MARSHALL DAY Acoustics

GELLIONDALE 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 Gelliondale Wind Farm that is proposed to be developed by Synergy Wind Pty Ltd. The assessment is based on the proposed wind farm layout comprising 13 multi-megawatt wind turbines and an associated transformer station.

The planning application for the wind farm seeks approval to develop wind turbines with a maximum tip height of 210 m. The actual wind turbine which would be used at the site would be determined at a later stage in the project, after the project has been granted planning approval. The final selection would be based on a range of design requirements including achieving compliance with the planning permit noise limits at surrounding noise sensitive locations (receivers). In advance of a final selection, this assessment considers a candidate wind turbine model that is representative of the size and type of wind turbine which could be used at the site. For this purpose, the GE Cypress 6.0-164 with a custom hub height of 128 m and rotor diameter of 164 m, has 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 *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines* 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 model achieve the base noise limits determined in accordance with NZS 6808 at all neighbouring receivers.

The EP Regulations require operational noise of the transformer station associated with the wind farm to be assessed in accordance with EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues*, dated May 2021 (the Noise Protocol). Considering that design of the transformer station is not sufficiently progressed to inform a detailed noise assessment, the report presents the applicable noise limits for an assessment to be undertaken at a later stage of the project.

Consideration was also given to the general environmental duty introduced by the *Environment Protection Act 2017* (the EP Act) in July 2021.

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

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1.0 INTRODUCTION

Synergy Wind Pty Ltd is proposing to develop a wind farm known as the Gelliondale Wind Farm within the Victorian local government area of the Wellington Shire, approximately 7 km southwest of Yarram.

The wind farm is proposed to comprise thirteen (13) wind turbines and an associated transformer station. Throughout this report, the term 'wind farm' refers to both the wind turbines and the transformer station.

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 transformer station is to be assessed in accordance with EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* dated May 2021 (Noise Protocol), as required by the EP Regulations, at a later stage of the project.

The noise assessment presented in this report is based on:

- Operational noise limits determined in accordance with NZS 6808 and the 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; and
- A comparison of the predicted noise levels with the applicable base noise limits determined in accordance with NZS 6808.

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

2.0 PROJECT DESCRIPTION

The wind farm is proposed to comprise thirteen (13) wind turbines. The coordinates of the proposed wind turbines are tabulated in Appendix B.

The proponent is seeking consent for a wind farm comprising wind turbines extending to a tip height of up to 210 m. The GE Cypress 6.0-164, with a power output of 6.0 MW and a rotor diameter of 164 m, has been selected as the candidate wind turbine model for this assessment. Further details of the candidate wind turbine model are presented in Section 6.2.

A transformer station is also proposed to be located close to the east-most wind turbine (see coordinates in Appendix B).

A total of two hundred and twenty-seven (227) 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 twelve (12) 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, transformer station and receivers is provided in 0.

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*
- 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 are separately defined in regulations made under the EP Act (see next section).

3.2 Environment Protection Regulations 2021

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

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

3.2.1 Wind turbine noise

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

Specifically, the EP Regulations outline the following:

- Noise agreements

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

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

- Wind energy facility operators' duties

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

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

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

3.2.2 Industry noise

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

3.3 Victorian Wind Energy Guidelines

The Victorian Department of Environment, Land, Water and Planning publication *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 Victorian Wind Energy Guidelines set out:

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

Section 5 of the Victorian Wind Energy Guidelines outlines the key criteria for evaluating the planning merits of a wind energy facility. The following guidance is provided for the assessment of noise levels from proposed new wind farm developments:

> *A wind energy facility must comply with the noise limits in the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (the Standard).* […]
>
> *The Standard specifies a general 40 decibel limit (40 dB $L_{A90(10min)}$) for wind energy facility sound levels outdoors at noise sensitive locations, or that the sound level should not exceed the background sound level by more than five decibels (referred to as 'background sound level +5 dB'), whichever is the greater.* […]
>
> *Noise sensitive locations are defined in the Standard 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.* […]
>
> *A 45-decibel limit is recommended for stakeholder dwellings. A stakeholder dwelling is a dwelling located on the same land as the wind energy facility, or one that has an agreement with the wind energy facility to exceed the noise limit.* […]
>
> *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].*
>
> *Measurement and compliance assessment methods are set out in the Standard. The assessment must be made without relying on noise reduction operation modes to achieve compliance.*

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

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

The Noise Protocol prescribes 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 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;
- assessing whether the development can achieve the requirements of Victorian policy and guidelines by comparing the predicted noise levels to the noise limits; and
- recommending reasonably practicable measures to minimise the risk of noise impact.

4.2 Background noise levels

Background noise level information is used to inform the setting of limits for both the transformer station 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 transformer station) are predicted using:

- Noise emission data for the wind turbines and associated transformer station;
- 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.

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 F.

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 F.
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 transformer station) 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 components of the wind farm, 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, obtained from Spatial Datamart Victoria.

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 F. • 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, with the exception of a hill to the northwest of the project. Based on comparison of predicted noise levels with and without terrain elevation data included, calculated terrain effects range between -0.9 dB and +0.2 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 F. 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 °C / relative humidity 70 % / atmospheric pressure: 101.325 kPa 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 demonstrate that predicted noise levels are between 35 and 40 dB L_{A90} for ten (10) non-involved receivers. In accordance with NZS 6808, background noise monitoring is therefore required to be undertaken at selected receivers.

Background noise monitoring has been carried out at five (5) involved receivers from 14 June to 2 September 2022. A detailed background noise assessment is currently being prepared. The background noise assessment will be used to derive applicable noise limits which will be detailed in subsequent revisions of this report.

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.

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 in Section 3.4.2 of this report 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 final 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 consider a candidate wind turbine model that is representative of the size and type of wind turbines being considered. The purpose of the candidate wind turbine is to assess the viability of achieving compliance with the applicable noise limits, based on noise emission levels that are typical of the size of wind turbines being considered for the site.

For this assessment, the proponent has nominated the GE Cypress 6.0-164 as the candidate wind turbine model.

This model is a variable speed wind turbine, 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.

Details of the assessed candidate wind turbine are provided in Table 3.

Table 3: Selected candidate wind turbine model

Item	Detail
Make	General Electric (GE)
Model	Cypress 6.0-164
Rotor diameter	164 m
Hub height	128 m
Blade serrations	Yes
Rated power	6.0 MW
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	12 m/s
Cut-out wind speed (hub height)	25 m/s

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

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

6.3 Wind turbine noise emissions

6.3.1 Sound power levels

The noise emissions of the wind turbines are described in terms of the sound power level for different wind speeds. The sound *power* level is a measure of the total sound energy produced by each 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 model, including sound frequency characteristics, has been sourced from the GE Renewables Energy Technical Documentation *Wind Turbine Generator Systems Cypress 6.0-164 – 50Hz* dated 16 March 2021.

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 4 with the octave band values presented in Table 5. These represent the total noise emissions of the wind turbine for each sound mode, including the secondary contribution of ancillary plant associated with each wind turbine (e.g. cooling fans).

