 60076-10:2009 has been used to determine an estimated standard maximum sound power level of 98 dB L_{WA} for each transformer.

The sound power levels include the noise from ancillary plant such as cooling plant.

AS 60076-10:2009 does not provide estimated sound frequency spectra for transformer noise emissions. However, the noise emissions of transformers and ancillary plant typically exhibit tonal characteristics which must be accounted for in the noise assessment. This is addressed in subsequent sections of the report.

Sound power level data used in this assessment for the equipment associated with the related infrastructure is summarised in Table 13.

Table 13: Related infrastructure - octave band sound power levels, dB L_W

	Octave band centre frequency, Hz							
Item	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**A-weighted total**
Substation	99	110	107	98	89	80	73	101
BESS (50 MW)*	98	103	111	105	102	96	81	107

* Based on overall sound power level of 90 dB L_{WA} for each 1 MW container unit

7.3 Predicted noise levels

Predicted noise levels have been determined on the basis of:

- the indicative equipment noise emission data detailed in Section 7.2; and
- the ISO 9613-2 noise prediction method described in Section 4.3.

An adjustment of +2 dB has then been applied to the predicted noise levels to account for the potential tonal characteristics of transformer noise. The relevance and magnitude of the adjustment in practice is dependent on several variables. This is discussed below.

Predicted effective noise levels (including the +2 dB adjustment) at the three nearest receivers, located within 1.5 km of the proposed related infrastructure are detailed in Table 14.

Table 14: Related infrastructure predicted noise levels, dB

Item	Receiver 404	Receiver 422	Receiver 423
BESS, L_{Aeq}	23-28	21-26	21-26
Substation, L_{Aeq}	19	16	16
Tonality adjustment	+2	+2	+2
Total, L_{eff}	27-31	24-28	24-28

The predicted effective noise levels in Table 14 are below the day, evening and night recommended levels for the site.

The following contextual notes are provided:

- The predicted effective noise levels are at least 3 dB below the minimum recommended levels for the night period;
- The predicted effective noise levels are very low and would be comparable to or less than background noise levels in many instances. The adjustment for tonality may therefore not be applicable if the noise of the transformer is not clearly audible. Conversely, in the unlikely event that the character of the noise warranted a larger adjustment of +5 dB (the maximum potential adjustment, which would only be triggered in the event that the selected transformers were atypically tonal and the noise was observed during very low background noise levels), compliance would still be achieved.

These results indicate that noise levels from the proposed transformer station associated with the Watta Wella Renewable Energy Project are unlikely to be a significant design consideration. However, predicted noise levels should be reviewed at the time when equipment numbers and selections are finalised, accounting for manufacturer noise emission data.

8.0 RECOMMENDED NOISE MANAGEMENT MEASURES

Providing that the operator of a wind farm complies with the requirements of Regulation 131C, their duty with respect to the general environmental duty under the EP Act has been addressed with regard to wind turbine noise.

Specifically, the EP Regulations require the following measures to be taken to address wind turbine noise:

- A noise management plan must be prepared as specified in Regulation 131E of the EP Regulations, prior to construction.
- Compliance noise monitoring must be undertaken as required by Regulation 131D of the EP Regulations.

In addition to the above, the following noise management measures should be implemented as part of the subsequent stages of development:

- The transformer equipment should be specified and selected to achieve noise emissions not exceeding the empirical values specified in AS 60076-10
- A detailed noise assessment should be prepared by a qualified acoustic consultant, prior to construction, addressing:
  - the final wind turbine selection and layout
  - the final location and equipment selection for the transformer station
  - compliance with the applicable noise limits at surrounding receivers
  - recommendation of reasonably practicable noise mitigation measures to control noise from the ancillary infrastructure.
- Development of reasonably practicable construction noise mitigation and management measures to be documented in a construction environmental management plan, prior to construction.

9.0 SUMMARY

An assessment of operational noise for the proposed Watta Wella Renewable Energy Project has been carried out based on the proposed wind farm comprising forty-four (44) multi-megawatt turbines, solar farm, battery energy storage system and related infrastructure.

Operational noise associated with the proposed wind turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the *Environment Protection Regulations 2021* and the Victorian Department of Environment, Land, Water and Planning *Policy and planning guidelines for development of wind energy facilities in Victoria,* November 2021.

Noise modelling was carried out based on a candidate turbine model (Vestas V162-5.6MW) which has been selected by the proponent as being representative of the size and type of turbines which could be used at the site.

The results of the modelling demonstrate that the proposed Watta Wella Renewable Energy Project is predicted to achieve compliance with the applicable noise limits determined in accordance with NZS 6808 for the wind turbine component of the project.

The noise limits determined in accordance with NZS 6808 apply to the total combined operational wind turbine noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore also considered the operational Bulgana Green Power Hub, adjacent to the south of the Watta Wella Renewable Energy Project. An assessment of the predicted noise levels for the Bulgana Green Power Hub has demonstrated that cumulative wind farms noise levels do not affect the compliance outcomes for either of the projects.

