MARSHALL DAY Acoustics

DARLINGTON WIND FARM
ENVIRONMENTAL NOISE ASSESSMENT

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Project:	**Darlington Wind Farm** **Environmental Noise Assessment**
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EXECUTIVE SUMMARY

This report presents the results of an assessment of environmental noise associated with the Darlington Wind Farm (the project) that is proposed to be developed by Global Power Generation Australia Pty Ltd (GPG, the proponent). The project is proposed to comprise sixty-one (61) multi-megawatt wind turbines with a maximum tip height of 240 m and an associated substation.

This assessment was prepared for GPG to support the Environment Effects Statement (EES) referral application for the project.

The actual wind turbine model 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, this assessment considers three (3) candidate wind turbine models that are representative of the size and type of wind turbine which could be used at the site. For this purpose, the Siemens Gamesa SG 6.6-170, General Electric GE 6.0-164 and Vestas V162-6.0MW, with hub heights ranging between 145 and 149 m and rotor diameters ranging between 162 and 170 m, have been nominated by the proponent.

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 *Environment Protection Regulations 2021* and the Victorian Department of Environment, Land, Water and Planning publication *Policy and planning guidelines for development of wind energy facilities in Victoria* dated November 2021. The operational wind farm noise assessment considers the base (minimum) noise limits determined in accordance with NZS 6808, accounting for the land zoning of the area.

Manufacturer specification data for the candidate wind turbine model has been used as the basis for the assessment. The specification provides noise emission data in accordance with the international standard referenced in NZS 6808. The noise emission data 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 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2) 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 farm noise assessment.

The results of the noise modelling demonstrate that the predicted noise levels for the proposed wind turbine layout and candidate wind turbine models achieve the base noise limits determined in accordance with NZS 6808 at all neighbouring receivers.

The assessment has also considered the operational noise of infrastructure associated with the wind farm (i.e., a substation), to be located in the centre of the site. Noise levels from the substation have been assessed in accordance with *Environment Protection Act 2017* (EP Act) and *Environment Protection Regulations 2021*. Accordingly, the assessment considers the general environmental duty under the EP Act and the noise limits determined in accordance with the 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 (the Noise Protocol). The assessment demonstrates that the substation can be designed and operated to achieve the noise limits determined in accordance with the Noise Protocol.

The noise assessment therefore demonstrates that the proposed Darlington Wind Farm can be designed and developed to achieve Victorian policy requirements.

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1.0 INTRODUCTION

Global Power Generation Australia Pty Ltd (the proponent) is proposing to develop a wind farm known as the Darlington Wind Farm within the Victorian local government area of the Moyne Shire, between Darlington and Mortlake in Victoria.

This report presents the results of an assessment of operational wind turbine noise 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 *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines* dated November 2021 (the Victorian Wind Energy Guidelines).

Operational noise of the proposed substation has been assessed in accordance with *Environment Protection Act 2017* (EP Act) and EP Regulations.

The noise assessment presented in this report was prepared to support an Environment Effects Statement (EES) referral application for the project and is based on:

- Operational noise limits determined in accordance with NZS 6808 and the 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), accounting for local land zoning;
- Predicted noise levels for the wind turbines, based on the proposed site layout and a candidate wind turbine model that is representative of the size and type of wind turbine that the planning application seeks consent for;
- Predicted noise levels for the proposed substation, 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; and
- A review of the predicted noise levels of the substation in the context of the general environmental duty of the EP Act.

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

2.0 PROJECT DESCRIPTION

The project is proposed to comprise sixty-one (61) wind turbines extending to a tip height of up to 240 m and an associated substation. Throughout this report, the term 'wind farm' refers to both the wind turbines and the substation.

Three (3) candidate wind turbine models (Siemens Gamesa SG 6.6-170, General Electric GE 6.0-164 and Vestas V162-6.0MW) with nominal hub heights ranging between 145 and 149 m and rotor diameters ranging between 162 and 170 m have been selected by the proponent for this assessment. Further details of the candidate wind turbine model are presented in Section 6.2.

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

A substation is also proposed to be located in the centre of the site (see coordinates in Appendix B).

A total of ninety-eight (98) noise sensitive locations (generally referred to as *receivers* herein) located within 5 km of the proposed wind turbines have been considered in this noise assessment. This includes eighteen (18) receivers where a noise agreement is in place or proposed between the landowners and the proponent (subsequently referred to as *involved receivers* herein).

The coordinates of the receivers are tabulated in Appendix C.

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

3.0 VICTORIAN LEGISLATION & 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 *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines* dated November 2021;
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise*; and
- 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.

Details of the guidance and noise limits 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 is 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 *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines* dated 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.*

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 should comply with the noise limits recommended for dwellings and other noise sensitive locations 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

New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (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 limits 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 limits 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 involved receivers irrespective of whether they are inside or outside of the boundary. However, the noise limits specified in the Standard do not apply to these locations on account of their participation with the wind farm.

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 noise limits 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 L_{A90}.

The noise limits specified in NZS 6808 apply to the combined wind turbine 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 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 is located within the predicted 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 wind turbine model is sometimes available from tonality audibility assessments conducted as part of manufacturer wind 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 substation is considered a 'commercial, industrial and trade premises' under the EP Act.

The Noise Protocol describes a procedure for determining noise limits that are used to assess whether a noise is prescribed to be unreasonable in accordance with the EP Regulations.

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 legislation and guidelines outlined in Section 3.0, assessing the operational noise levels of the proposed wind turbines and the substation involves:

- assessing background noise levels at noise sensitive locations around the wind farm;
- assessing the land zoning of the project site and surrounding areas;
- establishing suitable noise limits accounting for background noise levels and land zoning;
- predicting the level of noise expected to occur as a result of the proposed wind turbines and the substation;
- assessing whether the development can achieve the requirements of Victorian policy and guidelines by comparing the predicted noise levels to the noise limits and taking into consideration the general environmental duty under the EP Act.

4.2 Background noise levels

Background noise level information is used to inform the setting of limits for both the substation 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 wind turbines. This trend defines the value of the background noise for the different wind speeds in which the wind 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 wind farm noise levels (wind turbines and associated substation) are predicted using:

- Noise emission data for the wind turbines and the transformers within the associated substation;
- A 3D digital model of the site and the surrounding environment; and
- 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 substation 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.
Source characterisation	Each source of operational noise is modelled as a point source of sound. The total sound of the component of the wind farm being modelled (i.e. the wind turbines or the substation) 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 wind turbine noise, the following specific procedures are noted: • Calculations of wind 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 wind turbine. • Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each wind turbine. Further discussion of terrain screening effects is provided below.
Terrain data	10 m resolution within the site and surrounds, provided by the proponent.

Detail	Description
Terrain effects (wind 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 wind 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 wind turbine and the calculation point. The value of the screening effect is limited to a maximum value of -2 dB. The project is located in a relatively flat area characterised by little variations in ground elevation between the wind turbines and surrounding receivers. Based on comparison of predicted noise levels with and without terrain elevation data included, calculated terrain effects range between -0.3 dB and +1.3 dB for receivers within 5 km of the proposed wind turbines. For reference purposes, the ground elevations at the wind turbines 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 wind turbine to each receiver, whether as a result of thermal inversions or wind directed toward each calculation point.
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 farm). The magnitude of these differences is comparable and therefore balance each other out to provide similar predicted noise levels.

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

5.0 EXISTING NOISE ENVIRONMENT

The noise modelling results that are subsequently presented in Section 6.4 indicate that predicted noise levels are above 35 dB L_{A90} at up to five (5) non-involved receivers, where background noise monitoring would be required, in accordance with NZS 6808.

Background noise monitoring is not proposed to be undertaken at this stage of the project. As such, the applicable base (minimum) noise limits determined in accordance with NZS 6808 have been adopted for this assessment. This approach is conservative, as the background noise monitoring results would only increase the noise limits above the applicable base limit values.

It is however recommended that background noise monitoring be undertaken in the event an EES is required for the project or prior to construction of the wind farm. The results would be used to derive background noise dependant noise limits that would ultimately be used for a post-construction compliance assessment.

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.

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. Similar guidance concerning the Farming Zone is provided in EPA Victoria's *Wind Energy Facility Turbine Noise Regulation Guidelines* which indicates that the high amenity noise limit should not be applied to the Farming Zone.

Based on the above, the high amenity noise limit is not justified for the proposed wind farm.

6.1.2 Involved 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.

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 2.

Table 2: 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

In the absence of background noise data for the project, the wind farm has been conservatively assessed using the relevant base (minimum) noise limits presented above.

6.2 Wind turbine model

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

Accordingly, to assess the proposed wind farm at this stage in the project, it is necessary to a consider candidate wind turbine model that is representative of the size and type of wind turbines being considered. The purpose of a candidate wind turbine model 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 wind turbines being considered for the site.

For this assessment, the proponent has nominated three (3) candidate wind turbine models as detailed in Table 3.

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

This assessment has been based on the wind turbines operating in an unconstrained mode of generation (i.e. without 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 wind turbines being offered in the Australian market.

Table 3: Candidate wind turbine model details

Detail	SG 6.6-170	GE 6.0-164	V162 6.0MW
Rated power, MW	6.6	6.0	6.0
Rotor diameter, m	170	164	162
Modelled hub height, m	145	148	149
Operating mode	AM 0 [1]	-	PO6000 [2]
Serrated trailing edge	Yes	Yes	Yes

1 It is our understanding that 'AM 0' is a manufacturer designation which indicates *Application Mode 0* to achieve a power output of 6,600 kW – this is an unconstrained mode of operation (i.e. without noise reduction)

2 It is our understanding that 'PO6000' is a manufacturer designation which indicates a Power Optimisation mode to achieve a power output of 6,000 kW – this is an unconstrained mode of operation (i.e. without noise reduction)

The modelled hub heights detailed above are 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 changes is expected to be minor and inconsequential with respect to predicted noise levels.

Subsequent assessments as part of the development application would account for any changes to the hub height as part of the ongoing design of the project. Further, if the project is approved, a pre-construction noise assessment would need to be conducted using the final hub once the wind turbine layout has been finalised and the final wind turbine model selected.

It is understood that, as the project design progresses, the proponent may consider a wind turbine model with a rotor diameter of 172 m, the Vestas V172-7.2MW. At the time of preparing this report, noise emission data for this turbine model was not available.

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 wind turbine and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the wind turbine.

Sound power level data for the candidate wind turbine models, including sound frequency characteristics, has been sourced from the manufacturers' documents listed in Table 4.

Table 4: Candidate wind turbine model specification documents

Candidate model	Document No.	Date	Title
SG 6.6-170	D2830475/002	21 Jul. 2021	*Developer Package SG 6.6-170*
GE 6.0-164	0082273 Rev: 2	16 Mar. 2021	*Technical Documentation Wind Turbine Generator Systems Cypress 6.0-164 - 50Hz - Product Acoustic Specifications According to IEC 61400-11*
V162 6.0MW	0095-3732_01	3 Nov. 2020	*Third octave noise emission EnVentus™ V162-6.0MW*

Based on the data sourced from the manufacturer's documentation, the noise modelling undertaken for this assessment involved conversion of third octave band levels 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 +1.0 dB addition) as a function of hub height wind speed are presented in Table 5 with the octave band values presented in Table 6. These represent the total noise emissions of each candidate wind turbine model, including the secondary contribution of ancillary plant associated with each wind turbine (e.g. cooling fans).

Table 5: Sound power levels versus hub height wind speed, dB L_{WA}

	Hub height wind speed, m/s							
Candidate model	4	5	6	7	8	9	10	≥11
SG 6.6-170	93.0	95.5	99.4	102.8	105.7	107.5	107.5	107.5
GE 6.0-164	94.8	96.7	100.2	103.5	105.7	107.7	108.0	108.0
V162 6.0MW	95.1	95.3	97.2	100.2	103.0	105.1	105.3	105.3

Table 6: Octave band sound power levels, dB L_{WA}

	Octave band centre frequency, Hz								
Candidate model	31.5	63	125	250	500	1000	2000	4000	8000	Total
SG 6.6-170 [1]	-	89.0	95.8	98.0	99.0	102.2	101.9	97.4	85.6	107.5
GE 6.0-164 [2]	79.8	89.1	94.6	99.1	101.7	103.3	101.1	93.6	77.8	108.0
V162 6.0MW [3]	76.2	86.6	94.1	98.7	100.4	99.3	95.2	88.3	78.5	105.3

1 Based on octave band levels at 9 m/s
2 Based on octave band levels at 10 m/s
3 Based on one-third octave band levels at 10 m/s

These sound power levels are also illustrated in Appendix I.