Table 4: Sound power levels versus hub height wind speed, dB L_{WA}

	Hub height wind speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
L_{WA}	94.8	96.7	100.2	103.5	105.7	107.7	108.0	108.0	108.0

Table 5: Octave band sound power levels, dB L_{WA}

	Octave band centre frequency, Hz									
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**Total**
L_{WA}	79.8	89.1	94.6	99.1	101.7	103.3	101.1	93.6	77.8	108.0

Note: 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 model. 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

This section of the report presents the predicted noise levels of the wind farm at surrounding receivers.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. However, in the case of wind farm layout design, significant layout modifications may only give rise to fractional changes in the predicted noise level. This is a result of the relatively large number of sources influencing the total predicted noise level, as well as the typical separating distances between the 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 model and are summarised in Table 6 for the hub height wind speed which results in the highest predicted noise levels (15 m/s).

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

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

Table 6: Highest predicted noise level at receivers with predicted levels 30 dB L_{A90} or above

Receiver	Predicted level, dB L_{A90}
Non-involved receivers	
N039	30.5
N044	32.3
N046	36.2
N048	33.6
N049	30.9
N051	31.5

Receiver	Predicted level, dB L_{A90}
N057	30.0
N058	32.7
N066	33.6
N067	35.8
N068	38.2
N073	34.2
N074	31.2
N077	30.2
N079	36.1
N081	37.5
N085	37.2
N087	34.2
N088	37.5
N109	31.0
N110	31.2
N111	31.0
N113	33.8
N115	34.8
N116	35.0
N117	34.9
N119	35.9
N120	31.0
N121	36.9
N122	32.1
N124	31.0
N126	30.0
N128	30.3
N129	30.2
N130	31.4
N133	30.7

Receiver	Predicted level, dB L_{A90}
N134	31.6
N135	35.9
N137	30.2
N138	30.3
N139	33.0
N141	33.2
N142	33.0
N143	30.9
N146	33.4
N147	33.8
N151	30.6
N154	30.7
N155	32.1
N156	32.0
N158	30.1
Involved receivers	
H01	35.1
H02	39.2
H03	38.6
H04	33.6
H05	44.2
H06	38.0
H07	43.0
H10	39.3
H11	39.3
H12	36.7
Synergy properties	
H08	42.5
H09	46.6

Note that H08 and H09 are Synergy properties and will not be used for residential use once the Gelliondale Wind Farm has been constructed.

The following can be concluded from the predicted noise levels detailed in Table 6:

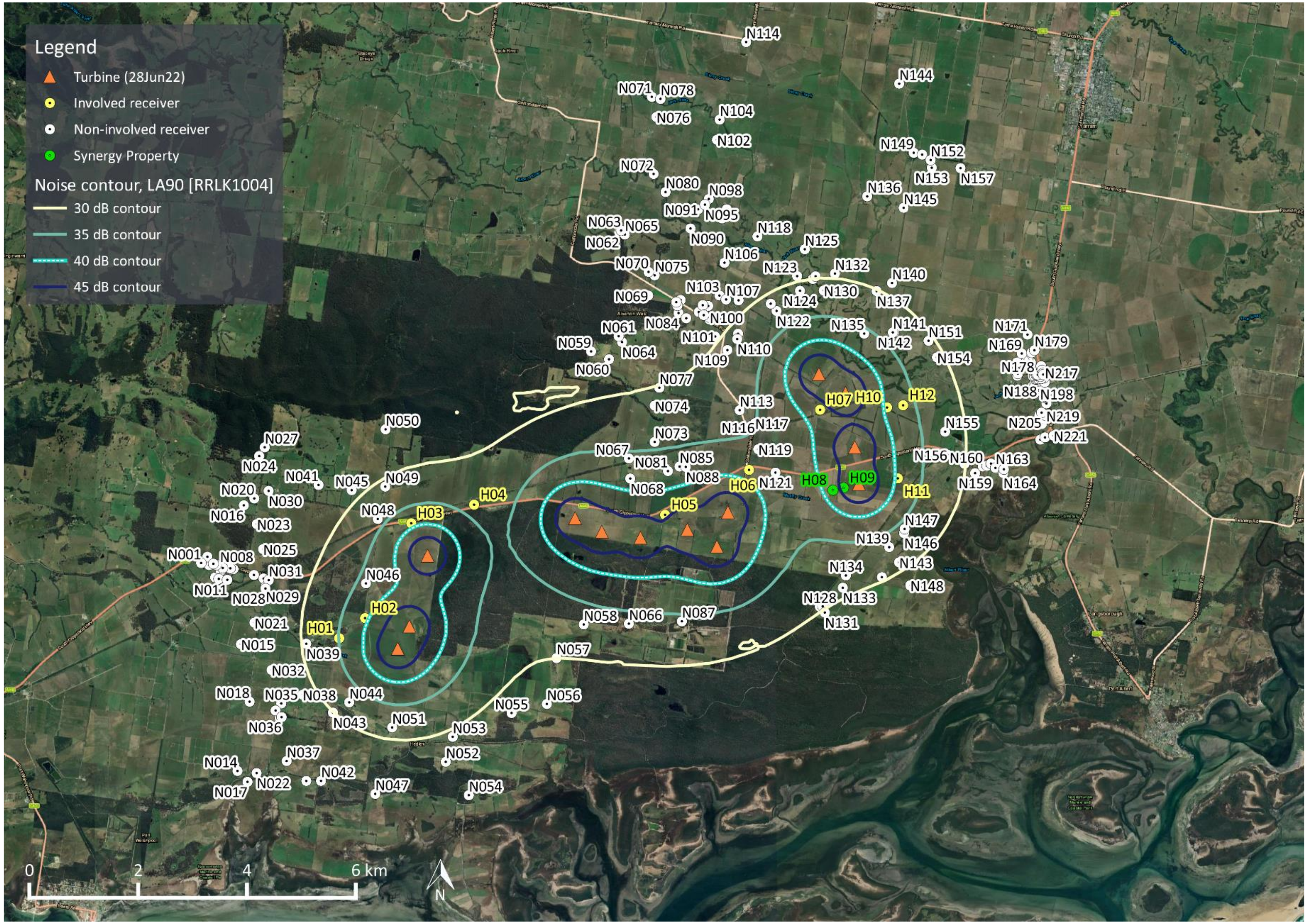
- Compliance with the applicable base noise limit of 40 dB L_{A90} by at least 1.8 dB at all non-involved receivers
- Compliance with the applicable base noise limit of 45 dB L_{A90} by at least 0.8 dB at all involved receivers.

6.5 Cumulative assessment

To our knowledge, the nearest approved and/or operating wind farm is the Toora Wind Farm (approximately 15 km to the west).

Due to the significant separating distance, cumulative assessment of noise levels from the Gelliondale Wind Farm and other surrounding wind farm(s) is not warranted.

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



7.0 TRANSFORMER STATION NOISE ASSESSMENT

7.1 Noise limits

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

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

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

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

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

Based on the above and considering that the transformer station would be defined in the Victorian Planning Provisions as a *utility*, the noise limits applicable at the nearest receivers, are summarised in Table 7.

Table 7: Noise Protocol time periods and noise limits, dB L_{eff}[3]

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

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

7.2 Transformer noise emissions

At this stage in the project, a detailed noise assessment of the transformer station cannot be undertaken as specific details of the transformer make and model are yet to be determined.

Once the specific requirements for the equipment at the transformer station have been determined, a detailed noise assessment will be carried out to assess compliance with the noise limits applicable at nearby noise sensitive receivers.