The assessment has also considered operational noise of the proposed related infrastructure comprising a battery energy storage system and substation. These noise levels have been assessed in accordance with Victorian EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol) dated May 2021.The assessment demonstrates that the related infrastructure is expected to result in noise levels at least 3 dB lower than the noise limit determined in accordance with Noise Protocol.

Consideration was also given to the general environmental duty, as required by the *Environment Protection Act 2017*.

The noise assessment therefore demonstrates that the proposed Watta Wella Renewable Energy Project can be designed and developed to achieve Victorian policy requirements for operational noise.

APPENDIX A GLOSSARY OF TERMINOLOGY

Term	Definition	Abbreviation
Amplitude modulation	Sound that is characterised by a rhythmic and higher than normal rise and fall in sound level at regular intervals.	-
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion below this table.
A-weighted 90th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
A-weighted average noise level	The equivalent continuous (time-averaged) A-weighted sound level.	L_{Aeq}
Decibel	The unit of sound level.	dB
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Impulsiveness	Sound that is characterised by a distinct and very rapid rise in sound level (e.g. a car door closing or the impact sound of a hammer)	-
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Special audible characteristics	A term used to define a set group of sound characteristics that increase the likelihood of adverse reaction to the sound. The characteristics comprise tonality, impulsiveness and amplitude modulation.	SAC
Tonality	A characteristic to describe sounds which are composed of distinct and narrow groups of audible sound frequencies (e.g. whistling or humming sounds).	-

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Basic quantities and assessment procedures*. Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report. For example, sound pressure levels measured using an "A" frequency weighting are expressed as dB L_A. Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report.

APPENDIX B TURBINE COORDINATES

The following table sets out the coordinates of the proposed turbine layout of the Watta Wella Renewable Energy Project.

(Layout supplied by the proponent on 15 October 2020).

Table 15: Turbine coordinates – MGA 94 zone 54

Turbine	Easting, m	Northing, m	Terrain elevation, m
1	669,444	5,901,185	257
2	669,738	5,905,755	210
3	670,241	5,899,957	259
4	669,429	5,900,492	269
5	670,668	5,907,054	208
6	671,168	5,906,245	210
7	672,627	5,900,081	233
8	670,786	5,899,686	240
9	671,239	5,901,414	230
10	671,558	5,899,817	230
11	673,186	5,903,128	230
12	670,226	5,905,394	210
13	674,797	5,897,777	242
14	669,836	5,900,227	253
15	672,628	5,903,518	229
16	672,051	5,904,230	220
17	670,418	5,903,851	213
18	671,627	5,906,410	208
19	672,168	5,906,326	210
20	675,363	5,898,078	236
21	671,082	5,899,916	240
22	673,163	5,900,326	234
23	672,473	5,905,084	212
24	673,164	5,899,126	240
25	672,605	5,899,133	235
26	674,502	5,902,083	220
27	674,268	5,903,473	210
28	670,360	5,906,355	210
29	671,647	5,905,106	213

Turbine	Easting, m	Northing, m	Terrain elevation, m
30	673,740	5,902,224	220
31	673,052	5,904,566	215
32	670,755	5,901,213	230
33	672,259	5,902,278	216
34	674,696	5,898,420	240
35	674,735	5,902,637	210
36	675,751	5,898,414	228
37	677,361	5,900,566	220
38	678,084	5,900,510	220
39	671,166	5,903,854	210
40	671,584	5,902,982	210
41	669,487	5,899,801	260
42	670,707	5,902,615	220
43	670,165	5,901,129	243
44	673,623	5,904,175	210

APPENDIX C RECEIVER LOCATIONS

The following table sets out the fifty-four (54) assessed receivers located within 3 km of the proposed turbines considered in the environmental noise assessment together with their respective distance to the nearest turbine. This includes eleven (11) stakeholder receivers.

(Data supplied by the proponent on 15 October 2020).