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

Information concerning potential tonality is often limited at the planning stage of a wind farm, and test data for tonality is presently unavailable for the selected candidate wind turbine models. However, the occurrence of tonality in the noise of contemporary multi-megawatt wind 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

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 wind 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 wind farm have been predicted using the sound power level data detailed in Section 6.3.1 for the selected candidate wind turbine models and are summarised in Table 7 for the hub height wind speed which results in the highest predicted noise levels.

The locations of the predicted 30, 35, 40 and 45 dB L_{A90} noise contours are illustrated in Figure 1 to Figure 3, for the hub height wind speed which results in the highest predicted noise levels for each candidate wind turbine model.

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 7: Highest predicted noise level at receivers with predicted levels 30 dB L_{A90} or above, dB L_{A90}

Receiver	SG 6.6-170	GE 6.0-164	V162 6.0MW
1 (S)	36.7	37.7	35.7
2 (S)	37.6	38.6	36.6
3 (S)	37.7	38.7	36.7
4 (S)	36.8	37.8	35.9
5 (S)	31.6	32.4	30.9
6 (S)	42.5	43.3	40.9
7 (S)	38.8	39.8	37.8
8 (S)	37.1	38.1	36.2
9 (S)	36.7	37.7	35.8
10 (S)	37.2	38.2	36.2
11 (S)	37.9	38.9	37.0
12 (S)	38.2	39.2	37.3
13 (S)	36.6	37.6	35.9
14 (S)	38.5	39.5	37.5
15 (S)	38.9	39.9	37.9
16 (S)	40.8	41.8	39.7
17 (S)	36.1	37.0	35.2
18 (S)	37.1	38.0	36.1
25	32.4	33.2	31.7
28	31.9	32.8	31.2
40	36.8	37.8	35.8
41	31.1	32.0	30.3
45	37.2	38.3	36.3
46	29.7	30.4	28.9
68	29.9	30.7	29.2
69	31.2	32.0	30.4
74	34.7	35.6	33.7
75	33.5	34.4	32.7
76	36.5	37.5	35.6
77	31.1	31.9	30.4
108	34.5	35.5	33.7
114	29.9	30.6	29.2

Receiver	SG 6.6-170	GE 6.0-164	V162 6.0MW
180	30.3	31.0	29.5

(S) Involved receiver

The following can be concluded from the predicted noise levels detailed in Table 7:

- Compliance with the applicable base noise limit of 40 dB L_{A90} by at least 1.7 dB at non-involved receivers, for all selected candidate wind turbine models
- Compliance with the applicable base noise limit of 45 dB L_{A90} by at least 1.7 dB at involved receivers, for all selected candidate wind turbine models.

Figure 1: Highest predicted noise level contours, dB L_{A90} – SG 6.6-170

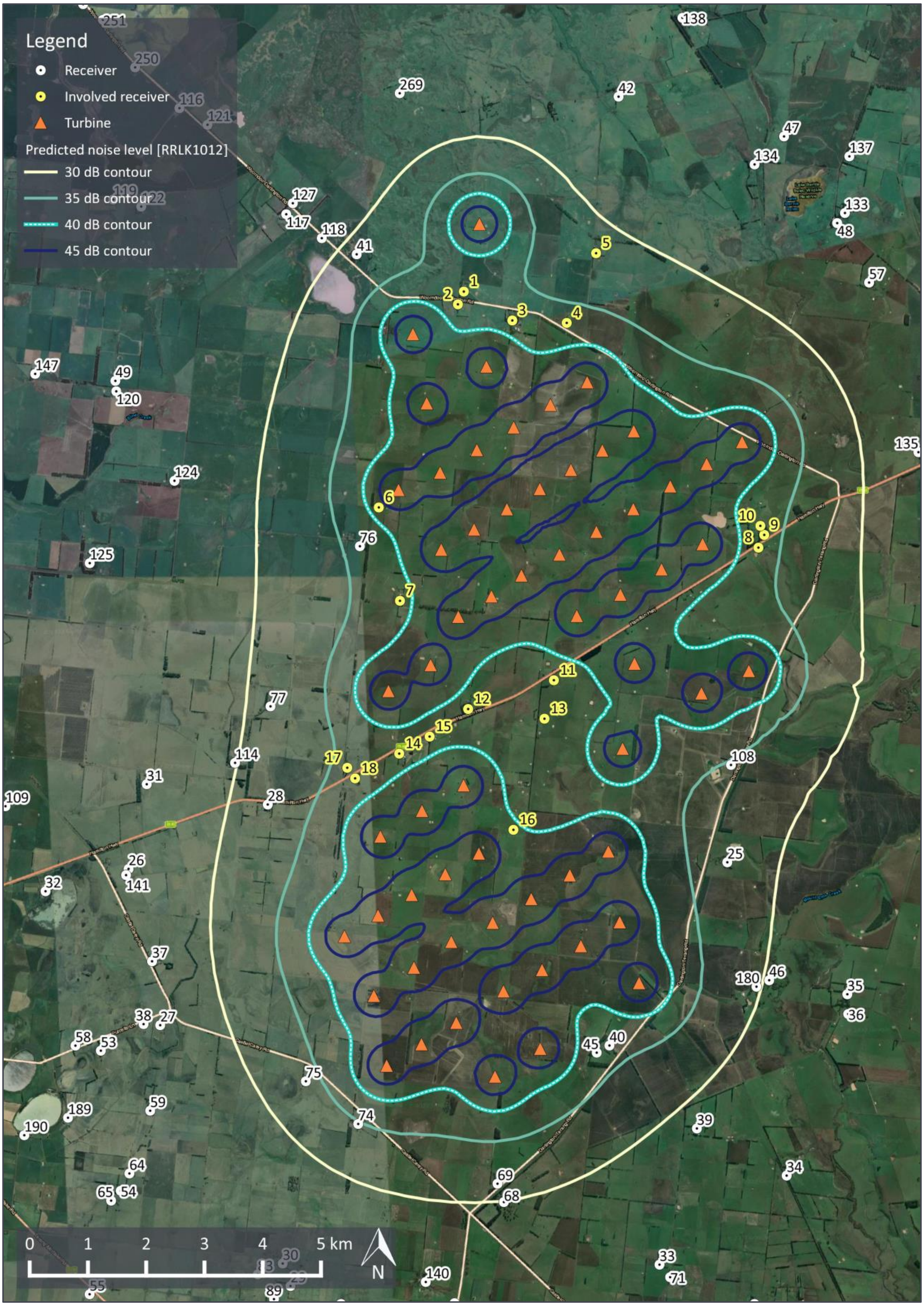


Figure 2: Highest predicted noise level contours, dB L_{A90} – GE 6.0-164

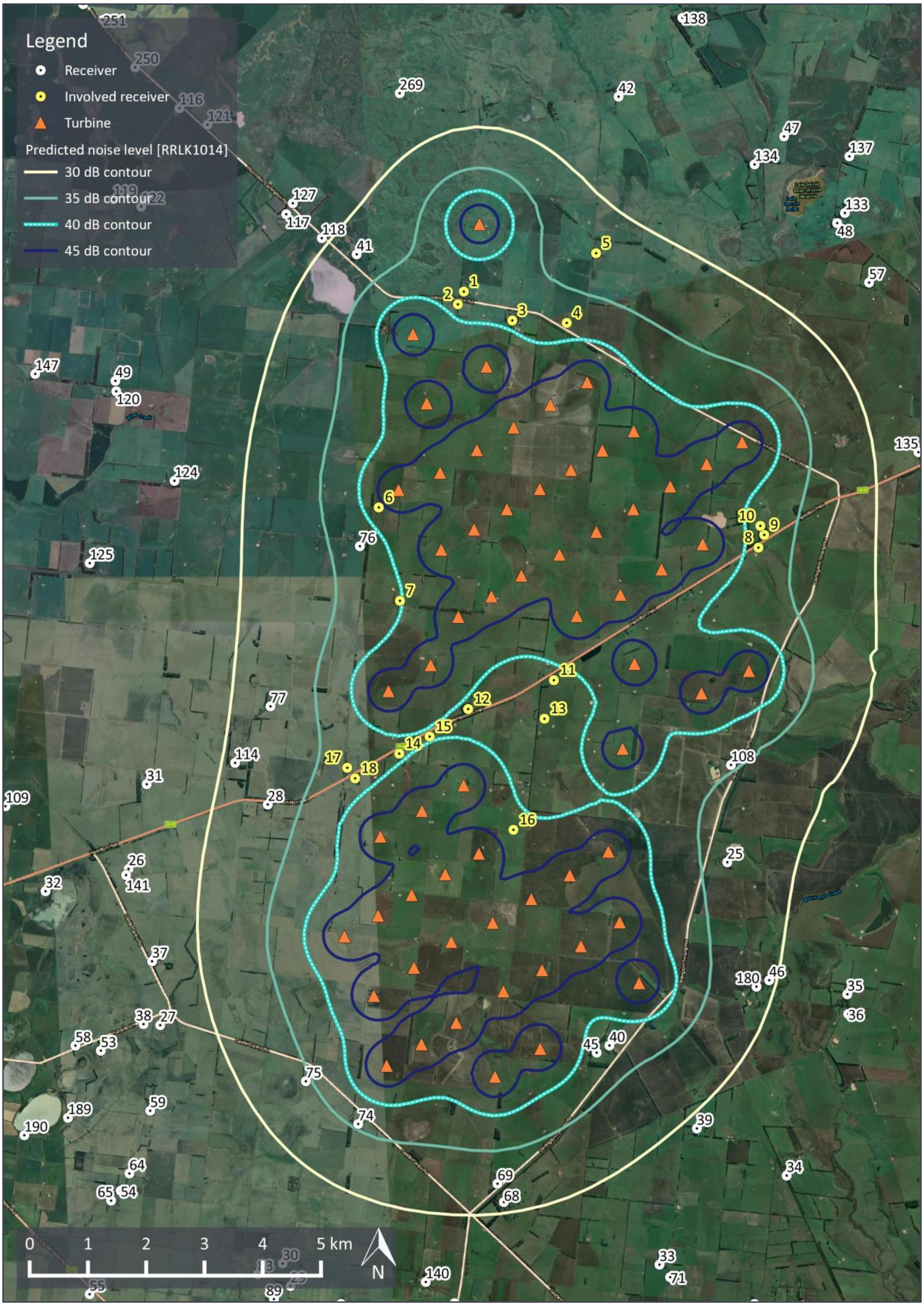
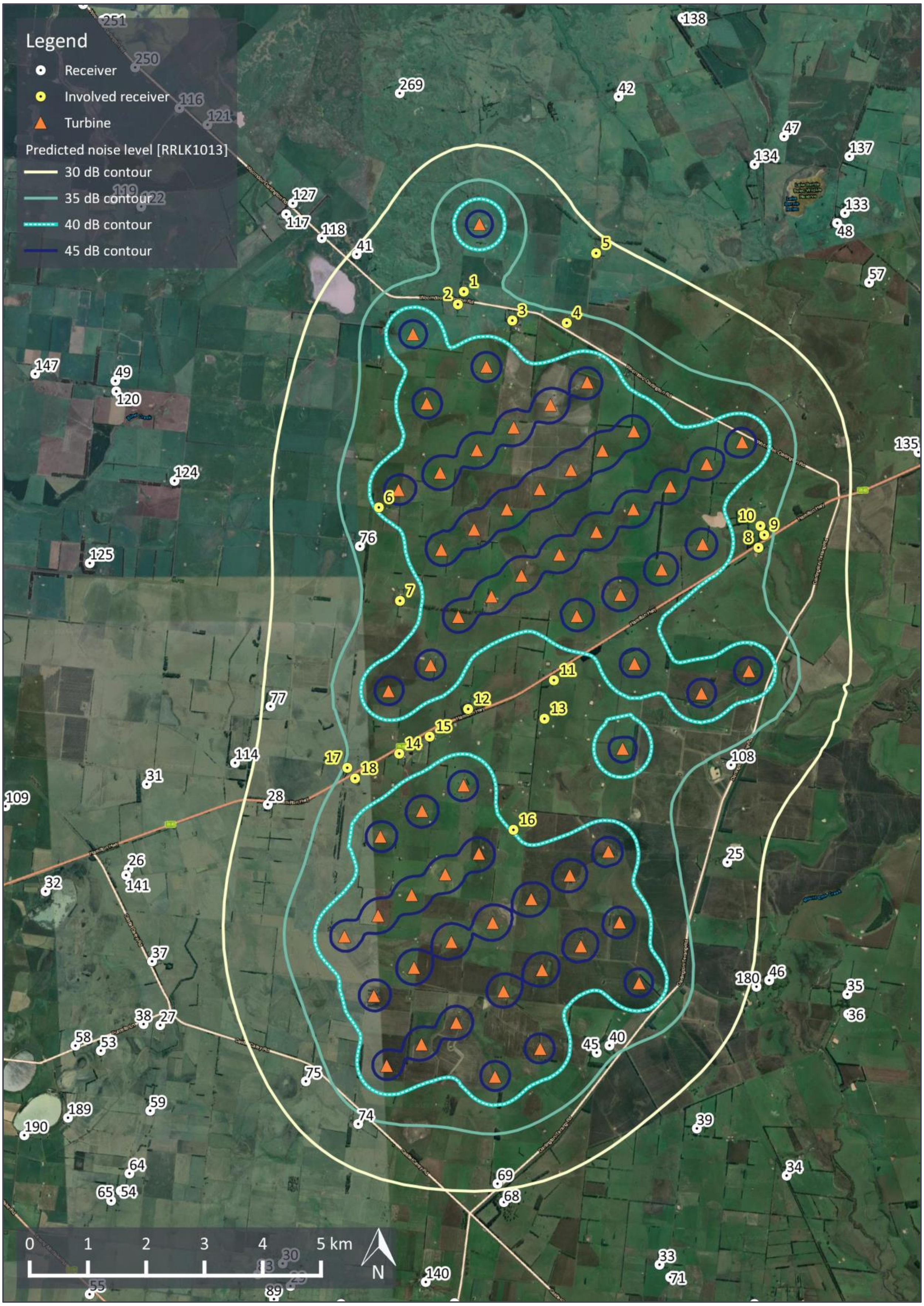


Figure 3: Highest predicted noise level contours, dB L_{A90} – V162-6.0MW



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 wind farm projects in the surrounding area.