[3] L_{eff} is the effective noise level of commercial or industrial noise determined in accordance with the Noise Protocol. 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.

8.0 RECOMMENDED NOISE MANAGEMENT MEASURES

Providing 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 not exceeding the empirical values specified in AS 60076-10
- A detailed noise assessment should be prepared by a qualified acoustic consultant, prior to construction, addressing:
  - the final wind turbine selection and layout
  - the final location and equipment selection for the transformer station
  - compliance with the applicable noise limits at surrounding receivers
  - recommendation of reasonably practicable noise mitigation measures to control noise from the transformer station.
- 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 Gelliondale Wind Farm has been carried out. The assessment is based on the proposed wind farm layout comprising 13 multi-megawatt wind turbines and a transformer station.

Operational noise associated with the proposed wind turbines has been assessed in accordance with NZS 6808, as required by the EP Regulations and the Victorian Wind Energy Guidelines.

Noise modelling was carried out based a candidate wind turbine model (GE Cypress 6.0-164) which has 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 current applicable noise limits determined in accordance with NZS 6808.

In advance of a detailed assessment of operational noise from the transformer station, applicable noise limits determined in accordance with the Noise Protocol have been determined.

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

The noise assessment therefore demonstrates that the proposed Gelliondale 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 2022-06, supplied by the proponent on 2 February 2023).

The terrain elevations for the wind turbines are based on terrain data obtained from Spatial Datamart Victoria (downloaded on 18 November 2021). This data may differ slightly from actual terrain elevations for each individual wind turbine; however, it provides a sufficiently accurate representation for the purpose of this assessment.

Table 8: Wind turbine coordinates – MGA 94 zone 55

Wind turbine	Easting, m	Northing, m	Terrain elevation, m
GWT01	459,100	5,721,210	10
GWT02	459,315	5,721,622	10
GWT03	459,649	5,722,922	10
GWT04	462,359	5,723,610	10
GWT05	462,850	5,723,361	10
GWT06	463,560	5,723,252	10
GWT07	464,422	5,723,400	10
GWT08	464,965	5,723,088	10
GWT09	465,167	5,723,719	10
GWT10	466,839	5,726,260	10
GWT11	467,329	5,725,912	10
GWT12	467,499	5,724,918	10
GWT13	467,573	5,724,240	10

The following table sets out the coordinates of the proposed transformer station (Reference 20220815, supplied by the proponent on 12 June 2022).

Table 9: Preliminary transformer station coordinates – MGA 94 zone 55

Item	Easting, m	Northing, m	Terrain elevation, m
Transformer station	462,308	5,724,584	14

APPENDIX C RECEIVER COORDINATES

The following table sets out the 227 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 12 involved receivers.

(Reference 20211118, supplied by the proponent on 18 November 2021).

Table 10: Receivers within 5 km of the proposed wind turbines – MGA 94 zone 55

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
Non-involved receivers					
N001	455,488	5,722,786	22	3,943	GWT01
N002	455,603	5,722,900	24	3,886	GWT01
N003	455,635	5,722,748	22	3,793	GWT01
N004	455,714	5,722,772	22	3,731	GWT01
N005	455,746	5,722,521	20	3,603	GWT01
N006	455,768	5,722,750	22	3,673	GWT01
N007	455,812	5,722,494	20	3,532	GWT01
N008	455,833	5,722,735	22	3,607	GWT01
N009	455,847	5,722,644	21	3,558	GWT01
N010	455,886	5,722,695	21	3,543	GWT01
N011	455,969	5,722,477	19	3,380	GWT01
N012	456,025	5,722,689	20	3,414	GWT01
N013	456,081	5,722,674	20	3,358	GWT01
N014	456,156	5,718,962	10	3,706	GWT01
N015	456,219	5,721,293	11	2,885	GWT01
N016	456,273	5,723,847	29	3,503	GWT03
N017	456,340	5,718,762	10	3,692	GWT01
N018	456,379	5,720,237	10	2,893	GWT01
N019	456,459	5,722,567	16	2,972	GWT01
N020	456,465	5,723,973	29	3,355	GWT03
N021	456,468	5,721,689	11	2,679	GWT01
N022	456,508	5,718,924	10	3,459	GWT01
N023	456,512	5,723,502	23	3,193	GWT03
N024	456,555	5,724,753	54	3,597	GWT03
N025	456,627	5,723,041	19	3,027	GWT03
N026	456,636	5,722,500	14	2,784	GWT01

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
N027	456,657	5,724,914	66	3,597	GWT03
N028	456,670	5,722,317	12	2,673	GWT01
N029	456,675	5,722,351	13	2,683	GWT01
N030	456,728	5,724,112	28	3,156	GWT03
N031	456,731	5,722,471	13	2,687	GWT01
N032	456,782	5,720,820	10	2,354	GWT01
N033	456,856	5,720,073	10	2,519	GWT01
N034	456,932	5,719,935	10	2,518	GWT01
N035	456,961	5,720,204	10	2,367	GWT01
N036	456,966	5,719,953	10	2,480	GWT01
N037	457,060	5,719,145	10	2,906	GWT01
N038	457,354	5,720,365	10	1,944	GWT01
N039	457,420	5,721,301	10	1,687	GWT01
N040	457,421	5,718,779	10	2,957	GWT01
N041	457,646	5,724,221	27	2,391	GWT03
N042	457,691	5,718,780	10	2,812	GWT01
N043	457,910	5,720,036	10	1,676	GWT01
N044	458,209	5,720,224	10	1,335	GWT01
N045	458,255	5,724,125	19	1,846	GWT03
N046	458,517	5,722,411	10	1,129	GWT02
N047	458,688	5,718,541	10	2,704	GWT01
N048	458,734	5,723,596	13	1,143	GWT03
N049	458,871	5,724,191	18	1,494	GWT03
N050	458,877	5,725,244	76	2,450	GWT03
N051	458,998	5,719,763	10	1,456	GWT01
N052	459,982	5,719,130	10	2,263	GWT01
N053	460,111	5,719,590	10	1,914	GWT01
N054	460,407	5,718,517	10	2,996	GWT01
N055	461,192	5,720,028	10	2,406	GWT01
N056	461,841	5,720,194	10	2,905	GWT02
N057	462,018	5,721,038	10	2,471	GWT05
N058	462,519	5,721,656	10	1,742	GWT05
N059	462,654	5,726,677	90	3,084	GWT04