Table 16: Receivers within 3 km of the proposed turbines – MGA 94 zone 54

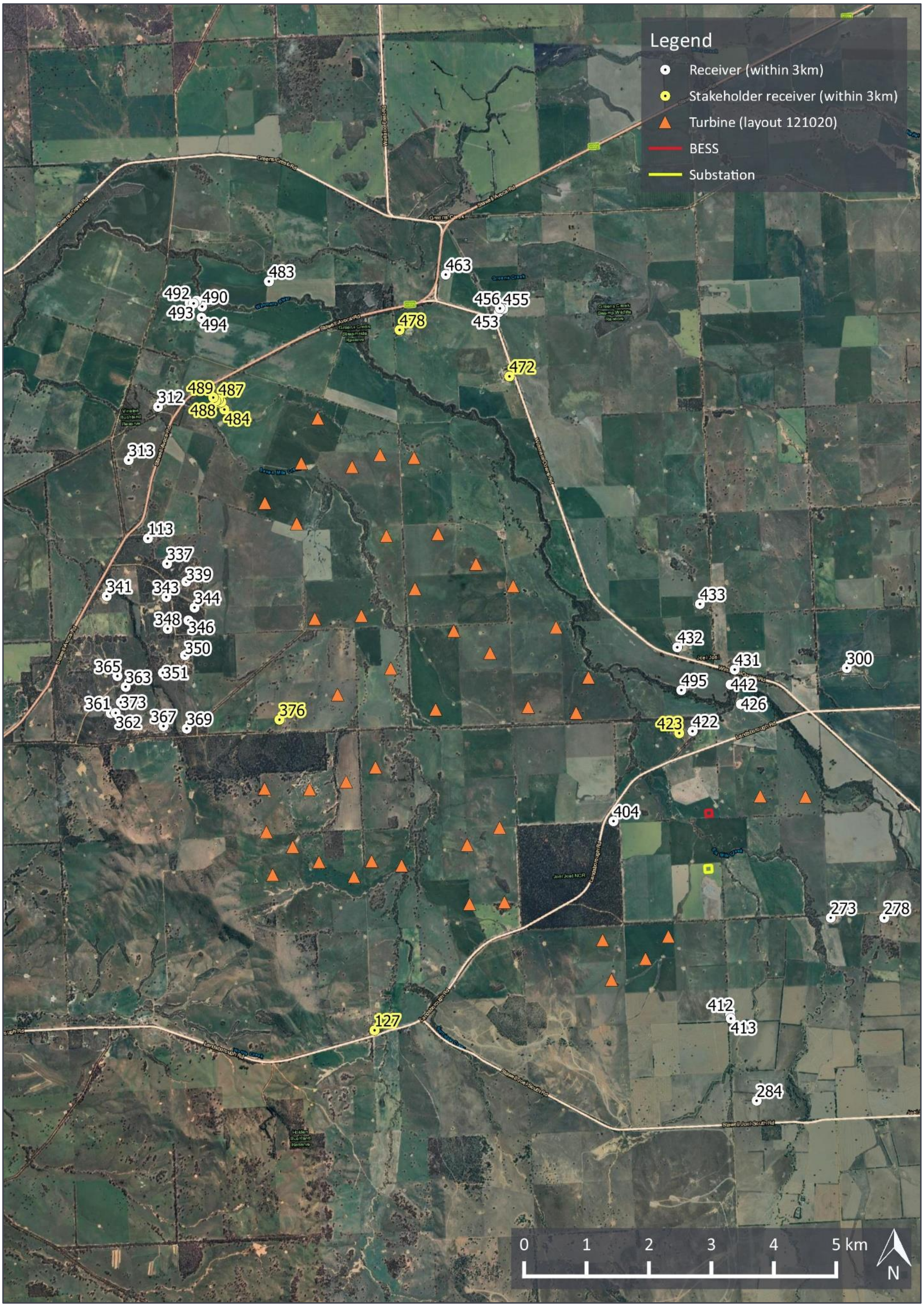
Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine
113	667,832	5,905,304	230	1,966	2
127 (S)	670,958	5,897,208	240	2,490	8
273	678,366	5,898,547	222	1,990	38
278	679,221	5,898,491	230	2,323	38
284	676,996	5,895,695	236	2,894	20
300	678,874	5,902,526	220	2,172	38
312	668,127	5,907,399	200	2,308	2
313	667,603	5,906,577	210	2,294	2
337	668,112	5,904,880	230	1,853	2
339	668,400	5,904,575	230	1,792	2
341	667,115	5,904,422	210	2,947	2
343	668,066	5,904,348	222	2,191	2
344	668,508	5,904,151	230	1,941	17
346	668,397	5,903,953	230	2,030	17
348	668,056	5,903,838	220	2,368	17
350	668,307	5,903,398	227	2,166	17
351	667,936	5,903,141	224	2,475	1
361	667,060	5,902,548	240	2,751	1
362	667,140	5,902,546	240	2,681	1
363	667,326	5,902,953	230	2,764	1
365	667,205	5,903,133	225	2,972	1
367	667,892	5,902,287	233	1,911	1
369	668,260	5,902,224	239	1,584	1
373	667,233	5,902,711	237	2,692	1
376 (S)	669,752	5,902,272	228	1,028	42
404	674,990	5,900,312	224	1,834	22
412	676,660	5,897,097	230	1,609	36
413	676,666	5,897,036	230	1,662	36