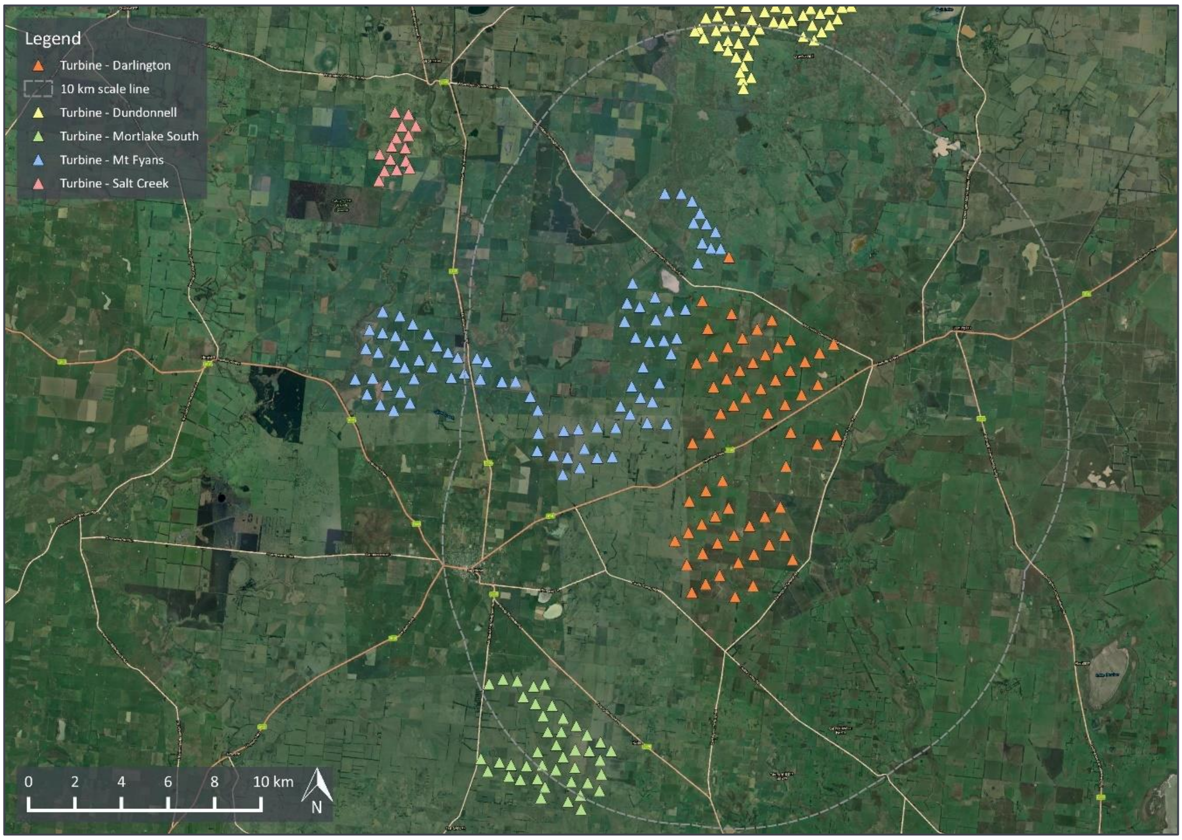
Based on publicly available information[3], the following wind farms have been identified within 10 km of the proposed wind farm for the review of potential cumulative noise considerations:

- The operational Dundonnell Wind Farm, located approximately 7 km to the north;
- The proposed Mt Fyans Wind Farm, directly adjacent to the northwest; and
- The approved Mortlake South Wind Farm, located approximately 8 km to the southwest.

Wind farms located farther than 10 km from the proposed project, like the Salt Creek Wind Farm, would not have cumulative effects likely to affect the assessment outcome.

A site plan showing the location of the identified neighbouring wind farms in relation to the Darlington Wind Farm is provided in Figure 4.

Figure 4: Darlington Wind Farm and neighbouring wind farms



3 https://www.energy.vic.gov.au/renewable-energy/wind-energy/wind-projects

6.5.1 Dundonnell Wind Farm

The Dundonnell Wind Farm commenced operation in early 2021 and comprises eighty (80) Vestas V150-4.2MW wind turbines with a hub height of 114 m[4]. The coordinates of the wind turbines were provided by the project developers, Tilt Renewables.

The noise emissions for the Vestas V150-4.2MW wind turbines of the Dundonnell Wind Farm have been represented for this study with data sourced from the publicly available noise assessment report[5] for the Golden Plains Wind Farm.

The planning permit[6] for the Dundonnell Wind Farm establishes a minimum operational noise limit of 40 dB for receivers around the wind farm.

6.5.2 Mortlake South Wind Farm

The Mortlake South Wind Farm is currently under construction, comprising thirty-five (35) Nordex N149/4.0-4.5 wind turbines with a hub height of 105 m[7].

The amended planning permit[8] establishes a minimum operational noise limit of 40 dB for receivers around the wind farm.

The application to amend the planning permit was accompanied by a noise assessment[9] for a forty-two (42) wind turbine layout using a Nordex N131/3000 candidate wind turbine with a hub height of 114 m. This information has been referenced in the present study as it is expected to be a conservative prediction of potential noise levels for the Mortlake South Wind Farm.

6.5.3 Mt Fyans Wind Farm

It is our understanding that a revised planning application for the Mt Fyans Wind Farm is currently being prepared.

The proposed wind farm layout and associated noise contours have been sourced from the preliminary noise assessment[10] submitted as part of the EES referral application in 2013.

6.5.1 Assessment

To inform the assessment of potential cumulative noise considerations, reference is made to Clause 5.6.4 of NZS 6808:2010 which states:

> *For the purposes of 5.6.1, if the predicted wind farm sound levels for a new wind farm are at least 10 dB below any existing wind farm sound levels permitted by any resource consent or plan, then the cumulative effect shall not be taken into account.*

4 weblink

5 MDA Report Rp 003 R01 20170122 *Golden Plains Wind Farm - Environmental Noise & Vibration Assessment*, dated 23 February 2018

6 Planning Permit no. 2015/23858/A

7 weblink / weblink

8 Planning Permit no. 2008/0538/A

9 MDA Report Rp 001 2015582ML *Mortlake South Wind Farm – NZS 6808:2010 Noise Assessment*, dated 29 March 2016

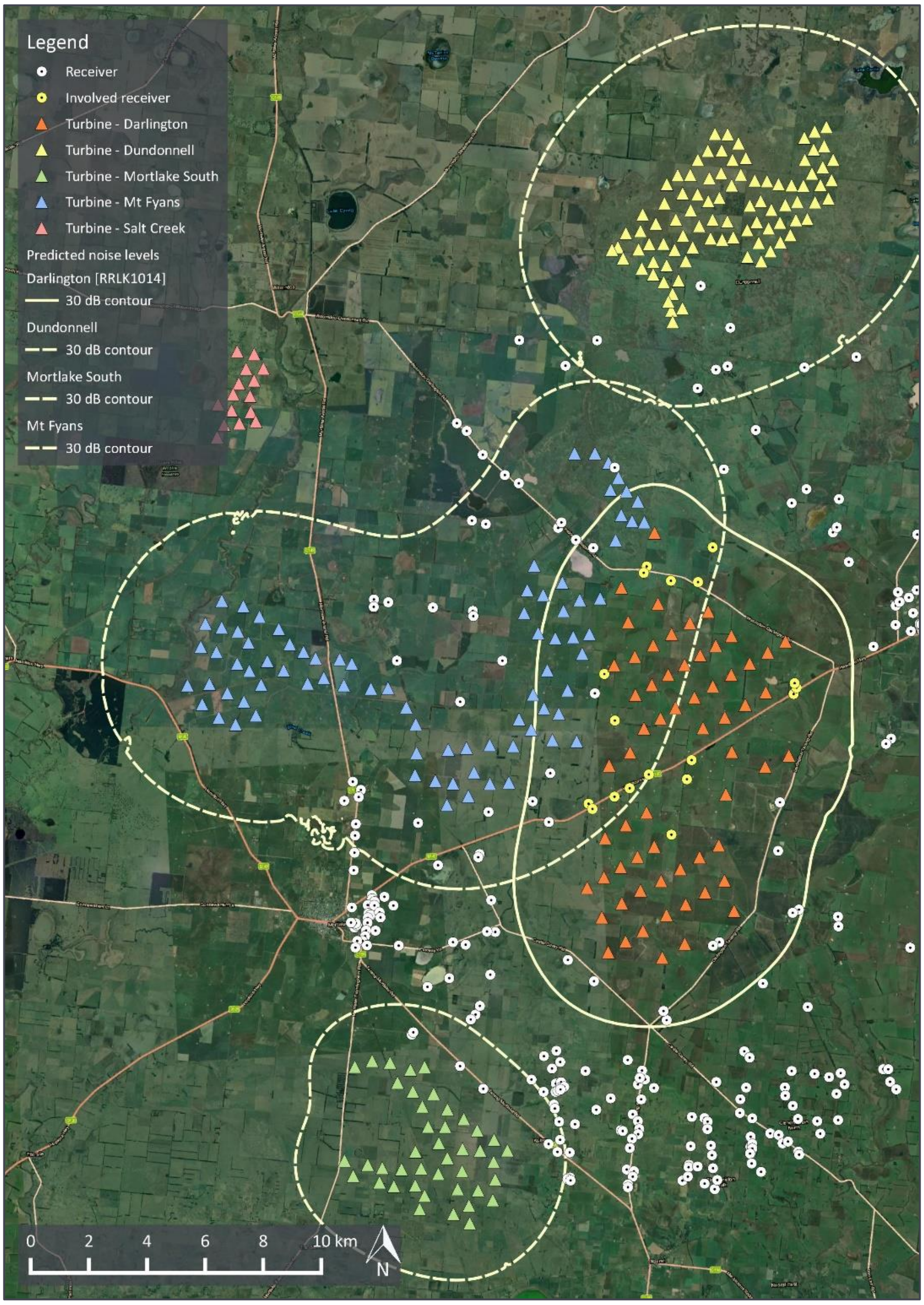
10 MDA Report Rp 001 2012102ML *Mt Fyans Wind Farm – EES initial submission – Acoustic considerations and preliminary predictions*, dated 9 February 2017

Additional contextual information is provided in the commentary to Clause 5.6.4 which notes:

> *If an existing wind farm sound level is say 40 dB and the predicted wind farm sound level for a new wind farm is say 30 dB then the combined level would be 40.4 dB. This increase of less than 0.5 dB cannot be reliably measured and would be undetectable to people, and will therefore not give rise to any adverse cumulative effect.*

Based on this guidance, a preliminary simplified assessment of potential cumulative noise considerations can be made by comparing the individual predicted 30 dB L_{A90} contours of each wind farm operating in isolation [11], as presented in Figure 5.