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
N060	462,983	5,726,533	80	2,991	GWT04
N061	463,160	5,726,958	35	3,444	GWT04
N062	463,170	5,728,867	31	4,503	GWT10
N063	463,205	5,728,901	30	4,494	GWT10
N064	463,221	5,726,849	32	3,354	GWT04
N065	463,273	5,728,826	30	4,395	GWT10
N066	463,347	5,721,670	10	1,601	GWT06
N067	463,348	5,724,709	16	1,443	GWT05
N068	463,373	5,724,339	11	1,110	GWT06
N069	463,703	5,727,704	23	3,455	GWT10
N070	463,709	5,728,138	22	3,652	GWT10
N072	463,802	5,729,940	20	4,773	GWT10
N073	463,821	5,725,012	17	1,725	GWT07
N074	463,822	5,725,680	21	2,361	GWT07
N075	463,822	5,728,076	20	3,523	GWT10
N077	463,907	5,726,008	25	2,616	GWT09
N079	463,958	5,724,677	13	1,365	GWT07
N080	464,021	5,729,607	20	4,377	GWT10
N081	464,066	5,724,476	10	1,141	GWT07
N082	464,218	5,727,583	20	2,939	GWT10
N083	464,240	5,727,520	20	2,891	GWT10
N084	464,260	5,727,382	20	2,815	GWT10
N085	464,278	5,724,560	10	1,176	GWT07
N086	464,299	5,727,622	20	2,885	GWT10
N087	464,322	5,721,714	10	1,523	GWT08
N088	464,393	5,724,553	10	1,145	GWT09
N089	464,402	5,727,287	20	2,648	GWT10
N090	464,480	5,728,937	10	3,570	GWT10
N091	464,619	5,729,290	10	3,758	GWT10
N092	464,632	5,727,402	19	2,488	GWT10
N093	464,705	5,727,527	18	2,485	GWT10
N094	464,723	5,727,344	18	2,381	GWT10
N095	464,745	5,729,376	10	3,756	GWT10

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
N096	464,746	5,727,334	18	2,356	GWT10
N097	464,805	5,727,514	17	2,393	GWT10
N098	464,816	5,729,479	10	3,804	GWT10
N099	464,828	5,727,267	18	2,252	GWT10
N100	464,830	5,727,303	18	2,267	GWT10
N101	464,933	5,726,951	17	2,031	GWT10
N102	464,967	5,730,568	20	4,699	GWT10
N103	465,012	5,727,704	16	2,332	GWT10
N105	465,058	5,729,122	10	3,373	GWT10
N106	465,104	5,728,307	14	2,686	GWT10
N107	465,134	5,727,632	15	2,192	GWT10
N108	465,145	5,729,290	10	3,474	GWT10
N109	465,158	5,726,702	15	1,743	GWT10
N110	465,338	5,726,904	15	1,638	GWT10
N111	465,354	5,727,002	15	1,665	GWT10
N112	465,363	5,727,616	14	2,009	GWT10
N113	465,384	5,725,596	11	1,604	GWT10
N115	465,624	5,725,326	10	1,538	GWT10
N116	465,662	5,725,284	10	1,534	GWT10
N117	465,666	5,725,357	10	1,486	GWT10
N118	465,711	5,728,791	10	2,774	GWT10
N119	465,725	5,724,878	10	1,292	GWT09
N120	465,954	5,727,554	11	1,573	GWT10
N121	466,041	5,724,449	10	1,146	GWT09
N122	466,061	5,727,421	10	1,403	GWT10
N123	466,440	5,728,061	10	1,849	GWT10
N124	466,491	5,727,792	10	1,576	GWT10
N125	466,580	5,728,555	11	2,313	GWT10
N126	466,729	5,728,009	10	1,757	GWT10
N127	466,778	5,728,057	10	1,802	GWT10
N128	466,856	5,721,983	10	2,194	GWT08
N129	466,910	5,721,990	10	2,237	GWT08
N130	466,928	5,727,796	10	1,544	GWT10

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
N131	466,948	5,721,875	10	2,328	GWT08
N132	467,134	5,728,108	10	1,876	GWT10
N133	467,278	5,722,331	10	1,936	GWT13
N134	467,335	5,722,557	10	1,704	GWT13
N135	467,672	5,727,004	10	1,124	GWT10
N136	467,727	5,729,528	14	3,389	GWT10
N137	467,900	5,727,786	10	1,863	GWT10
N138	467,997	5,722,526	10	1,770	GWT13
N139	468,130	5,723,078	10	1,295	GWT13
N140	468,183	5,727,934	10	2,150	GWT10
N141	468,197	5,727,026	10	1,418	GWT11
N142	468,222	5,727,026	10	1,433	GWT11
N143	468,312	5,722,799	10	1,625	GWT13
N145	468,397	5,729,317	14	3,433	GWT10
N146	468,403	5,723,337	10	1,233	GWT13
N147	468,414	5,723,412	10	1,187	GWT13
N148	468,517	5,722,375	10	2,094	GWT13
N149	468,582	5,730,329	17	4,428	GWT10
N150	468,737	5,730,295	17	4,461	GWT10
N151	468,854	5,726,872	10	1,806	GWT11
N152	468,893	5,730,195	17	4,441	GWT10
N153	468,913	5,730,054	16	4,326	GWT10
N154	469,009	5,726,568	10	1,807	GWT11
N155	469,159	5,725,201	10	1,689	GWT12
N156	469,199	5,724,779	10	1,710	GWT12
N157	469,441	5,730,047	16	4,596	GWT10
N158	469,516	5,724,609	10	1,982	GWT13
N159	469,709	5,724,438	10	2,149	GWT13
N160	469,851	5,724,561	10	2,304	GWT13
N161	469,926	5,724,573	10	2,380	GWT13
N162	470,000	5,724,614	10	2,459	GWT13
N163	470,084	5,724,535	10	2,531	GWT13
N164	470,226	5,724,440	10	2,664	GWT13