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine
422	676,344	5,901,671	214	1,511	37
423 (S)	676,130	5,901,653	213	1,650	37
426	677,145	5,902,054	219	1,513	37
431	677,081	5,902,614	218	2,074	37
432	676,186	5,903,029	214	1,512	35
433	676,591	5,903,697	217	2,144	35
442	677,000	5,902,379	215	1,856	37
453	673,668	5,908,568	210	2,702	19
455	673,745	5,908,618	210	2,787	19
456	673,692	5,908,630	210	2,767	19
463	672,860	5,909,224	203	2,984	19
472 (S)	673,775	5,907,532	210	2,016	19
478 (S)	672,066	5,908,386	203	1,938	5
483	670,026	5,909,293	200	2,335	5
484 (S)	669,185	5,907,289	201	1,511	28
485 (S)	669,115	5,907,402	201	1,599	5
486 (S)	669,142	5,907,412	201	1,576	5
487 (S)	669,099	5,907,458	201	1,629	5
488 (S)	669,054	5,907,436	200	1,667	5
489 (S)	669,019	5,907,492	200	1,714	5
490	668,933	5,908,959	200	2,582	5
491	668,850	5,909,059	200	2,711	5
492	668,738	5,909,030	200	2,767	5
493	668,800	5,909,017	200	2,715	5
494	668,911	5,908,782	200	2,470	5
495	676,207	5,902,340	210	1,511	35