Figure 5: Predicted 30 dB L_{A90} contours for the Darlington Wind Farm and neighbouring wind farms



[11] GE 6.0-164 wind turbine model used for the Darlington Wind Farm

The results demonstrate that the predicted 30 dB L_{A90} contour of the Darlington Wind Farm (using the GE 6.0-164 candidate turbine model) do not overlap with the predicted 30 dB L_{A90} contour of the Dundonnell and Mortlake South wind farms. Based on this finding, the following can be concluded for these two neighbouring wind farms:

- At any receiver where the predicted noise level of one of the wind farms is between 30 and 40 dB, the predicted noise level from an adjoining wind farm will be less than 30 dB, and significantly lower in most cases
- At any receiver where the predicted noise level from one of the wind farms approaches the 40 dB base noise limit applicable to the sites, the predicted noise level associated with one of the two neighbouring wind farms will be more than 10 dB lower. Based on the guidance of NZS 6808, the cumulative effect does not need to be taken in account for the nearest receivers to each of these wind farm developments.

The predicted noise levels therefore demonstrate that cumulative wind farm noise considerations between the Darlington Wind Farm, the Dundonnell Wind Farm and the Mortlake South Wind Farm are not applicable. Specifically, the noise contribution of the Dundonnell and Mortlake South wind farms is sufficiently low to be inconsequential to the noise assessment for the Darlington Wind Farm. The predicted noise contribution of the Darlington Wind Farm at the receivers in the vicinity of the Dundonnell and Mortlake South wind farms would not affect the compliance outcomes for these developments.

As a visual guide to identify potential cumulative noise considerations between the Darlington Wind Farm and the proposed Mt Fyans Wind Farm, Figure 6 presents the overlap area between the respective predicted 30 dB L_{A90} noise contours.

Figure 6: Predicted 30 dB L_{A90} contours for the Darlington Wind Farm and Mt Fyans wind farm (overlap area)

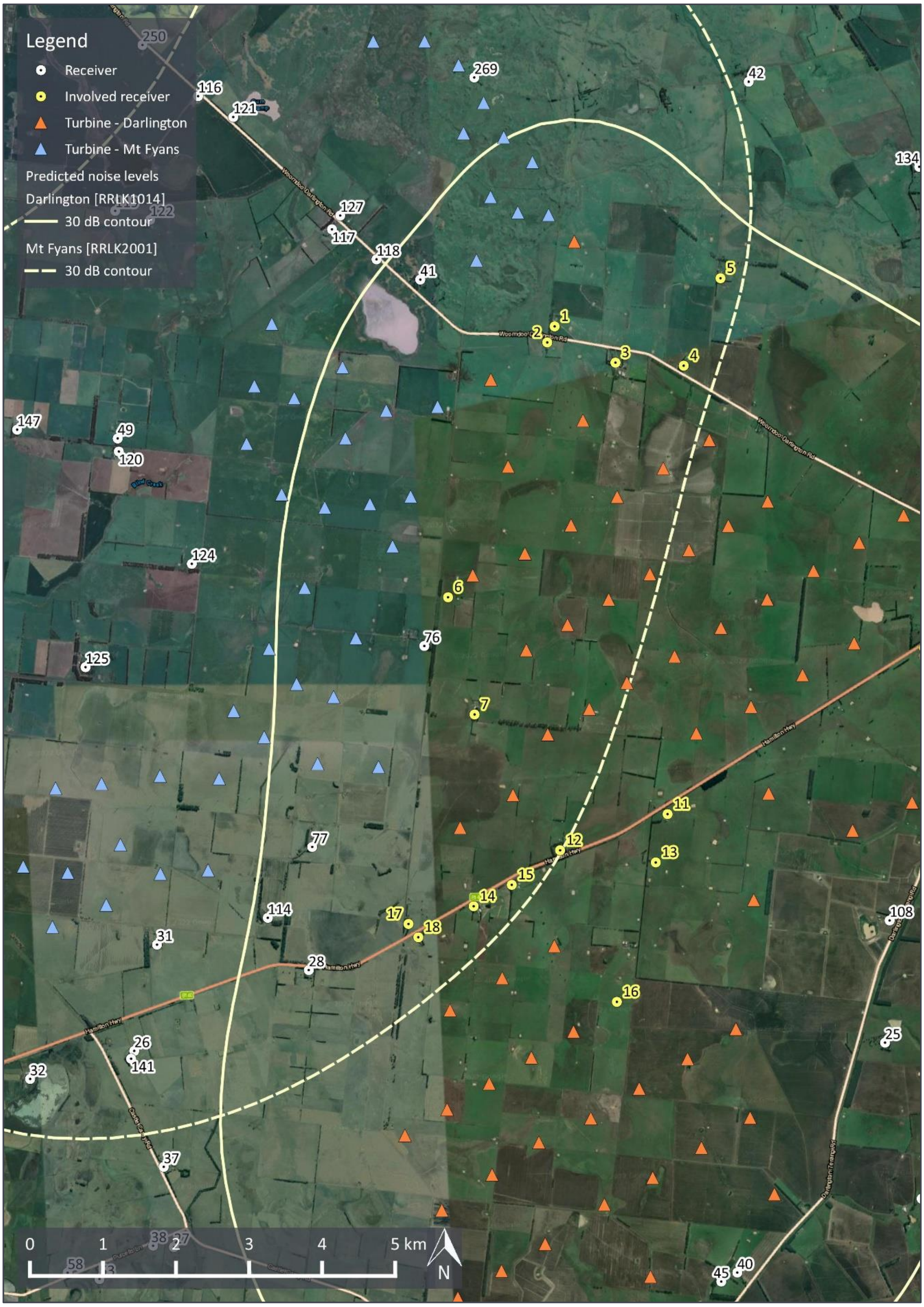


Table 8 presents predicted cumulative noise levels for the receivers within the intersection of 30 dB L_{A90} noise contours from the Darlington Wind Farm (using the GE 6.0-164 candidate turbine model) and the proposed Mt Fyans Wind Farm.

The predicted noise levels presented in Table 8 are for the wind speeds which give rise to the highest noise emissions from each site respectively. It is also noted that the noise level 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[12] for the purpose of considering cumulative noise levels.

Table 8: Cumulative assessment

Receiver	Predicted noise level, dB L_{A90}			Change in compliance outcome due to cumulative effects
	Darlington only	Mt Fyans only	Cumulative	
1 (S)	37.7	36.9	40.3	No
2 (S)	38.6	36.6	40.7	No
3 (S)	38.7	33.4	39.8	No
4 (S)	37.8	31.1	38.6	No
5 (S)	32.4	30.8	34.7	No
6 (S)	43.3	38.9	44.6	No
7 (S)	39.8	35.7	41.2	No
12 (S)	39.2	30.1	39.7	No
14 (S)	39.5	31.4	40.1	No
15 (S)	39.9	30.8	40.4	No
17 (S)	37.0	32.6	38.3	No
18 (S)	38.0	31.9	39.0	No
28	32.8	33.5	36.2	No
41*	32.0	40.0	40.6	No
76*	37.5	39.4	41.6	No
77*	31.9	38.8	39.6	No
114*	30.6	37.6	38.4	No

(S) Involved receiver for the Darlington Wind Farm
* Involved receiver for the Mt Fyans Wind Farm

It can be concluded from the above table that the compliance outcome for both the Darlington Wind Farm and the proposed Mt Fyans Wind Farm would not be affected by the noise contribution from the other project.

12 By a margin of up to 3 dB when compared to downwind predictions from each wind farm individually. This is distinct to variation of noise levels when a receiver is upwind of each wind farm when noise levels would be significantly lower than the downwind predictions.

7.0 SUBSTATION NOISE ASSESSMENT

7.1 Noise limits

The Noise Protocol procedure for determining noise limits depends on whether the noise source or the receivers are located in a rural or 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 substation 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 substation 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 substation (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 substation would be defined in the Victorian Planning Provisions as a *utility*, the noise limits applicable at the nearest receivers, are summarised in Table 9.

Table 9: Noise Protocol time periods and noise limits&, dB L_{eff} [13]

Period	Day of week	Start time	End time	Noise limit
Day	Monday-Friday	0700hrs	1800hrs	45
	Saturday	0700hrs	1300hrs	
Evening	Monday-Friday	1800hrs	2200hrs	39
	Saturday	1300hrs	2200hrs	
	Sunday, Public holidays	0700hrs	2200hrs	
Night	Monday-Sunday	2200hrs	0700hrs	34

As the substation 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.

[13] L_{eff} is the effective noise level of commercial or industrial noise determined in accordance with SEPP N-1. This is 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 Transformer noise emissions

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 feasibility of the substation, the proponent advised the following transformers are proposed:

- Three (3) 22/132kv transformers each rated to 210 MVA each; and
- One (1) 132/500 kV transformer rated to 420 MVA.

In lieu of manufacturer 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) which provides a method for estimating transformer sound power levels. Specifically, Figure ZA1 from AS 60076-10 has been used to determine estimated sound power levels of 99 and 103 dB L_{WA}, for the individual 210 and 420 MVA transformers, respectively.

The sound power levels include the noise from ancillary plant such as cooling plant. AS 60076-10 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.

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.

The predicted noise level from the substation at the nearest receiver (involved receiver 11), located approximately 950 m to the south-southeast, is 34 dB L_{eff} (including the +2 dB adjustment for potential tonality). At the nearest non-involved receiver (receiver 76, approximately 3.2 km to the northwest), the predicted noise level from the substation is 19 dB L_{eff} (including the +2 dB adjustment for potential tonality).

The predicted effective noise levels do not exceed the noise limits applicable to the day, evening and night periods. As such, noise from the proposed substation is not prescribed to be unreasonable for the purposes of the EP Act

However, considering noise levels from the proposed substation associated with the wind farm are predicted at the applicable night-time noise limit, it would need to be considered during the subsequent planning and design stages of the wind farm, at the time when equipment selections are finalised, accounting for manufacturer noise emission data.

In order to address the general environmental duty under the EP Act, all reasonably practicable noise mitigation measures, including selection of transformer with noise emissions lower than the AS 60076-10 empirical values referenced in this assessment, must be considered and implemented during the subsequent stages of the development application. It is noted that actual noise emission values for contemporary transformer designs are usually lower than the empirical values of the standard. Accordingly, this is considered a reasonably practicable noise mitigation measure of the purposes of the EP Act.

8.0 RECOMMENDED NOISE MANAGEMENT MEASURES

Provided that the operator of a wind farm complies with the requirements of Regulation 131C, their obligations with respect to the general environmental duty (GED) under the EP Act will be addressed with regard to wind turbine noise.

Specifically, to address the GED under the EP Act with respect to wind turbine noise, the operator of the wind farm:

- Must ensure that wind turbine noise complies with NZS 6808; and
- Must implement all applicable actions under Division 5.3 of the EP Regulations to manage and review wind turbine noise from the facility, including:
  - preparation of a noise management plan;
  - conducting noise compliance testing when the wind farm begins operating;
  - preparing annual compliance statements; and
  - conducting verification wind turbine noise monitoring every 5 years.

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 lower than the empirical values specified in AS 60076-10
- All reasonably practicable measures available to reduce transformer noise levels should be identified, including consideration of potential alternative locations for the transformers
- A revised noise assessment should be prepared by a qualified acoustic consultant, as part of subsequent stages of the planning process
- 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 substation
  - compliance with the applicable noise limits at surrounding receivers
  - recommendation of reasonably practicable noise mitigation measures to control noise from the substation.
- 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 Darlington Wind Farm has been carried out based on the proposed wind farm layout comprising sixty-one (61) multi-megawatt wind turbines and a substation.

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* (EP Regulations) and the Victorian Department of Environment, Land, Water and Planning publication *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines* dated November 2021.

Noise modelling was carried out based three (3) candidate wind turbine models which have been selected by the proponent as being representative of the size and type of wind turbines which could be used at the site.

The results of the modelling demonstrate that the proposed wind turbines are predicted to achieve compliance with the applicable noise limits determined in accordance with NZS 6808 for all selected candidate wind turbine models.

The assessment has also considered operational noise associated with the proposed substation. These noise levels have been assessed in accordance with the *Environment Protection Act 2017* (EP Act) and EP Regulations. The assessment demonstrates that the substation is expected to result in noise levels below the noise limits determined in accordance with the Victorian 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.

Consideration was also given to the general environmental duty, as required by the EP Act.

The noise assessment therefore demonstrates that the proposed Darlington Wind Farm 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 SOURCE COORDINATES

The following table sets out the coordinates of the proposed wind turbine layout.

(Reference V17B, supplied by the proponent on 7 June 2022).