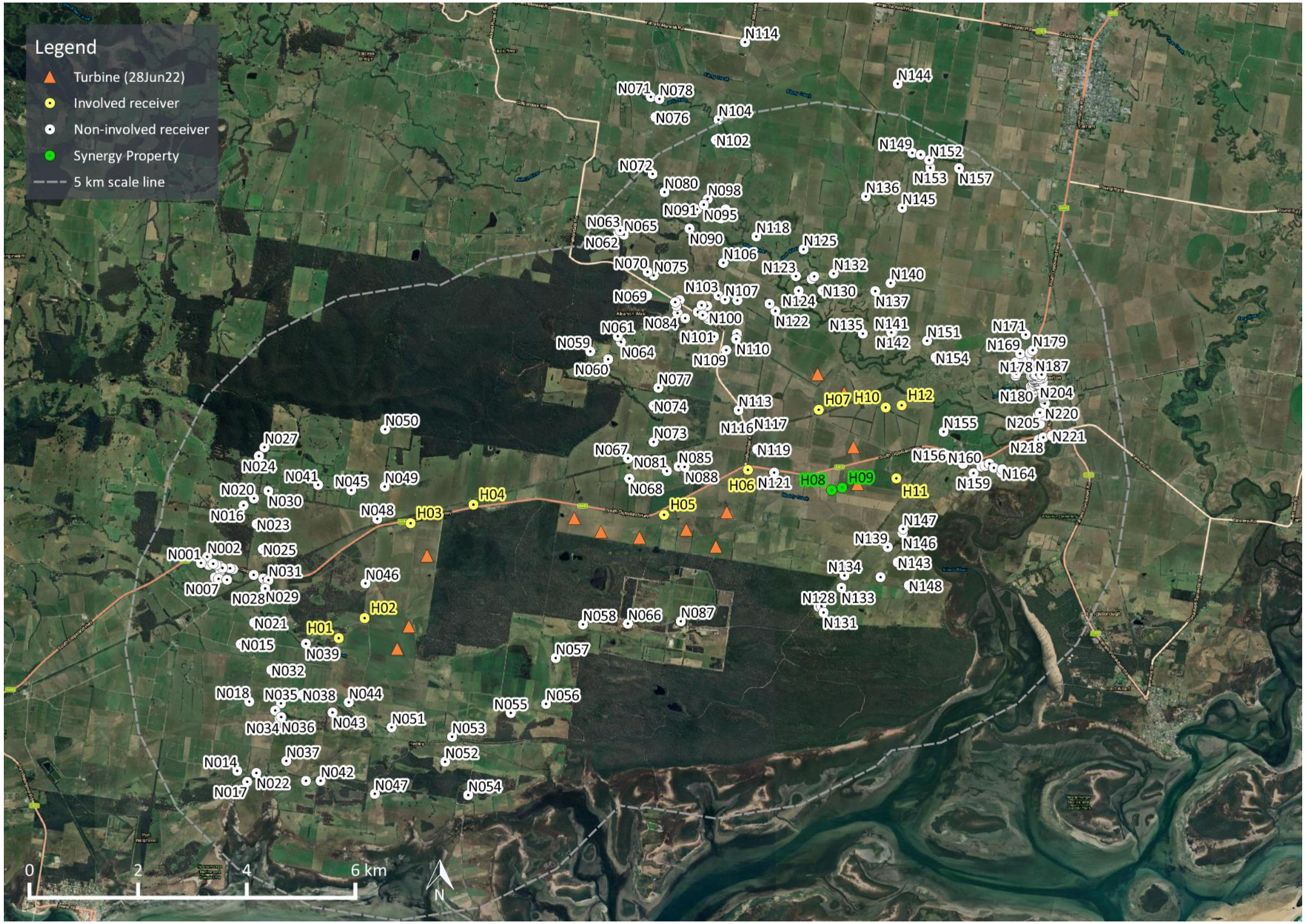
Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
N165	470,239	5,724,509	10	2,683	GWT13
N166	470,482	5,726,475	10	3,205	GWT11
N167	470,484	5,726,230	10	3,174	GWT11
N168	470,495	5,726,268	10	3,189	GWT11
N169	470,567	5,726,638	10	3,321	GWT11
N170	470,607	5,726,505	10	3,334	GWT11
N171	470,672	5,726,985	10	3,513	GWT11
N172	470,680	5,726,524	10	3,408	GWT11
N173	470,736	5,726,467	10	3,454	GWT11
N174	470,749	5,726,656	10	3,503	GWT11
N175	470,764	5,726,033	10	3,439	GWT11
N176	470,770	5,726,225	10	3,458	GWT11
N177	470,799	5,725,910	10	3,448	GWT12
N178	470,799	5,726,231	10	3,487	GWT11
N179	470,800	5,726,699	10	3,561	GWT11
N180	470,802	5,726,038	10	3,478	GWT11
N181	470,809	5,726,117	10	3,488	GWT11
N182	470,817	5,726,164	10	3,499	GWT11
N183	470,827	5,725,983	10	3,496	GWT12
N184	470,828	5,726,054	10	3,504	GWT11
N185	470,831	5,726,247	10	3,520	GWT11
N186	470,832	5,726,166	10	3,515	GWT11
N187	470,844	5,726,248	10	3,534	GWT11
N188	470,848	5,726,128	10	3,528	GWT11
N189	470,850	5,726,173	10	3,533	GWT11
N190	470,855	5,725,991	10	3,525	GWT12
N191	470,861	5,726,249	10	3,551	GWT11
N192	470,866	5,726,077	10	3,544	GWT11
N193	470,871	5,726,133	10	3,551	GWT11
N194	470,874	5,726,176	10	3,557	GWT11
N195	470,885	5,726,063	10	3,562	GWT11
N196	470,888	5,726,133	10	3,568	GWT11
N197	470,890	5,725,499	10	3,443	GWT12

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
N198	470,900	5,726,075	10	3,577	GWT11
N199	470,907	5,726,215	10	3,593	GWT11
N200	470,909	5,725,054	10	3,415	GWT12
N201	470,916	5,726,146	10	3,596	GWT11
N202	470,923	5,726,177	10	3,606	GWT11
N203	470,924	5,726,405	10	3,631	GWT11
N204	470,927	5,726,108	10	3,605	GWT11
N205	470,931	5,725,551	10	3,492	GWT12
N206	470,934	5,725,341	10	3,464	GWT12
N207	470,938	5,726,086	10	3,615	GWT11
N208	470,940	5,726,330	10	3,637	GWT11
N209	470,953	5,726,271	10	3,644	GWT11
N210	470,963	5,726,251	10	3,652	GWT11
N211	470,967	5,725,975	10	3,628	GWT12
N212	470,978	5,725,900	10	3,617	GWT12
N213	470,978	5,726,195	10	3,662	GWT11
N214	470,981	5,725,876	10	3,613	GWT12
N215	470,982	5,725,850	10	3,608	GWT12
N216	470,983	5,725,826	10	3,603	GWT12
N217	470,989	5,726,113	10	3,668	GWT11
N218	470,994	5,725,095	10	3,502	GWT12
N219	471,014	5,725,496	10	3,564	GWT12
N220	471,020	5,725,720	10	3,614	GWT12
N221	471,152	5,725,128	10	3,661	GWT12
Involved receivers					
H01	458,025	5,721,403	10	1,099	GWT01
H02	458,501	5,721,772	10	831	GWT01
H03	459,349	5,723,517	11	678	GWT03
H04	460,504	5,723,858	13	1,274	GWT03
H05	464,013	5,723,672	10	507	GWT07
H06	465,556	5,724,498	10	880	GWT09
H07	466,861	5,725,604	10	574	GWT11
H10	468,091	5,725,646	10	817	GWT11

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
H11	468,290	5,724,343	10	735	GWT13
H12	468,387	5,725,686	10	1,089	GWT11
Synergy properties					
H08	467,097	5,724,126	10	506	GWT13
H09	467,292	5,724,169	10	316	GWT13