(S) Stakeholder receiver

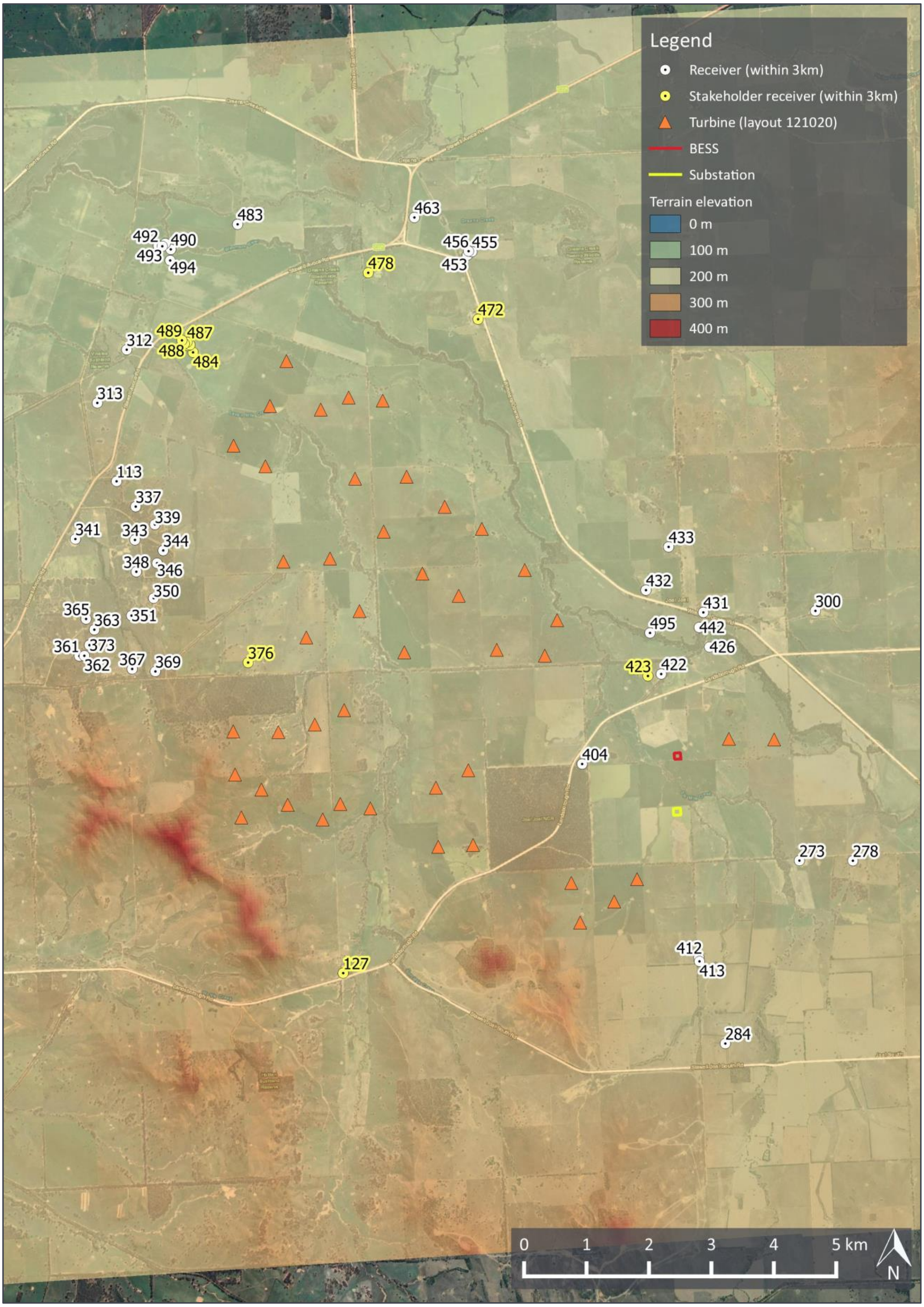
APPENDIX D SITE LAYOUT PLAN

Figure 4: Proposed wind farm and receivers



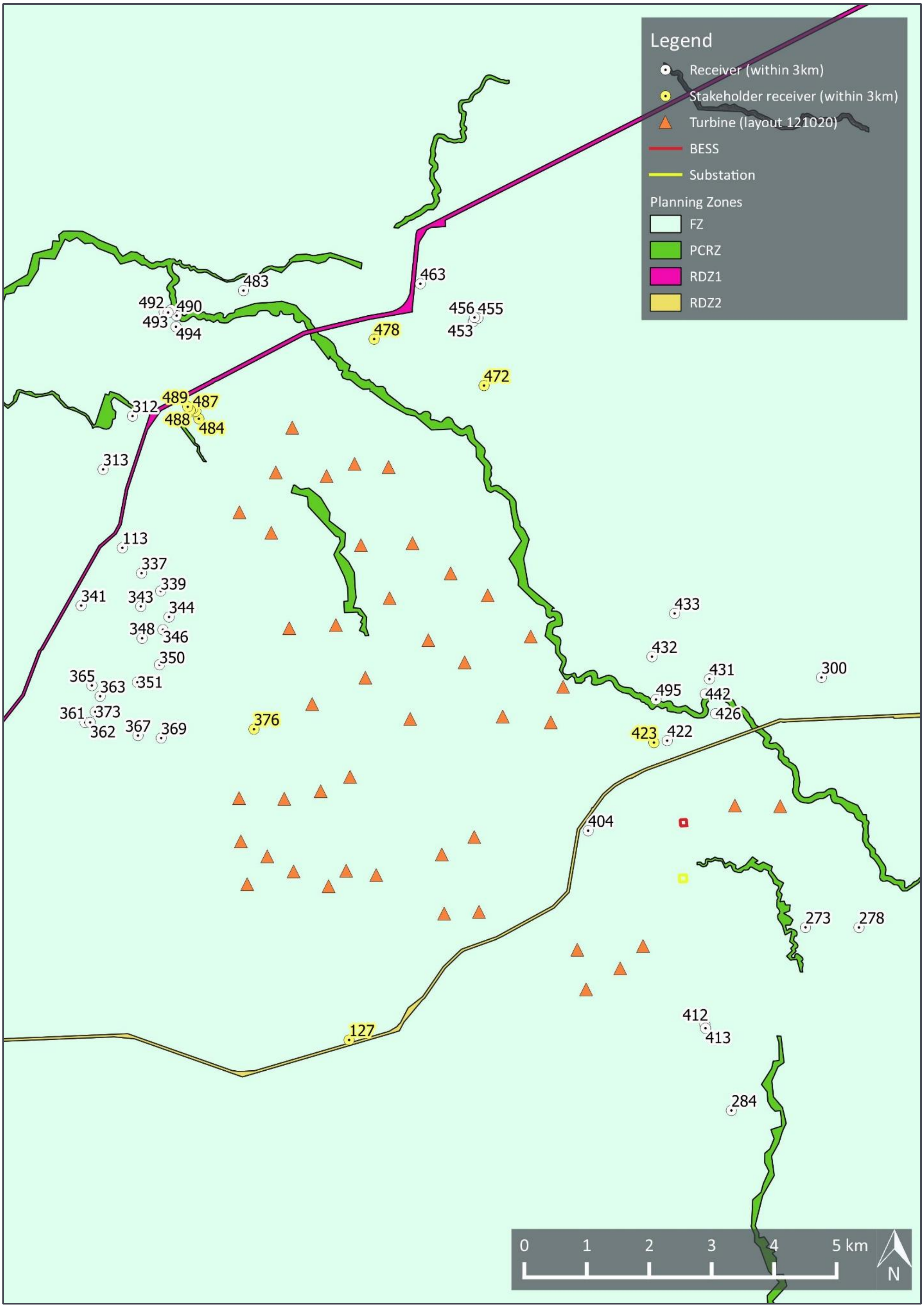
APPENDIX E SITE TOPOGRAPHY

Figure 5: Terrain elevation map for the Watta Wella Renewable Energy Project and surrounding area



APPENDIX F ZONING MAP

Figure 6: Zoning map for the Watta Wella Renewable Energy Project and surrounding area



APPENDIX G NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods. The international standard ISO 9613 *Acoustics – Attenuation of sound during propagation outdoors* has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered the most robust and widely used international method for the prediction of wind farm noise.

The use of this standard is supported by international research publications, measurement studies conducted by Marshall Day Acoustics and direct reference to the standard in NZS 6808:2010 *Acoustics – Wind farm noise*, AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* and the South Australian EPA 2009 wind farm noise guidelines.