Table 10: Wind turbine coordinates – MGA 94 zone 54

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
DG01	670,555	5,796,326	168
DG02	669,293	5,794,516	160
DG03	669,452	5,793,316	160
DG04	670,516	5,793,879	160
DG05	668,874	5,791,864	160
DG06	669,605	5,792,113	160
DG07	670,260	5,792,460	160
DG08	670,915	5,792,806	160
DG09	671,570	5,793,153	160
DG10	672,225	5,793,500	160
DG11	669,539	5,790,794	159
DG12	670,124	5,791,104	160
DG13	670,709	5,791,413	160
DG14	671,294	5,791,723	160
DG15	671,849	5,792,017	160
DG16	672,409	5,792,313	160
DG17	672,968	5,792,609	158
DG18	669,757	5,789,625	158
DG19	670,348	5,789,938	160
DG20	670,885	5,790,262	160
DG21	671,559	5,790,579	160
DG22	672,217	5,790,927	159
DG23	672,875	5,791,275	157
DG24	673,533	5,791,624	155
DG25	674,181	5,791,967	153
DG26	674,812	5,792,301	152
DG27	668,479	5,788,432	154
DG28	669,230	5,788,829	156
DG29	671,788	5,789,509	160

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
DG30	672,559	5,789,824	159
DG31	673,291	5,790,212	155
DG32	674,024	5,790,599	152
DG33	672,724	5,788,627	160
DG34	672,426	5,787,185	159
DG35	673,838	5,788,045	160
DG36	674,675	5,788,376	153
DG37	668,179	5,785,949	152
DG38	668,920	5,786,342	157
DG39	669,661	5,786,734	160
DG40	667,453	5,784,281	148
DG41	668,052	5,784,598	149
DG42	668,650	5,784,915	150
DG43	669,249	5,785,231	157
DG44	669,848	5,785,548	160
DG45	667,891	5,783,228	148
DG46	668,609	5,783,668	153
DG47	669,277	5,784,067	158
DG48	670,007	5,784,349	160
DG49	670,694	5,784,712	158
DG50	671,381	5,785,076	157
DG51	672,068	5,785,440	156
DG52	668,033	5,782,019	150
DG53	668,653	5,782,347	153
DG54	669,273	5,782,676	158
DG55	670,116	5,783,163	160
DG56	670,801	5,783,484	158
DG57	671,492	5,783,851	151
DG58	672,184	5,784,217	150
DG59	669,877	5,781,711	160
DG60	670,682	5,782,137	160
DG61	672,449	5,783,154	150

The following table sets out the coordinates created by MDA from the centroid of the proposed substation area provided by the proponent on 27 May 2022.

Table 11: Substation coordinates – MGA 94 zone 54

Item	Easting, m	Northing, m	Terrain elevation, m
Substation	670,905	5,789,286	160

APPENDIX C RECEIVER COORDINATES

The following table sets out the ninety-eight (98) assessed receivers located within 5 km of the proposed wind turbines considered in the environmental noise assessment, and their distance to the nearest wind turbine. This includes eighteen (18) involved receivers.

(Data supplied by the proponent on 14 July 2022).

Table 12: Receivers within 5 km of the proposed wind turbines – MGA 94 zone 54

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
1 (S)	670,212	5,795,187	164	1,147	DG02
2 (S)	670,097	5,794,974	163	937	DG02
3 (S)	671,011	5,794,638	160	918	DG04
4 (S)	671,940	5,794,536	160	1,085	DG10
5 (S)	672,520	5,795,697	160	2,069	DG01
6 (S)	668,517	5,791,584	159	476	DG05
7 (S)	668,776	5,789,962	156	1,048	DG18
8 (S)	674,976	5,790,476	150	971	DG32
9 (S)	675,089	5,790,687	150	1,079	DG32
10 (S)	675,033	5,790,847	150	1,049	DG32
11 (S)	671,325	5,788,432	160	1,181	DG29
12 (S)	669,824	5,788,033	158	1,004	DG28
13 (S)	671,121	5,787,783	160	1,443	DG34
14 (S)	668,594	5,787,346	156	1,066	DG38
15 (S)	669,134	5,787,605	157	1,029	DG39
16 (S)	670,466	5,785,915	160	734	DG44
17 (S)	667,688	5,787,162	151	1,317	DG37
18 (S)	667,811	5,786,972	151	1,097	DG37
20	669,302	5,777,251	150	4,500	DG59
22	668,840	5,776,888	150	4,936	DG59
23	668,759	5,777,410	150	4,447	DG59
25	674,094	5,785,122	150	2,056	DG51
26	663,830	5,785,673	150	3,884	DG40
27	664,199	5,782,962	138	3,515	DG40
28	666,285	5,786,621	148	2,015	DG37
29	666,141	5,778,351	137	4,130	DG52
30	666,032	5,778,745	137	3,839	DG52

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
31	664,235	5,787,102	150	4,112	DG37
33	672,486	5,778,308	145	4,236	DG60
34	674,763	5,779,691	140	4,760	DG60
35	676,004	5,782,729	140	4,102	DG58
36	675,997	5,782,390	140	4,230	DG58
37	664,130	5,784,065	140	3,333	DG40
38	663,915	5,782,998	138	3,766	DG40
39	673,278	5,780,598	150	3,021	DG60
40	671,872	5,782,115	153	1,199	DG60
41	668,417	5,795,943	161	1,681	DG02
42	673,078	5,798,353	167	3,240	DG01
45	671,646	5,782,007	155	983	DG60
46	674,681	5,783,056	140	2,757	DG58
48	676,684	5,795,946	159	4,100	DG26
50	665,941	5,777,618	135	4,875	DG52
51	666,125	5,777,657	135	4,764	DG52
52	679,548	5,792,333	150	4,738	DG26
53	663,154	5,782,591	136	4,622	DG40
56	678,678	5,793,287	150	3,992	DG26
57	677,165	5,794,892	155	3,503	DG26
58	662,724	5,782,706	134	4,987	DG40
59	663,933	5,781,508	135	4,134	DG52
60	679,783	5,792,602	150	4,982	DG26
64	663,507	5,780,457	133	4,790	DG52
66	679,715	5,792,610	150	4,914	DG26
67	679,705	5,792,540	150	4,901	DG26
68	669,890	5,779,552	151	2,164	DG59
69	669,801	5,779,873	153	1,846	DG59
71	672,655	5,778,081	144	4,513	DG60
74	667,481	5,781,051	142	1,124	DG52
75	666,631	5,781,840	140	1,420	DG52
76	668,150	5,790,941	157	1,182	DG05
77	666,441	5,788,298	150	2,047	DG27

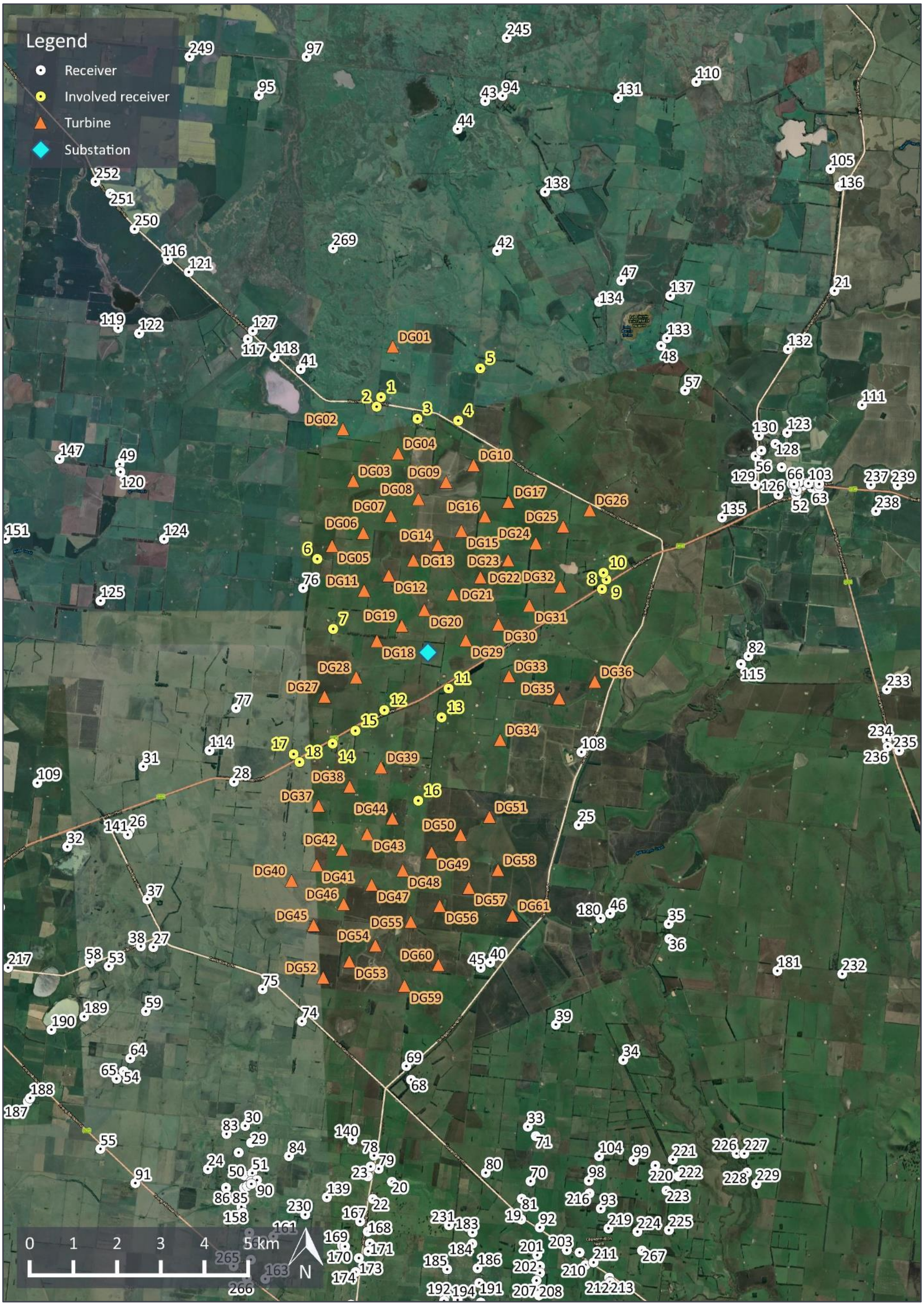
Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
78	668,932	5,777,876	150	3,953	DG59
79	669,017	5,777,566	150	4,236	DG59
80	671,457	5,777,317	150	4,672	DG59
82	678,222	5,788,730	142	3,567	DG36
83	665,594	5,778,587	135	4,213	DG52
84	666,987	5,777,987	139	4,168	DG52
87	666,087	5,777,465	135	4,955	DG52
88	668,837	5,777,632	150	4,213	DG59
89	665,843	5,778,145	136	4,452	DG52
90	666,222	5,777,489	135	4,881	DG52
100	678,820	5,793,405	150	4,159	DG26
101	679,259	5,792,994	150	4,503	DG26
102	679,620	5,792,623	150	4,821	DG26
106	679,519	5,792,450	150	4,711	DG26
107	679,571	5,792,439	150	4,763	DG26
108	674,264	5,786,785	153	1,338	DG35
112	679,462	5,792,602	150	4,662	DG26
113	679,516	5,792,587	150	4,715	DG26
114	665,772	5,787,370	150	2,799	DG37
115	678,038	5,788,558	145	3,371	DG36
117	667,256	5,796,707	160	2,995	DG02
118	667,838	5,796,258	160	2,275	DG02
121	666,006	5,798,326	164	4,971	DG01
123	679,436	5,793,774	150	4,855	DG26
124	665,046	5,792,267	160	3,852	DG05
126	679,143	5,792,374	150	4,333	DG26
127	667,380	5,796,888	160	3,051	DG02
128	679,150	5,793,536	150	4,513	DG26
129	678,631	5,792,628	150	3,835	DG26
130	678,786	5,793,747	150	4,231	DG26
133	676,828	5,796,111	159	4,312	DG26
134	675,333	5,797,042	160	4,715	DG10
135	677,822	5,791,933	150	3,035	DG26

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
138	674,260	5,799,633	170	4,968	DG01
140	668,463	5,778,270	146	3,724	DG59
141	663,780	5,785,569	150	3,895	DG40
180	674,456	5,782,960	140	2,600	DG58
269	669,333	5,798,653	174	2,633	DG01