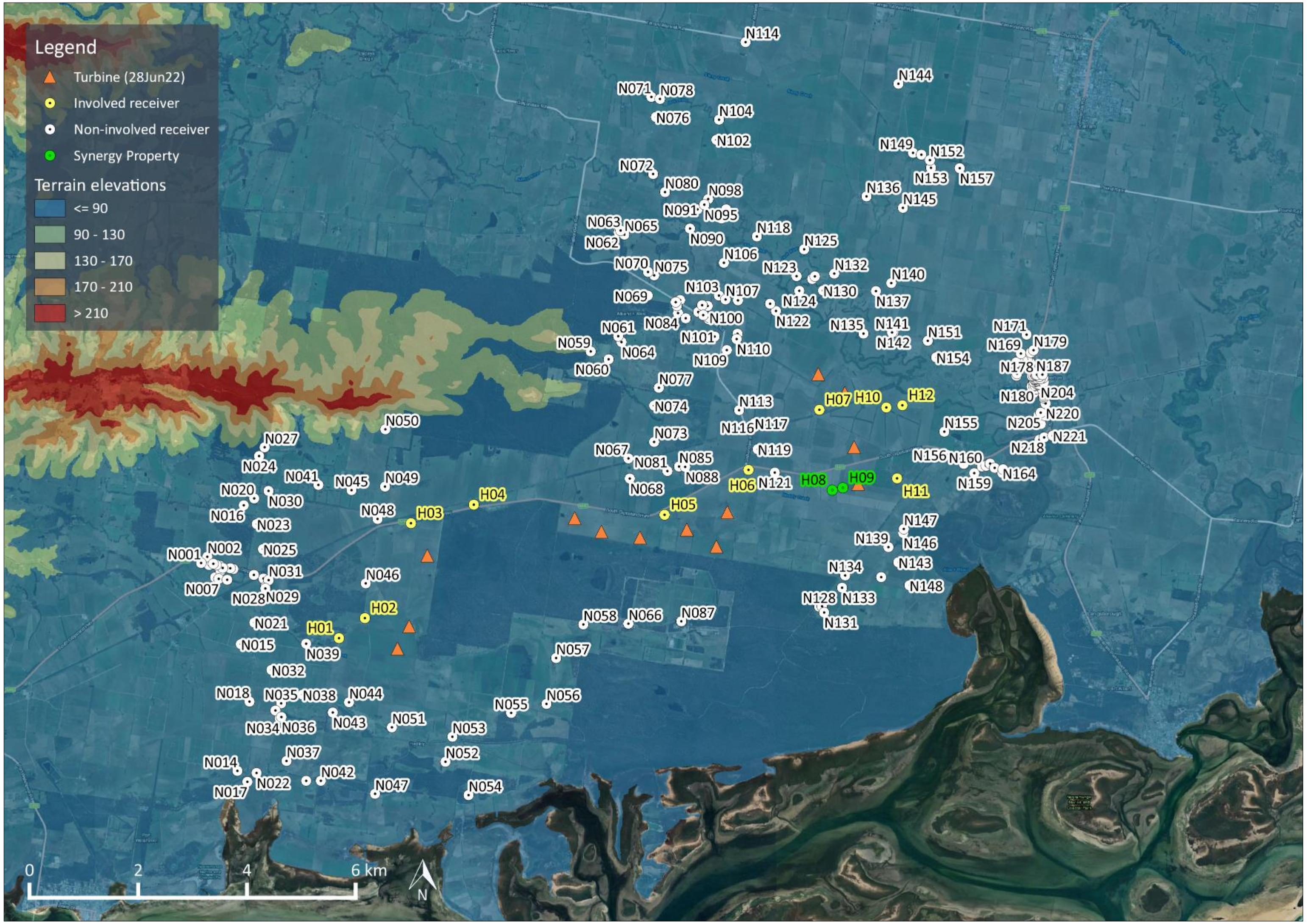
APPENDIX D SITE LAYOUT PLAN

Figure 2: Proposed wind turbine layout and receivers



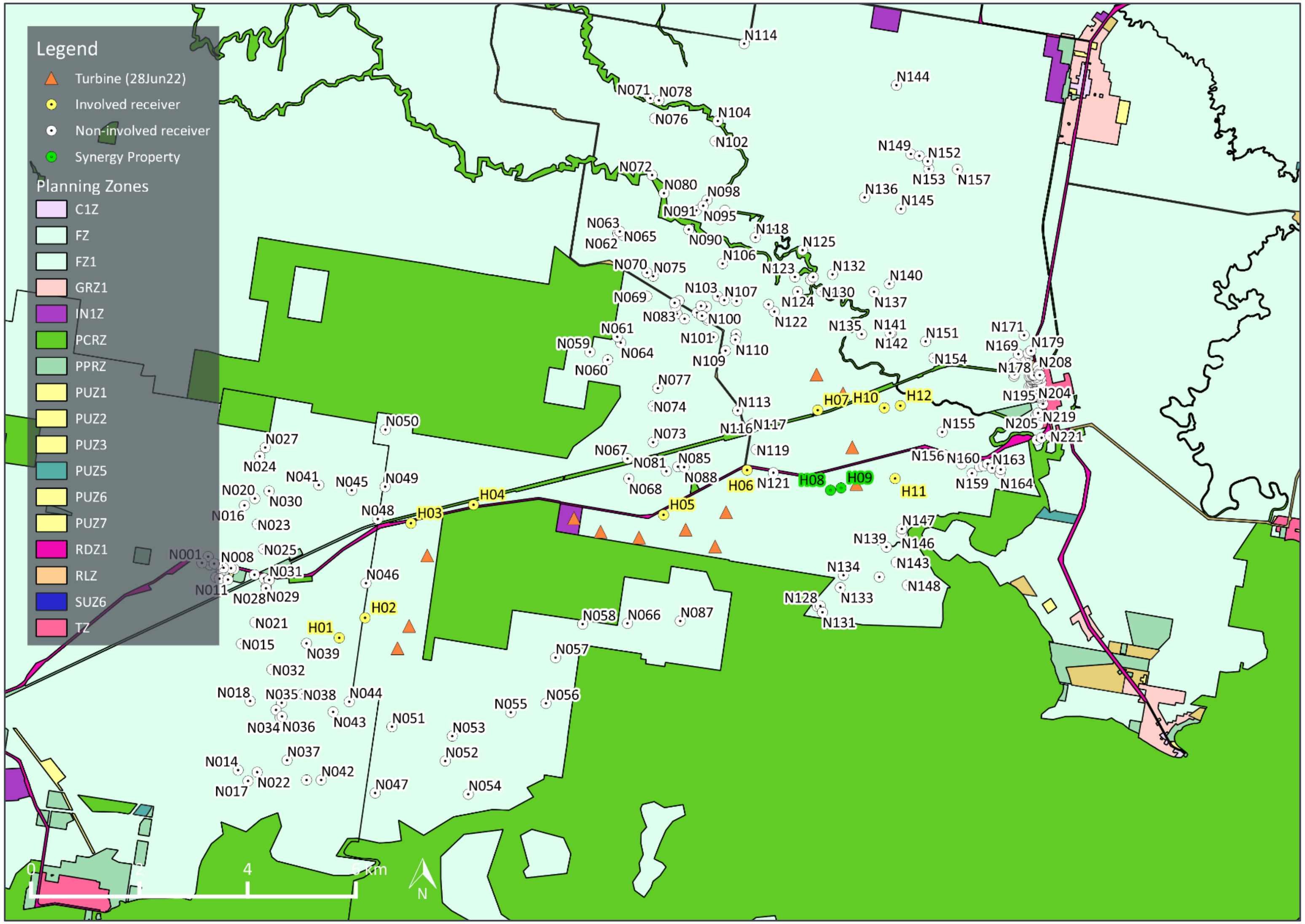
APPENDIX E SITE TOPOGRAPHY

Figure 3: Terrain elevation map for the wind farm and surrounding area



APPENDIX F ZONING MAP

Figure 4: 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[4, 5, 6] 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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4 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.

5 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.