The standard specifies an engineering method for calculating noise at a known distance from a variety of sources under meteorological conditions favourable to sound propagation. The standard defines favourable conditions as downwind propagation where the source blows from the source to the receiver within an angle of +/-45 degrees from a line connecting the source to the receiver, at wind speeds between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground. Equivalently, the method accounts for average propagation under a well-developed moderate ground based thermal inversion. In this respect, it is noted that at the wind speeds relevant to noise emissions from wind turbines, atmospheric conditions do not favour the development of thermal inversions throughout the propagation path from the source to the receiver.

To calculate far-field noise levels according to the ISO 9613, the noise emissions of each turbine are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- Geometric divergence
- Air absorption
- Reflecting obstacles
- Screening
- Vegetation
- Ground reflections.

The octave band attenuation factors are then applied to the noise emission data to determine the corresponding octave band and total calculated noise level at receivers.

Calculating the attenuation factors for each effect requires a relevant description of the environment into which the sound propagation such as the physical dimensions of the environment, atmospheric conditions and the characteristics of the ground between the source and the receiver.

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of G = 0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all turbines operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 ^{o}C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

In support of the use of ISO 9613 and the choice of G = 0.5 as an appropriate ground characterisation, the following references are noted:

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- NZS 6808 refers to ISO 9613 as an appropriate prediction method for wind farm noise, and notes that soft ground conditions should be characterised by a ground factor of G = 0.5
- In 1998, a comprehensive study (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613 method generally tends to marginally over predict noise levels expected in practice
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613 method as the appropriate standard and specifically designated G = 0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics publication A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise (UK IOA good practice guide). It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methods.

A range of measurement and prediction studies[6, 7, 8] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

The findings of these studies demonstrate the suitability of the ISO 9613 method to predict the propagation of wind turbine noise for:

- The types of noise source heights associated with a modern wind farm, extending the scope of application of the method beyond the 30 m maximum source heights considered in the original ISO 9613;
- The types of environments in which wind farms are typically developed, and the range of atmospheric conditions and wind speeds typically observed around wind farm sites. Importantly, this supports the extended scope of application to wind speeds in excess of 5 m/s.

---

6 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

7 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009.

8 Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

In addition to the choice of ground factor referred to above, adjustments to the ISO 9613 standard for screening and valleys effects are applied based on recommendations of the Joule Report, UK IOA 2009 joint agreement and the UK IOA Good Practice Guide. The following adjustments are applied to the calculations:

- Screening effects as a result of terrain are limited to 2 dB
- Screening effects are assessed based on each turbine being represented by a single noise source located at the maximum tip height of the turbine rotor
- An adjustment of 3 dB is added to the predicted noise contribution of a turbine if the terrain between the turbine and receiver in question is characterised by a significant valley. A significant valley is defined as a situation where the mean sound propagation height is at least 50 % greater than it would be otherwise over flat ground.

The adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLAN 8.2 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the site to evaluate the path between each turbine and receiver pairing, and then subsequently applies the adjustments to each turbine's predicted noise contribution where appropriate.

The prediction method inherently accounts for uncertainty through a combination of an uncertainty margin added to the input sound power level, and the use of conservative input parameters to the model, as described in this appendix, which have been shown to enable a reliable prediction of upper wind farm noise levels.

As an example of this, the ISO 9613-2 indicates an uncertainty margin of the order of +/-3 dB in relation to calculated noise levels at distances between 100 m and 1000 m for situations with an average propagation height between 5 m and 30 m (noting the information provided earlier in this appendix regarding the validation work undertaken to support the application of ISO 9613-2 to greater propagation heights). However, the uncertainty margins are noted for a prediction conducted in accordance with the inputs described in ISO 9613-2. A strict application of ISO 9613-2 would involve designating a ground factor of G = 1 (instead of the more conservative G = 0.5 ground factor used in the calculations) to represent the porous ground conditions around the site which ISO 9613-2 defines as follows:

> ***Porous ground**, which includes ground covered by grass, trees or other vegetation, and all other ground surfaces suitable for the growth of vegetation, such as farming land. For porous ground G = 1.*

A prediction based on a ground factor of G = 1 instead of G = 0.5 used in the modelling would typically result in predicted noise levels approximately 3 dB lower, thus effectively offsetting the quoted uncertainty margin. This also does not account for the other conservative aspects of the model, such as the assumption that all turbines are operating simultaneously at their maximum noise emissions and that each receiver is simultaneously downwind of every turbine at all times (in contrast to NZS 6808 compliance procedures which are based on assessing noise levels for a range of wind directions, consistent with broader Victorian noise assessment policies which do not evaluate compliance based solely on downwind noise levels).