(S) Involved receiver

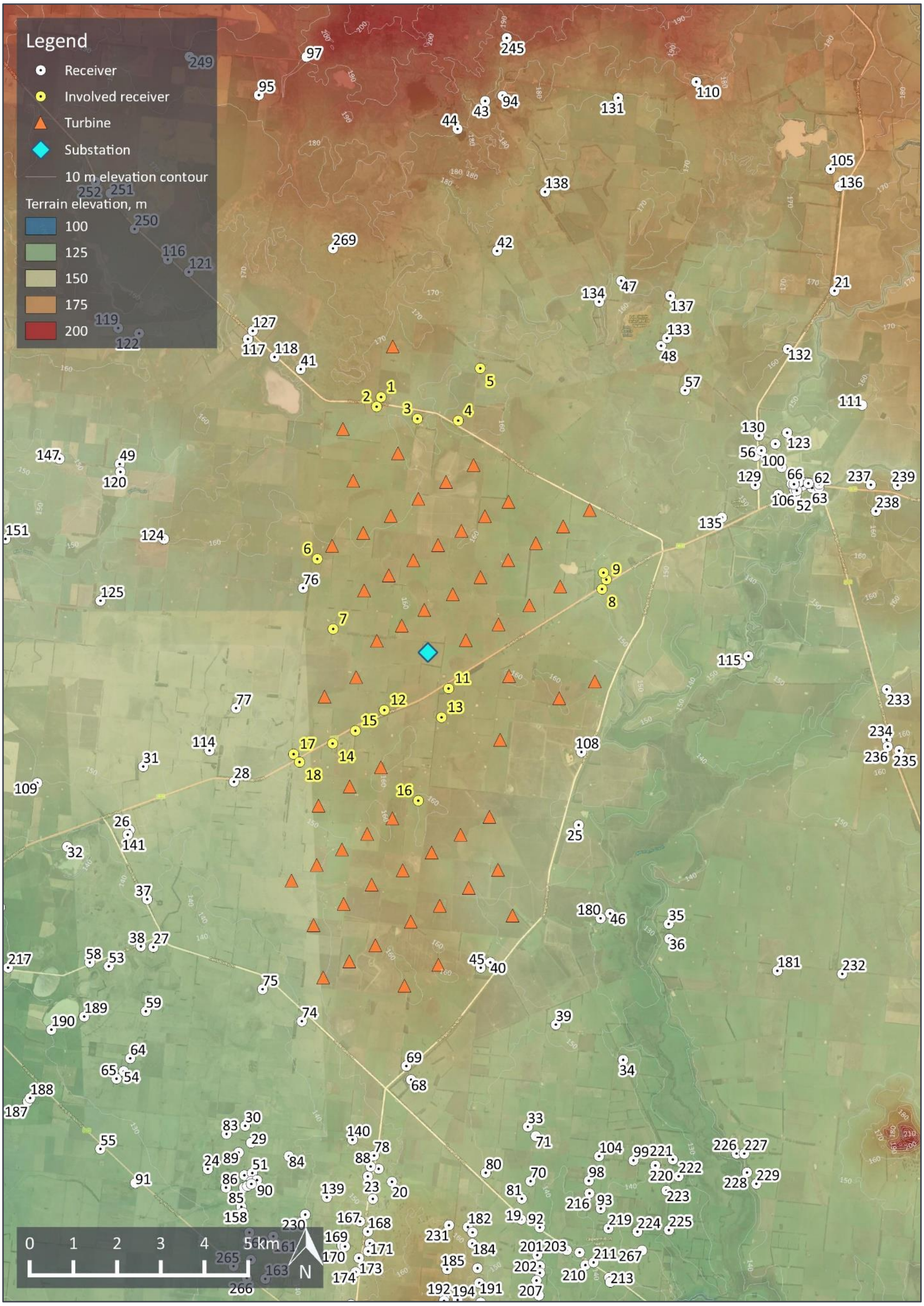
APPENDIX D SITE LAYOUT PLAN

Figure 7: Proposed wind turbine layout, substation and receivers



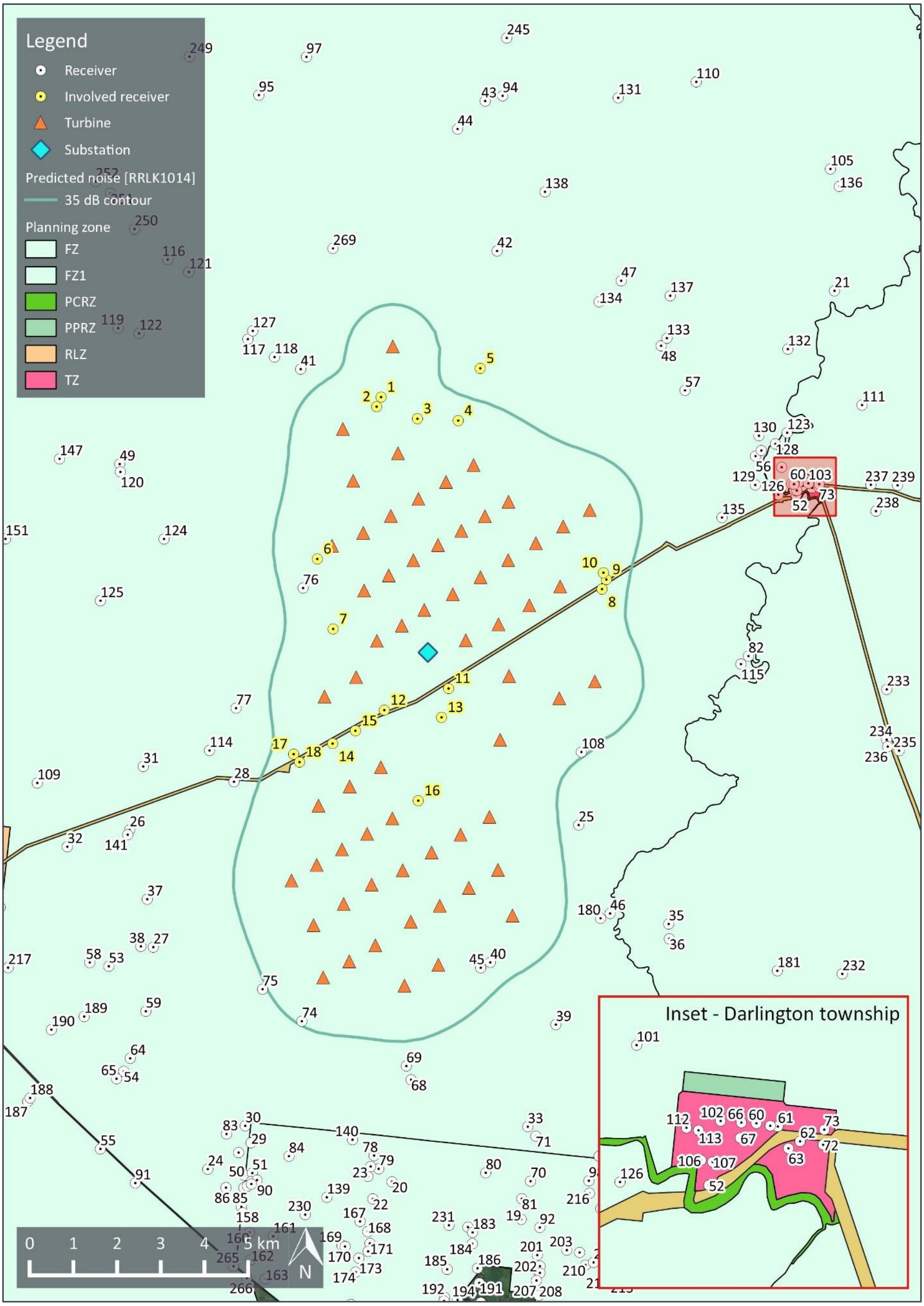
APPENDIX E SITE TOPOGRAPHY

Figure 8: Terrain elevation map for the wind farm and surrounding area



APPENDIX F ZONING MAP

Figure 9: Zoning map for the wind farm and surrounding area



APPENDIX G NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods. The international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors* (ISO 9613-2) 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 9613-2, the noise emissions of each wind 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 9613-2 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 wind 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 °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 9613-2 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 9613-2 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 9613-2 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 methods such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613-2 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 9613-2 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[14, 15, 16] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613-2 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 9613-2 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 9613-2;
- 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.

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14 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.

15 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.

16 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 9613-2 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 wind turbine being represented by a single noise source located at the maximum tip height of the wind turbine rotor
- An adjustment of 3 dB is added to the predicted noise contribution of a wind turbine if the terrain between the wind 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 wind turbine and receiver pairing, and then subsequently applies the adjustments to each wind 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 wind turbines are operating simultaneously at their maximum noise emissions and that each receiver is simultaneously downwind of every wind 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 13: Predicted noise levels, dB L_{A90} – SG 6.6-170

Receiver	Hub-height wind speed, m/s							
	4	5	6	7	8	9	10	11	≥12
1 (S)	22.2	24.7	28.6	32.0	34.9	36.7	36.7	36.7	36.7
2 (S)	23.1	25.6	29.5	32.9	35.8	37.6	37.6	37.6	37.6
3 (S)	23.2	25.7	29.6	33.0	35.9	37.7	37.7	37.7	37.7
4 (S)	22.3	24.8	28.7	32.1	35.0	36.8	36.8	36.8	36.8
5 (S)	17.1	19.6	23.5	26.9	29.8	31.6	31.6	31.6	31.6
6 (S)	28.0	30.5	34.4	37.8	40.7	42.5	42.5	42.5	42.5
7 (S)	24.3	26.8	30.7	34.1	37.0	38.8	38.8	38.8	38.8
8 (S)	22.6	25.1	29.0	32.4	35.3	37.1	37.1	37.1	37.1
9 (S)	22.2	24.7	28.6	32.0	34.9	36.7	36.7	36.7	36.7
10 (S)	22.7	25.2	29.1	32.5	35.4	37.2	37.2	37.2	37.2
11 (S)	23.4	25.9	29.8	33.2	36.1	37.9	37.9	37.9	37.9
12 (S)	23.7	26.2	30.1	33.5	36.4	38.2	38.2	38.2	38.2
13 (S)	22.1	24.6	28.5	31.9	34.8	36.6	36.6	36.6	36.6
14 (S)	24.0	26.5	30.4	33.8	36.7	38.5	38.5	38.5	38.5
15 (S)	24.4	26.9	30.8	34.2	37.1	38.9	38.9	38.9	38.9
16 (S)	26.3	28.8	32.7	36.1	39.0	40.8	40.8	40.8	40.8
17 (S)	21.6	24.1	28.0	31.4	34.3	36.1	36.1	36.1	36.1
18 (S)	22.6	25.1	29.0	32.4	35.3	37.1	37.1	37.1	37.1
20	9.8	12.3	16.2	19.6	22.5	24.3	24.3	24.3	24.3
22	9.1	11.6	15.5	18.9	21.8	23.6	23.6	23.6	23.6
23	10.0	12.5	16.4	19.8	22.7	24.5	24.5	24.5	24.5
25	17.9	20.4	24.3	27.7	30.6	32.4	32.4	32.4	32.4
26	12.1	14.6	18.5	21.9	24.8	26.6	26.6	26.6	26.6
27	12.5	15.0	18.9	22.3	25.2	27.0	27.0	27.0	27.0
28	17.4	19.9	23.8	27.2	30.1	31.9	31.9	31.9	31.9
29	10.1	12.6	16.5	19.9	22.8	24.6	24.6	24.6	24.6
30	10.6	13.1	17.0	20.4	23.3	25.1	25.1	25.1	25.1
31	12.4	14.9	18.8	22.2	25.1	26.9	26.9	26.9	26.9
33	10.6	13.1	17.0	20.4	23.3	25.1	25.1	25.1	25.1
34	10.5	13.0	16.9	20.3	23.2	25.0	25.0	25.0	25.0

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
35	12.0	14.5	18.4	21.8	24.7	26.5	26.5	26.5	26.5
36	11.7	14.2	18.1	21.5	24.4	26.2	26.2	26.2	26.2
37	12.7	15.2	19.1	22.5	25.4	27.2	27.2	27.2	27.2
38	11.9	14.4	18.3	21.7	24.6	26.4	26.4	26.4	26.4
39	14.1	16.6	20.5	23.9	26.8	28.6	28.6	28.6	28.6
40	22.3	24.8	28.7	32.1	35.0	36.8	36.8	36.8	36.8
41	16.6	19.1	23.0	26.4	29.3	31.1	31.1	31.1	31.1
42	10.9	13.4	17.3	20.7	23.6	25.4	25.4	25.4	25.4
45	22.7	25.2	29.1	32.5	35.4	37.2	37.2	37.2	37.2
46	15.2	17.7	21.6	25.0	27.9	29.7	29.7	29.7	29.7
48	10.9	13.4	17.3	20.7	23.6	25.4	25.4	25.4	25.4
50	8.8	11.3	15.2	18.6	21.5	23.3	23.3	23.3	23.3
51	9.0	11.5	15.4	18.8	21.7	23.5	23.5	23.5	23.5
52	9.5	12.0	15.9	19.3	22.2	24.0	24.0	24.0	24.0
53	10.3	12.8	16.7	20.1	23.0	24.8	24.8	24.8	24.8
56	10.5	13.0	16.9	20.3	23.2	25.0	25.0	25.0	25.0
57	11.5	14.0	17.9	21.3	24.2	26.0	26.0	26.0	26.0
58	9.7	12.2	16.1	19.5	22.4	24.2	24.2	24.2	24.2
59	10.9	13.4	17.3	20.7	23.6	25.4	25.4	25.4	25.4
60	9.1	11.6	15.5	18.9	21.8	23.6	23.6	23.6	23.6
64	9.4	11.9	15.8	19.2	22.1	23.9	23.9	23.9	23.9
66	9.2	11.7	15.6	19.0	21.9	23.7	23.7	23.7	23.7
67	9.2	11.7	15.6	19.0	21.9	23.7	23.7	23.7	23.7
68	15.4	17.9	21.8	25.2	28.1	29.9	29.9	29.9	29.9
69	16.7	19.2	23.1	26.5	29.4	31.2	31.2	31.2	31.2
71	10.2	12.7	16.6	20.0	22.9	24.7	24.7	24.7	24.7
74	20.2	22.7	26.6	30.0	32.9	34.7	34.7	34.7	34.7
75	19.0	21.5	25.4	28.8	31.7	33.5	33.5	33.5	33.5
76	22.0	24.5	28.4	31.8	34.7	36.5	36.5	36.5	36.5
77	16.6	19.1	23.0	26.4	29.3	31.1	31.1	31.1	31.1
78	10.9	13.4	17.3	20.7	23.6	25.4	25.4	25.4	25.4
79	10.3	12.8	16.7	20.1	23.0	24.8	24.8	24.8	24.8