6 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 11: Predicted noise levels, dB L_{A90}

Receiver	Hub-height wind speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
Non-involved receivers									
N001	8.8	10.7	14.2	17.5	19.7	21.7	22.0	22.0	22.0
N002	9.1	11.0	14.5	17.8	20.0	22.0	22.3	22.3	22.3
N003	9.2	11.1	14.6	17.9	20.1	22.1	22.4	22.4	22.4
N004	9.4	11.3	14.8	18.1	20.3	22.3	22.6	22.6	22.6
N005	9.7	11.6	15.1	18.4	20.6	22.6	22.9	22.9	22.9
N006	9.6	11.5	15.0	18.3	20.5	22.5	22.8	22.8	22.8
N007	9.9	11.8	15.3	18.6	20.8	22.8	23.1	23.1	23.1
N008	9.8	11.7	15.2	18.5	20.7	22.7	23.0	23.0	23.0
N009	9.9	11.8	15.3	18.6	20.8	22.8	23.1	23.1	23.1
N010	10.0	11.9	15.4	18.7	20.9	22.9	23.2	23.2	23.2
N011	10.4	12.3	15.8	19.1	21.3	23.3	23.6	23.6	23.6
N012	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N013	10.6	12.5	16.0	19.3	21.5	23.5	23.8	23.8	23.8
N014	8.3	10.2	13.7	17.0	19.2	21.2	21.5	21.5	21.5
N015	11.5	13.4	16.9	20.2	22.4	24.4	24.7	24.7	24.7
N016	10.0	11.9	15.4	18.7	20.9	22.9	23.2	23.2	23.2
N017	8.3	10.2	13.7	17.0	19.2	21.2	21.5	21.5	21.5
N018	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N019	12.1	14.0	17.5	20.8	23.0	25.0	25.3	25.3	25.3
N020	10.3	12.2	15.7	19.0	21.2	23.2	23.5	23.5	23.5
N021	12.5	14.4	17.9	21.2	23.4	25.4	25.7	25.7	25.7
N022	8.9	10.8	14.3	17.6	19.8	21.8	22.1	22.1	22.1
N023	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
N024	9.4	11.3	14.8	18.1	20.3	22.3	22.6	22.6	22.6
N025	12.2	14.1	17.6	20.9	23.1	25.1	25.4	25.4	25.4
N026	12.8	14.7	18.2	21.5	23.7	25.7	26.0	26.0	26.0
N027	9.3	11.2	14.7	18.0	20.2	22.2	22.5	22.5	22.5
N028	13.1	15.0	18.5	21.8	24.0	26.0	26.3	26.3	26.3
N029	13.1	15.0	18.5	21.8	24.0	26.0	26.3	26.3	26.3

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
N030	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N031	13.2	15.1	18.6	21.9	24.1	26.1	26.4	26.4	26.4
N032	13.4	15.3	18.8	22.1	24.3	26.3	26.6	26.6	26.6
N033	12.4	14.3	17.8	21.1	23.3	25.3	25.6	25.6	25.6
N034	12.4	14.3	17.8	21.1	23.3	25.3	25.6	25.6	25.6
N035	13.1	15.0	18.5	21.8	24.0	26.0	26.3	26.3	26.3
N036	12.6	14.5	18.0	21.3	23.5	25.5	25.8	25.8	25.8
N037	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N038	15.3	17.2	20.7	24.0	26.2	28.2	28.5	28.5	28.5
N039	17.3	19.2	22.7	26.0	28.2	30.2	30.5	30.5	30.5
N040	10.6	12.5	16.0	19.3	21.5	23.5	23.8	23.8	23.8
N041	13.4	15.3	18.8	22.1	24.3	26.3	26.6	26.6	26.6
N042	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
N043	16.7	18.6	22.1	25.4	27.6	29.6	29.9	29.9	29.9
N044	19.1	21.0	24.5	27.8	30.0	32.0	32.3	32.3	32.3
N045	15.7	17.6	21.1	24.4	26.6	28.6	28.9	28.9	28.9
N046	23.0	24.9	28.4	31.7	33.9	35.9	36.2	36.2	36.2
N047	11.7	13.6	17.1	20.4	22.6	24.6	24.9	24.9	24.9
N048	20.4	22.3	25.8	29.1	31.3	33.3	33.6	33.6	33.6
N049	17.7	19.6	23.1	26.4	28.6	30.6	30.9	30.9	30.9
N050	13.1	15.0	18.5	21.8	24.0	26.0	26.3	26.3	26.3
N051	18.3	20.2	23.7	27.0	29.2	31.2	31.5	31.5	31.5
N052	14.1	16.0	19.5	22.8	25.0	27.0	27.3	27.3	27.3
N053	16.0	17.9	21.4	24.7	26.9	28.9	29.2	29.2	29.2
N054	11.5	13.4	16.9	20.2	22.4	24.4	24.7	24.7	24.7
N055	15.1	17.0	20.5	23.8	26.0	28.0	28.3	28.3	28.3
N056	14.6	16.5	20.0	23.3	25.5	27.5	27.8	27.8	27.8
N057	16.8	18.7	22.2	25.5	27.7	29.7	30.0	30.0	30.0
N058	19.5	21.4	24.9	28.2	30.4	32.4	32.7	32.7	32.7
N059	13.7	15.6	19.1	22.4	24.6	26.6	26.9	26.9	26.9
N060	14.5	16.4	19.9	23.2	25.4	27.4	27.7	27.7	27.7
N061	12.7	14.6	18.1	21.4	23.6	25.6	25.9	25.9	25.9

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
N062	9.4	11.3	14.8	18.1	20.3	22.3	22.6	22.6	22.6
N063	9.4	11.3	14.8	18.1	20.3	22.3	22.6	22.6	22.6
N064	12.8	14.7	18.2	21.5	23.7	25.7	26.0	26.0	26.0
N065	9.6	11.5	15.0	18.3	20.5	22.5	22.8	22.8	22.8
N066	20.4	22.3	25.8	29.1	31.3	33.3	33.6	33.6	33.6
N067	22.6	24.5	28.0	31.3	33.5	35.5	35.8	35.8	35.8
N068	25.0	26.9	30.4	33.7	35.9	37.9	38.2	38.2	38.2
N069	12.2	14.1	17.6	20.9	23.1	25.1	25.4	25.4	25.4
N070	11.3	13.2	16.7	20.0	22.2	24.2	24.5	24.5	24.5
N072	8.0	9.9	13.4	16.7	18.9	20.9	21.2	21.2	21.2
N073	21.0	22.9	26.4	29.7	31.9	33.9	34.2	34.2	34.2
N074	18.0	19.9	23.4	26.7	28.9	30.9	31.2	31.2	31.2
N075	11.6	13.5	17.0	20.3	22.5	24.5	24.8	24.8	24.8
N077	17.0	18.9	22.4	25.7	27.9	29.9	30.2	30.2	30.2
N079	22.9	24.8	28.3	31.6	33.8	35.8	36.1	36.1	36.1
N080	8.7	10.6	14.1	17.4	19.6	21.6	21.9	21.9	21.9
N081	24.3	26.2	29.7	33.0	35.2	37.2	37.5	37.5	37.5
N082	13.2	15.1	18.6	21.9	24.1	26.1	26.4	26.4	26.4
N083	13.4	15.3	18.8	22.1	24.3	26.3	26.6	26.6	26.6
N084	13.8	15.7	19.2	22.5	24.7	26.7	27.0	27.0	27.0
N085	24.0	25.9	29.4	32.7	34.9	36.9	37.2	37.2	37.2
N086	13.3	15.2	18.7	22.0	24.2	26.2	26.5	26.5	26.5
N087	21.0	22.9	26.4	29.7	31.9	33.9	34.2	34.2	34.2
N088	24.3	26.2	29.7	33.0	35.2	37.2	37.5	37.5	37.5
N089	14.3	16.2	19.7	23.0	25.2	27.2	27.5	27.5	27.5
N090	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N091	9.9	11.8	15.3	18.6	20.8	22.8	23.1	23.1	23.1
N092	14.5	16.4	19.9	23.2	25.4	27.4	27.7	27.7	27.7
N093	14.3	16.2	19.7	23.0	25.2	27.2	27.5	27.5	27.5
N094	14.8	16.7	20.2	23.5	25.7	27.7	28.0	28.0	28.0
N095	9.8	11.7	15.2	18.5	20.7	22.7	23.0	23.0	23.0
N096	14.9	16.8	20.3	23.6	25.8	27.8	28.1	28.1	28.1