Given the above, it is not necessary to apply uncertainty margins to the prediction results, as the results represent the upper predicted noise levels associated with the operation of the wind farm when measured and assessed in accordance with NZS 6808. This finding is supported by extensive post-construction noise compliance monitoring undertaken at wind farm sites across Australia.

APPENDIX H TABULATED PREDICTED NOISE LEVEL DATA

Table 17: Predicted noise levels, dB L_{A90}

Receiver	Hub-height wind speed, m/s						
	4	5	6	7	8	9	≥10
113	19.7	20.3	23.3	26.2	28.9	30.0	30.0
127 (S)	20.1	20.7	23.7	26.6	29.3	30.4	30.4
273	18.5	19.1	22.1	25.0	27.7	28.8	28.8
278	16.3	16.9	19.9	22.8	25.5	26.6	26.6
284	15.7	16.3	19.3	22.2	24.9	26.0	26.0
300	17.0	17.6	20.6	23.5	26.2	27.3	27.3
312	18.6	19.2	22.2	25.1	27.8	28.9	28.9
313	18.1	18.7	21.7	24.6	27.3	28.4	28.4
337	20.7	21.3	24.3	27.2	29.9	31.0	31.0
339	21.6	22.2	25.2	28.1	30.8	31.9	31.9
341	17.6	18.2	21.2	24.1	26.8	27.9	27.9
343	20.3	20.9	23.9	26.8	29.5	30.6	30.6
344	21.8	22.4	25.4	28.3	31.0	32.1	32.1
346	21.4	22.0	25.0	27.9	30.6	31.7	31.7
348	20.3	20.9	23.9	26.8	29.5	30.6	30.6
350	21.2	21.8	24.8	27.7	30.4	31.5	31.5
351	20.2	20.8	23.8	26.7	29.4	30.5	30.5
361	18.3	18.9	21.9	24.8	27.5	28.6	28.6
362	18.5	19.1	22.1	25.0	27.7	28.8	28.8
363	18.7	19.3	22.3	25.2	27.9	29.0	29.0
365	18.3	18.9	21.9	24.8	27.5	28.6	28.6
367	21.0	21.6	24.6	27.5	30.2	31.3	31.3
369	22.4	23.0	26.0	28.9	31.6	32.7	32.7
373	18.6	19.2	22.2	25.1	27.8	28.9	28.9
376 (S)	27.5	28.1	31.1	34.0	36.7	37.8	37.8
404	23.8	24.4	27.4	30.3	33.0	34.1	34.1
412	21.1	21.7	24.7	27.6	30.3	31.4	31.4
413	20.8	21.4	24.4	27.3	30.0	31.1	31.1
422	22.4	23.0	26.0	28.9	31.6	32.7	32.7
423 (S)	22.8	23.4	26.4	29.3	32.0	33.1	33.1

Receiver	Hub-height wind speed, m/s						
	4	5	6	7	8	9	≥10
426	21.2	21.8	24.8	27.7	30.4	31.5	31.5
431	19.9	20.5	23.5	26.4	29.1	30.2	30.2
432	22.1	22.7	25.7	28.6	31.3	32.4	32.4
433	19.8	20.4	23.4	26.3	29.0	30.1	30.1
442	20.5	21.1	24.1	27.0	29.7	30.8	30.8
453	17.4	18.0	21.0	23.9	26.6	27.7	27.7
455	17.1	17.7	20.7	23.6	26.3	27.4	27.4
456	17.2	17.8	20.8	23.7	26.4	27.5	27.5
463	16.8	17.4	20.4	23.3	26.0	27.1	27.1
472 (S)	19.9	20.5	23.5	26.4	29.1	30.2	30.2
478 (S)	20.7	21.3	24.3	27.2	29.9	31.0	31.0
483	17.3	17.9	20.9	23.8	26.5	27.6	27.6
484 (S)	22.8	23.4	26.4	29.3	32.0	33.1	33.1
485 (S)	22.2	22.8	25.8	28.7	31.4	32.5	32.5
486 (S)	22.2	22.8	25.8	28.7	31.4	32.5	32.5
487 (S)	21.9	22.5	25.5	28.4	31.1	32.2	32.2
488 (S)	21.8	22.4	25.4	28.3	31.0	32.1	32.1
489 (S)	21.5	22.1	25.1	28.0	30.7	31.8	31.8
490	16.8	17.4	20.4	23.3	26.0	27.1	27.1
491	16.3	16.9	19.9	22.8	25.5	26.6	26.6
492	16.2	16.8	19.8	22.7	25.4	26.5	26.5
493	16.4	17.0	20.0	22.9	25.6	26.7	26.7
494	17.2	17.8	20.8	23.7	26.4	27.5	27.5
495	22.5	23.1	26.1	29.0	31.7	32.8	32.8