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
80	9.6	12.1	16.0	19.4	22.3	24.1	24.1	24.1	24.1
82	11.8	14.3	18.2	21.6	24.5	26.3	26.3	26.3	26.3
83	9.9	12.4	16.3	19.7	22.6	24.4	24.4	24.4	24.4
84	10.2	12.7	16.6	20.0	22.9	24.7	24.7	24.7	24.7
87	8.7	11.2	15.1	18.5	21.4	23.2	23.2	23.2	23.2
88	10.4	12.9	16.8	20.2	23.1	24.9	24.9	24.9	24.9
89	9.5	12.0	15.9	19.3	22.2	24.0	24.0	24.0	24.0
90	8.9	11.4	15.3	18.7	21.6	23.4	23.4	23.4	23.4
100	10.2	12.7	16.6	20.0	22.9	24.7	24.7	24.7	24.7
101	9.7	12.2	16.1	19.5	22.4	24.2	24.2	24.2	24.2
102	9.3	11.8	15.7	19.1	22.0	23.8	23.8	23.8	23.8
106	9.5	12.0	15.9	19.3	22.2	24.0	24.0	24.0	24.0
107	9.5	12.0	15.9	19.3	22.2	24.0	24.0	24.0	24.0
108	20.0	22.5	26.4	29.8	32.7	34.5	34.5	34.5	34.5
112	9.6	12.1	16.0	19.4	22.3	24.1	24.1	24.1	24.1
113	9.5	12.0	15.9	19.3	22.2	24.0	24.0	24.0	24.0
114	15.4	17.9	21.8	25.2	28.1	29.9	29.9	29.9	29.9
115	12.1	14.6	18.5	21.9	24.8	26.6	26.6	26.6	26.6
117	12.3	14.8	18.7	22.1	25.0	26.8	26.8	26.8	26.8
118	14.3	16.8	20.7	24.1	27.0	28.8	28.8	28.8	28.8
121	8.6	11.1	15.0	18.4	21.3	23.1	23.1	23.1	23.1
123	9.1	11.6	15.5	18.9	21.8	23.6	23.6	23.6	23.6
124	12.3	14.8	18.7	22.1	25.0	26.8	26.8	26.8	26.8
126	10.1	12.6	16.5	19.9	22.8	24.6	24.6	24.6	24.6
127	12.2	14.7	18.6	22.0	24.9	26.7	26.7	26.7	26.7
128	9.6	12.1	16.0	19.4	22.3	24.1	24.1	24.1	24.1
129	10.9	13.4	17.3	20.7	23.6	25.4	25.4	25.4	25.4
130	10.0	12.5	16.4	19.8	22.7	24.5	24.5	24.5	24.5
133	10.5	13.0	16.9	20.3	23.2	25.0	25.0	25.0	25.0
134	10.9	13.4	17.3	20.7	23.6	25.4	25.4	25.4	25.4
135	12.7	15.2	19.1	22.5	25.4	27.2	27.2	27.2	27.2
138	8.3	10.8	14.7	18.1	21.0	22.8	22.8	22.8	22.8

Receiver	Hub-height wind speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
140	11.5	14.0	17.9	21.3	24.2	26.0	26.0	26.0	26.0
141	12.0	14.5	18.4	21.8	24.7	26.5	26.5	26.5	26.5
180	15.8	18.3	22.2	25.6	28.5	30.3	30.3	30.3	30.3
269	11.4	13.9	17.8	21.2	24.1	25.9	25.9	25.9	25.9

(S) Involved receiver

Table 14: Predicted noise levels, dB L_{A90} – GE 6.0-164

Receiver	Hub-height wind speed, m/s							
	4	5	6	7	8	9	10	11	≥12
1 (S)	24.5	26.4	29.9	33.2	35.4	37.4	37.7	37.7	37.7
2 (S)	25.4	27.3	30.8	34.1	36.3	38.3	38.6	38.6	38.6
3 (S)	25.5	27.4	30.9	34.2	36.4	38.4	38.7	38.7	38.7
4 (S)	24.6	26.5	30.0	33.3	35.5	37.5	37.8	37.8	37.8
5 (S)	19.2	21.1	24.6	27.9	30.1	32.1	32.4	32.4	32.4
6 (S)	30.1	32.0	35.5	38.8	41.0	43.0	43.3	43.3	43.3
7 (S)	26.6	28.5	32.0	35.3	37.5	39.5	39.8	39.8	39.8
8 (S)	24.9	26.8	30.3	33.6	35.8	37.8	38.1	38.1	38.1
9 (S)	24.5	26.4	29.9	33.2	35.4	37.4	37.7	37.7	37.7
10 (S)	25.0	26.9	30.4	33.7	35.9	37.9	38.2	38.2	38.2
11 (S)	25.7	27.6	31.1	34.4	36.6	38.6	38.9	38.9	38.9
12 (S)	26.0	27.9	31.4	34.7	36.9	38.9	39.2	39.2	39.2
13 (S)	24.4	26.3	29.8	33.1	35.3	37.3	37.6	37.6	37.6
14 (S)	26.3	28.2	31.7	35.0	37.2	39.2	39.5	39.5	39.5
15 (S)	26.7	28.6	32.1	35.4	37.6	39.6	39.9	39.9	39.9
16 (S)	28.6	30.5	34.0	37.3	39.5	41.5	41.8	41.8	41.8
17 (S)	23.8	25.7	29.2	32.5	34.7	36.7	37.0	37.0	37.0
18 (S)	24.8	26.7	30.2	33.5	35.7	37.7	38.0	38.0	38.0
20	11.5	13.4	16.9	20.2	22.4	24.4	24.7	24.7	24.7
22	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
23	11.7	13.6	17.1	20.4	22.6	24.6	24.9	24.9	24.9
25	20.0	21.9	25.4	28.7	30.9	32.9	33.2	33.2	33.2
26	13.8	15.7	19.2	22.5	24.7	26.7	27.0	27.0	27.0
27	14.3	16.2	19.7	23.0	25.2	27.2	27.5	27.5	27.5
28	19.6	21.5	25.0	28.3	30.5	32.5	32.8	32.8	32.8
29	11.8	13.7	17.2	20.5	22.7	24.7	25.0	25.0	25.0
30	12.3	14.2	17.7	21.0	23.2	25.2	25.5	25.5	25.5
31	14.2	16.1	19.6	22.9	25.1	27.1	27.4	27.4	27.4
33	12.4	14.3	17.8	21.1	23.3	25.3	25.6	25.6	25.6
34	12.2	14.1	17.6	20.9	23.1	25.1	25.4	25.4	25.4
35	13.7	15.6	19.1	22.4	24.6	26.6	26.9	26.9	26.9

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
36	13.4	15.3	18.8	22.1	24.3	26.3	26.6	26.6	26.6
37	14.5	16.4	19.9	23.2	25.4	27.4	27.7	27.7	27.7
38	13.7	15.6	19.1	22.4	24.6	26.6	26.9	26.9	26.9
39	16.1	18.0	21.5	24.8	27.0	29.0	29.3	29.3	29.3
40	24.6	26.5	30.0	33.3	35.5	37.5	37.8	37.8	37.8
41	18.8	20.7	24.2	27.5	29.7	31.7	32.0	32.0	32.0
42	12.7	14.6	18.1	21.4	23.6	25.6	25.9	25.9	25.9
45	25.1	27.0	30.5	33.8	36.0	38.0	38.3	38.3	38.3
46	17.2	19.1	22.6	25.9	28.1	30.1	30.4	30.4	30.4
48	12.6	14.5	18.0	21.3	23.5	25.5	25.8	25.8	25.8
50	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
51	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
52	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
53	12.0	13.9	17.4	20.7	22.9	24.9	25.2	25.2	25.2
56	12.1	14.0	17.5	20.8	23.0	25.0	25.3	25.3	25.3
57	13.3	15.2	18.7	22.0	24.2	26.2	26.5	26.5	26.5
58	11.4	13.3	16.8	20.1	22.3	24.3	24.6	24.6	24.6
59	12.7	14.6	18.1	21.4	23.6	25.6	25.9	25.9	25.9
60	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
64	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
66	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
67	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
68	17.5	19.4	22.9	26.2	28.4	30.4	30.7	30.7	30.7
69	18.8	20.7	24.2	27.5	29.7	31.7	32.0	32.0	32.0
71	11.9	13.8	17.3	20.6	22.8	24.8	25.1	25.1	25.1
74	22.4	24.3	27.8	31.1	33.3	35.3	35.6	35.6	35.6
75	21.2	23.1	26.6	29.9	32.1	34.1	34.4	34.4	34.4
76	24.3	26.2	29.7	33.0	35.2	37.2	37.5	37.5	37.5
77	18.7	20.6	24.1	27.4	29.6	31.6	31.9	31.9	31.9
78	12.7	14.6	18.1	21.4	23.6	25.6	25.9	25.9	25.9
79	12.0	13.9	17.4	20.7	22.9	24.9	25.2	25.2	25.2
80	11.3	13.2	16.7	20.0	22.2	24.2	24.5	24.5	24.5

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
82	13.6	15.5	19.0	22.3	24.5	26.5	26.8	26.8	26.8
83	11.6	13.5	17.0	20.3	22.5	24.5	24.8	24.8	24.8
84	11.9	13.8	17.3	20.6	22.8	24.8	25.1	25.1	25.1
87	10.4	12.3	15.8	19.1	21.3	23.3	23.6	23.6	23.6
88	12.1	14.0	17.5	20.8	23.0	25.0	25.3	25.3	25.3
89	11.2	13.1	16.6	19.9	22.1	24.1	24.4	24.4	24.4
90	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
100	11.8	13.7	17.2	20.5	22.7	24.7	25.0	25.0	25.0
101	11.3	13.2	16.7	20.0	22.2	24.2	24.5	24.5	24.5
102	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
106	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
107	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
108	22.3	24.2	27.7	31.0	33.2	35.2	35.5	35.5	35.5
112	11.2	13.1	16.6	19.9	22.1	24.1	24.4	24.4	24.4
113	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
114	17.4	19.3	22.8	26.1	28.3	30.3	30.6	30.6	30.6
115	13.9	15.8	19.3	22.6	24.8	26.8	27.1	27.1	27.1
117	14.2	16.1	19.6	22.9	25.1	27.1	27.4	27.4	27.4
118	16.3	18.2	21.7	25.0	27.2	29.2	29.5	29.5	29.5
121	10.2	12.1	15.6	18.9	21.1	23.1	23.4	23.4	23.4
123	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
124	14.0	15.9	19.4	22.7	24.9	26.9	27.2	27.2	27.2
126	11.8	13.7	17.2	20.5	22.7	24.7	25.0	25.0	25.0
127	14.1	16.0	19.5	22.8	25.0	27.0	27.3	27.3	27.3
128	11.2	13.1	16.6	19.9	22.1	24.1	24.4	24.4	24.4
129	12.6	14.5	18.0	21.3	23.5	25.5	25.8	25.8	25.8
130	11.7	13.6	17.1	20.4	22.6	24.6	24.9	24.9	24.9
133	12.2	14.1	17.6	20.9	23.1	25.1	25.4	25.4	25.4
134	12.6	14.5	18.0	21.3	23.5	25.5	25.8	25.8	25.8
135	14.6	16.5	20.0	23.3	25.5	27.5	27.8	27.8	27.8
138	9.8	11.7	15.2	18.5	20.7	22.7	23.0	23.0	23.0
140	13.4	15.3	18.8	22.1	24.3	26.3	26.6	26.6	26.6

Receiver	Hub-height wind speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
141	13.7	15.6	19.1	22.4	24.6	26.6	26.9	26.9	26.9
180	17.8	19.7	23.2	26.5	28.7	30.7	31.0	31.0	31.0
269	13.3	15.2	18.7	22.0	24.2	26.2	26.5	26.5	26.5

(S) Involved receiver

Table 15: Predicted noise levels, dB L_{A90} – V162-6.0MW

Receiver	Hub-height wind speed, m/s							
	4	5	6	7	8	9	10	11	≥12
1 (S)	25.5	25.7	27.6	30.6	33.4	35.5	35.7	35.7	35.7
2 (S)	26.4	26.6	28.5	31.5	34.3	36.4	36.6	36.6	36.6
3 (S)	26.5	26.7	28.6	31.6	34.4	36.5	36.7	36.7	36.7
4 (S)	25.7	25.9	27.8	30.8	33.6	35.7	35.9	35.9	35.9
5 (S)	20.7	20.9	22.8	25.8	28.6	30.7	30.9	30.9	30.9
6 (S)	30.7	30.9	32.8	35.8	38.6	40.7	40.9	40.9	40.9
7 (S)	27.6	27.8	29.7	32.7	35.5	37.6	37.8	37.8	37.8
8 (S)	26.0	26.2	28.1	31.1	33.9	36.0	36.2	36.2	36.2
9 (S)	25.6	25.8	27.7	30.7	33.5	35.6	35.8	35.8	35.8
10 (S)	26.0	26.2	28.1	31.1	33.9	36.0	36.2	36.2	36.2
11 (S)	26.8	27.0	28.9	31.9	34.7	36.8	37.0	37.0	37.0
12 (S)	27.1	27.3	29.2	32.2	35.0	37.1	37.3	37.3	37.3
13 (S)	25.7	25.9	27.8	30.8	33.6	35.7	35.9	35.9	35.9
14 (S)	27.3	27.5	29.4	32.4	35.2	37.3	37.5	37.5	37.5
15 (S)	27.7	27.9	29.8	32.8	35.6	37.7	37.9	37.9	37.9
16 (S)	29.5	29.7	31.6	34.6	37.4	39.5	39.7	39.7	39.7
17 (S)	25.0	25.2	27.1	30.1	32.9	35.0	35.2	35.2	35.2
18 (S)	25.9	26.1	28.0	31.0	33.8	35.9	36.1	36.1	36.1
20	13.1	13.3	15.2	18.2	21.0	23.1	23.3	23.3	23.3
22	12.4	12.6	14.5	17.5	20.3	22.4	22.6	22.6	22.6
23	13.3	13.5	15.4	18.4	21.2	23.3	23.5	23.5	23.5
25	21.5	21.7	23.6	26.6	29.4	31.5	31.7	31.7	31.7
26	15.5	15.7	17.6	20.6	23.4	25.5	25.7	25.7	25.7
27	15.9	16.1	18.0	21.0	23.8	25.9	26.1	26.1	26.1
28	21.0	21.2	23.1	26.1	28.9	31.0	31.2	31.2	31.2
29	13.4	13.6	15.5	18.5	21.3	23.4	23.6	23.6	23.6
30	13.9	14.1	16.0	19.0	21.8	23.9	24.1	24.1	24.1
31	15.8	16.0	17.9	20.9	23.7	25.8	26.0	26.0	26.0
33	14.0	14.2	16.1	19.1	21.9	24.0	24.2	24.2	24.2
34	13.8	14.0	15.9	18.9	21.7	23.8	24.0	24.0	24.0
35	15.3	15.5	17.4	20.4	23.2	25.3	25.5	25.5	25.5

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
36	15.1	15.3	17.2	20.2	23.0	25.1	25.3	25.3	25.3
37	16.2	16.4	18.3	21.3	24.1	26.2	26.4	26.4	26.4
38	15.3	15.5	17.4	20.4	23.2	25.3	25.5	25.5	25.5
39	17.7	17.9	19.8	22.8	25.6	27.7	27.9	27.9	27.9
40	25.6	25.8	27.7	30.7	33.5	35.6	35.8	35.8	35.8
41	20.1	20.3	22.2	25.2	28.0	30.1	30.3	30.3	30.3
42	14.3	14.5	16.4	19.4	22.2	24.3	24.5	24.5	24.5
45	26.1	26.3	28.2	31.2	34.0	36.1	36.3	36.3	36.3
46	18.7	18.9	20.8	23.8	26.6	28.7	28.9	28.9	28.9
48	14.2	14.4	16.3	19.3	22.1	24.2	24.4	24.4	24.4
50	12.0	12.2	14.1	17.1	19.9	22.0	22.2	22.2	22.2
51	12.3	12.5	14.4	17.4	20.2	22.3	22.5	22.5	22.5
52	12.7	12.9	14.8	17.8	20.6	22.7	22.9	22.9	22.9
53	13.6	13.8	15.7	18.7	21.5	23.6	23.8	23.8	23.8
56	13.7	13.9	15.8	18.8	21.6	23.7	23.9	23.9	23.9
57	14.9	15.1	17.0	20.0	22.8	24.9	25.1	25.1	25.1
58	13.0	13.2	15.1	18.1	20.9	23.0	23.2	23.2	23.2
59	14.3	14.5	16.4	19.4	22.2	24.3	24.5	24.5	24.5
60	12.3	12.5	14.4	17.4	20.2	22.3	22.5	22.5	22.5
64	12.7	12.9	14.8	17.8	20.6	22.7	22.9	22.9	22.9
66	12.4	12.6	14.5	17.5	20.3	22.4	22.6	22.6	22.6
67	12.4	12.6	14.5	17.5	20.3	22.4	22.6	22.6	22.6
68	19.0	19.2	21.1	24.1	26.9	29.0	29.2	29.2	29.2
69	20.2	20.4	22.3	25.3	28.1	30.2	30.4	30.4	30.4
71	13.5	13.7	15.6	18.6	21.4	23.5	23.7	23.7	23.7
74	23.5	23.7	25.6	28.6	31.4	33.5	33.7	33.7	33.7
75	22.5	22.7	24.6	27.6	30.4	32.5	32.7	32.7	32.7
76	25.4	25.6	27.5	30.5	33.3	35.4	35.6	35.6	35.6
77	20.2	20.4	22.3	25.3	28.1	30.2	30.4	30.4	30.4
78	14.3	14.5	16.4	19.4	22.2	24.3	24.5	24.5	24.5
79	13.6	13.8	15.7	18.7	21.5	23.6	23.8	23.8	23.8
80	12.8	13.0	14.9	17.9	20.7	22.8	23.0	23.0	23.0

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
82	15.2	15.4	17.3	20.3	23.1	25.2	25.4	25.4	25.4
83	13.2	13.4	15.3	18.3	21.1	23.2	23.4	23.4	23.4
84	13.5	13.7	15.6	18.6	21.4	23.5	23.7	23.7	23.7
87	11.9	12.1	14.0	17.0	19.8	21.9	22.1	22.1	22.1
88	13.7	13.9	15.8	18.8	21.6	23.7	23.9	23.9	23.9
89	12.7	12.9	14.8	17.8	20.6	22.7	22.9	22.9	22.9
90	12.1	12.3	14.2	17.2	20.0	22.1	22.3	22.3	22.3
100	13.4	13.6	15.5	18.5	21.3	23.4	23.6	23.6	23.6
101	12.9	13.1	15.0	18.0	20.8	22.9	23.1	23.1	23.1
102	12.5	12.7	14.6	17.6	20.4	22.5	22.7	22.7	22.7
106	12.7	12.9	14.8	17.8	20.6	22.7	22.9	22.9	22.9
107	12.6	12.8	14.7	17.7	20.5	22.6	22.8	22.8	22.8
108	23.5	23.7	25.6	28.6	31.4	33.5	33.7	33.7	33.7
112	12.8	13.0	14.9	17.9	20.7	22.8	23.0	23.0	23.0
113	12.7	12.9	14.8	17.8	20.6	22.7	22.9	22.9	22.9
114	19.0	19.2	21.1	24.1	26.9	29.0	29.2	29.2	29.2
115	15.5	15.7	17.6	20.6	23.4	25.5	25.7	25.7	25.7
117	15.7	15.9	17.8	20.8	23.6	25.7	25.9	25.9	25.9
118	17.8	18.0	19.9	22.9	25.7	27.8	28.0	28.0	28.0
121	11.7	11.9	13.8	16.8	19.6	21.7	21.9	21.9	21.9
123	12.2	12.4	14.3	17.3	20.1	22.2	22.4	22.4	22.4
124	15.7	15.9	17.8	20.8	23.6	25.7	25.9	25.9	25.9
126	13.4	13.6	15.5	18.5	21.3	23.4	23.6	23.6	23.6
127	15.6	15.8	17.7	20.7	23.5	25.6	25.8	25.8	25.8
128	12.8	13.0	14.9	17.9	20.7	22.8	23.0	23.0	23.0
129	14.2	14.4	16.3	19.3	22.1	24.2	24.4	24.4	24.4
130	13.3	13.5	15.4	18.4	21.2	23.3	23.5	23.5	23.5
133	13.8	14.0	15.9	18.9	21.7	23.8	24.0	24.0	24.0
134	14.2	14.4	16.3	19.3	22.1	24.2	24.4	24.4	24.4
135	16.2	16.4	18.3	21.3	24.1	26.2	26.4	26.4	26.4
138	11.4	11.6	13.5	16.5	19.3	21.4	21.6	21.6	21.6
140	15.0	15.2	17.1	20.1	22.9	25.0	25.2	25.2	25.2

Receiver	Hub-height wind speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
141	15.4	15.6	17.5	20.5	23.3	25.4	25.6	25.6	25.6
180	19.3	19.5	21.4	24.4	27.2	29.3	29.5	29.5	29.5
269	14.8	15.0	16.9	19.9	22.7	24.8	25.0	25.0	25.0

(S) Involved receiver

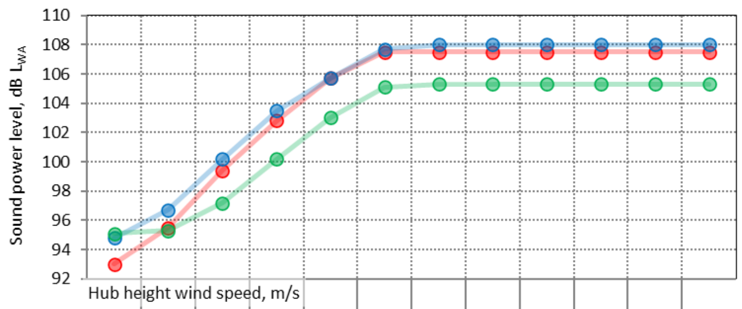
APPENDIX I NZS 6808 DOCUMENTATION

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

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

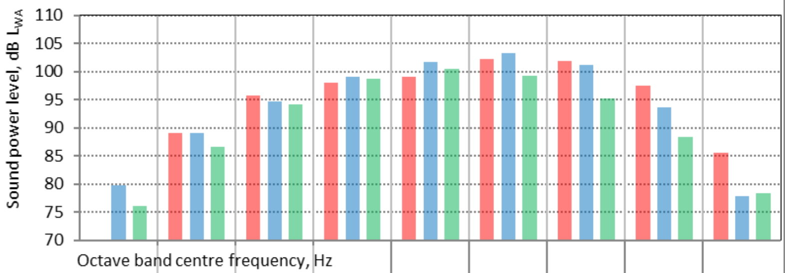
(c) Wind turbine sound power levels: See Section 6.3.1

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



Hub height wind speed, m/s	4	5	6	7	8	9	10	11	12	13	14	15
SG 6.6-170	93.0	95.5	99.4	102.8	105.7	107.5	107.5	107.5	107.5	107.5	107.5	107.5
GE 6.0-164	94.8	96.7	100.2	103.5	105.7	107.7	108.0	108.0	108.0	108.0	108.0	108.0
V162 6.0MW	95.1	95.3	97.2	100.2	103.0	105.1	105.3	105.3	105.3	105.3	105.3	105.3

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



Octave band centre frequency, Hz	31.5	63	125	250	500	1000	2000	4000	8000
SG 6.6-170		89.0	95.8	98.0	99.0	102.2	101.9	97.4	85.6
GE 6.0-164	79.8	89.1	94.6	99.1	101.7	103.3	101.1	93.6	77.8
V162 6.0MW	76.2	86.6	94.1	98.7	100.4	99.3	95.2	88.3	78.5

(d) Wind turbine model: See Section 6.2

(e) Wind turbine hub height: See Table 3 of Section 6.2

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

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

(h) Meteorological conditions assumed: See Table 1 of Section 4.3

(i) Air absorption parameters:

	Octave band mid frequency, Hz							
Description	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
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.