(S) Stakeholder receiver

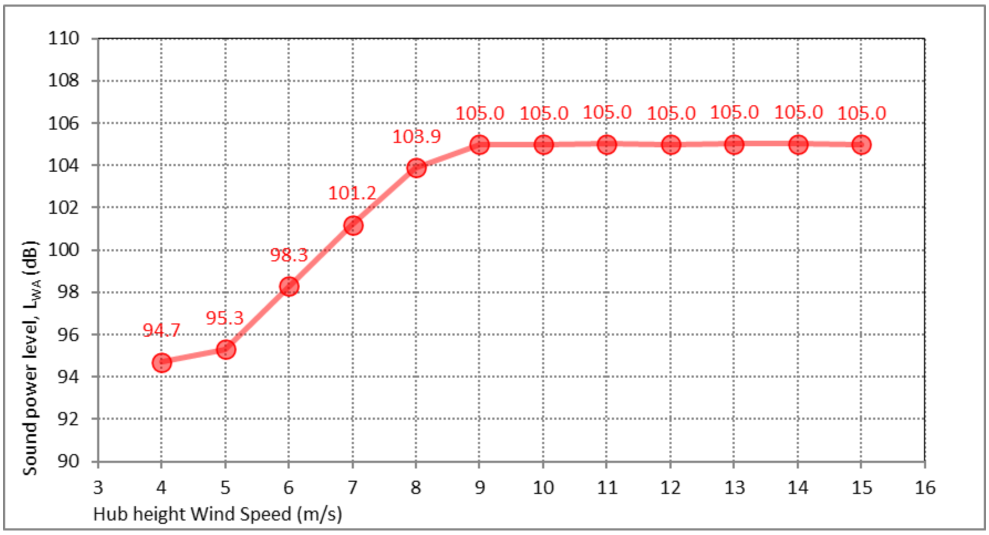
APPENDIX I NZS 6808 DOCUMENTATION

(a) Map of the site showing topography, turbines and residential properties: See Appendix E

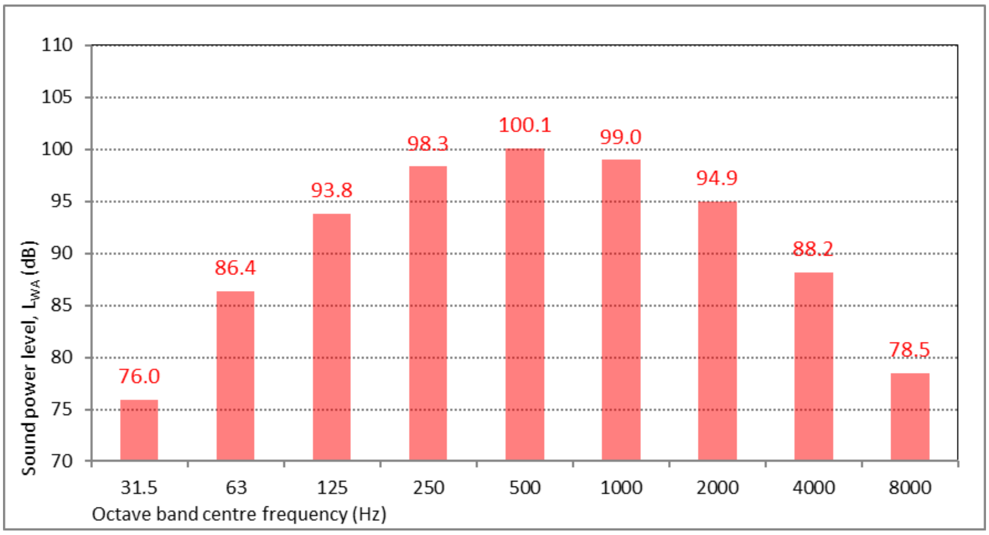
(b) Noise sensitive locations: See Section 2.0 and Appendix C

(c) Wind turbine sound power levels, dB L_{WA} (refer to Section 6.3.1)

Sound power levels (manufacturer specification +1 dB margin for uncertainty), dB L_{WA}



Reference octave band spectra adjusted to the highest sound power level detailed above dB L_{WA}



(d) Wind turbine model: See Table 7 of Section 6.2

(e) Turbine hub height: See Table 7 of Section 6.2

(f) Distance of noise sensitive locations from the wind turbines: See Appendix C

(g) Calculation procedure used: ISO 9613-2:1996 prediction algorithm as implemented in SoundPLAN v8.2 (See Section 4.3 and Appendix G)

(h) Meteorological conditions assumed:

- Temperature: 10 °C
- Relative humidity: 70 %
- Atmospheric pressure: 101.325 kPa

(i) Air absorption parameters:

	Octave band mid frequency, Hz							
Description	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Atmospheric attenuation (dB/km)	0.12	0.41	1.04	1.93	3.66	9.66	32.8	116.9

(j) Topography/screening: 10 m resolution elevation contours – See Appendix E

(k) Predicted far-field wind farm sound levels: See Section 6.4 and Appendix H.