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
N097	14.6	16.5	20.0	23.3	25.5	27.5	27.8	27.8	27.8
N098	9.6	11.5	15.0	18.3	20.5	22.5	22.8	22.8	22.8
N099	15.3	17.2	20.7	24.0	26.2	28.2	28.5	28.5	28.5
N100	15.2	17.1	20.6	23.9	26.1	28.1	28.4	28.4	28.4
N101	16.4	18.3	21.8	25.1	27.3	29.3	29.6	29.6	29.6
N102	7.5	9.4	12.9	16.2	18.4	20.4	20.7	20.7	20.7
N103	14.5	16.4	19.9	23.2	25.4	27.4	27.7	27.7	27.7
N105	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N106	13.0	14.9	18.4	21.7	23.9	25.9	26.2	26.2	26.2
N107	15.1	17.0	20.5	23.8	26.0	28.0	28.3	28.3	28.3
N108	10.4	12.3	15.8	19.1	21.3	23.3	23.6	23.6	23.6
N109	17.8	19.7	23.2	26.5	28.7	30.7	31.0	31.0	31.0
N110	18.0	19.9	23.4	26.7	28.9	30.9	31.2	31.2	31.2
N111	17.8	19.7	23.2	26.5	28.7	30.7	31.0	31.0	31.0
N112	15.7	17.6	21.1	24.4	26.6	28.6	28.9	28.9	28.9
N113	20.6	22.5	26.0	29.3	31.5	33.5	33.8	33.8	33.8
N115	21.6	23.5	27.0	30.3	32.5	34.5	34.8	34.8	34.8
N116	21.8	23.7	27.2	30.5	32.7	34.7	35.0	35.0	35.0
N117	21.7	23.6	27.1	30.4	32.6	34.6	34.9	34.9	34.9
N118	12.3	14.2	17.7	21.0	23.2	25.2	25.5	25.5	25.5
N119	22.7	24.6	28.1	31.4	33.6	35.6	35.9	35.9	35.9
N120	17.8	19.7	23.2	26.5	28.7	30.7	31.0	31.0	31.0
N121	23.7	25.6	29.1	32.4	34.6	36.6	36.9	36.9	36.9
N122	18.9	20.8	24.3	27.6	29.8	31.8	32.1	32.1	32.1
N123	16.2	18.1	21.6	24.9	27.1	29.1	29.4	29.4	29.4
N124	17.8	19.7	23.2	26.5	28.7	30.7	31.0	31.0	31.0
N125	14.0	15.9	19.4	22.7	24.9	26.9	27.2	27.2	27.2
N126	16.8	18.7	22.2	25.5	27.7	29.7	30.0	30.0	30.0
N127	16.5	18.4	21.9	25.2	27.4	29.4	29.7	29.7	29.7
N128	17.1	19.0	22.5	25.8	28.0	30.0	30.3	30.3	30.3
N129	17.0	18.9	22.4	25.7	27.9	29.9	30.2	30.2	30.2
N130	18.2	20.1	23.6	26.9	29.1	31.1	31.4	31.4	31.4

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
N131	16.6	18.5	22.0	25.3	27.5	29.5	29.8	29.8	29.8
N132	16.3	18.2	21.7	25.0	27.2	29.2	29.5	29.5	29.5
N133	17.5	19.4	22.9	26.2	28.4	30.4	30.7	30.7	30.7
N134	18.4	20.3	23.8	27.1	29.3	31.3	31.6	31.6	31.6
N135	22.7	24.6	28.1	31.4	33.6	35.6	35.9	35.9	35.9
N136	10.3	12.2	15.7	19.0	21.2	23.2	23.5	23.5	23.5
N137	17.0	18.9	22.4	25.7	27.9	29.9	30.2	30.2	30.2
N138	17.1	19.0	22.5	25.8	28.0	30.0	30.3	30.3	30.3
N139	19.8	21.7	25.2	28.5	30.7	32.7	33.0	33.0	33.0
N140	15.5	17.4	20.9	24.2	26.4	28.4	28.7	28.7	28.7
N141	20.0	21.9	25.4	28.7	30.9	32.9	33.2	33.2	33.2
N142	19.8	21.7	25.2	28.5	30.7	32.7	33.0	33.0	33.0
N143	17.7	19.6	23.1	26.4	28.6	30.6	30.9	30.9	30.9
N145	10.3	12.2	15.7	19.0	21.2	23.2	23.5	23.5	23.5
N146	20.2	22.1	25.6	28.9	31.1	33.1	33.4	33.4	33.4
N147	20.6	22.5	26.0	29.3	31.5	33.5	33.8	33.8	33.8
N148	15.3	17.2	20.7	24.0	26.2	28.2	28.5	28.5	28.5
N149	7.7	9.6	13.1	16.4	18.6	20.6	20.9	20.9	20.9
N150	7.7	9.6	13.1	16.4	18.6	20.6	20.9	20.9	20.9
N151	17.4	19.3	22.8	26.1	28.3	30.3	30.6	30.6	30.6
N152	7.7	9.6	13.1	16.4	18.6	20.6	20.9	20.9	20.9
N153	8.0	9.9	13.4	16.7	18.9	20.9	21.2	21.2	21.2
N154	17.5	19.4	22.9	26.2	28.4	30.4	30.7	30.7	30.7
N155	18.9	20.8	24.3	27.6	29.8	31.8	32.1	32.1	32.1
N156	18.8	20.7	24.2	27.5	29.7	31.7	32.0	32.0	32.0
N157	7.5	9.4	12.9	16.2	18.4	20.4	20.7	20.7	20.7
N158	16.9	18.8	22.3	25.6	27.8	29.8	30.1	30.1	30.1
N159	15.8	17.7	21.2	24.5	26.7	28.7	29.0	29.0	29.0
N160	15.2	17.1	20.6	23.9	26.1	28.1	28.4	28.4	28.4
N161	14.9	16.8	20.3	23.6	25.8	27.8	28.1	28.1	28.1
N162	14.6	16.5	20.0	23.3	25.5	27.5	27.8	27.8	27.8
N163	14.2	16.1	19.6	22.9	25.1	27.1	27.4	27.4	27.4

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
N164	13.5	15.4	18.9	22.2	24.4	26.4	26.7	26.7	26.7
N165	13.5	15.4	18.9	22.2	24.4	26.4	26.7	26.7	26.7
N166	11.7	13.6	17.1	20.4	22.6	24.6	24.9	24.9	24.9
N167	12.0	13.9	17.4	20.7	22.9	24.9	25.2	25.2	25.2
N168	11.9	13.8	17.3	20.6	22.8	24.8	25.1	25.1	25.1
N169	11.3	13.2	16.7	20.0	22.2	24.2	24.5	24.5	24.5
N170	11.3	13.2	16.7	20.0	22.2	24.2	24.5	24.5	24.5
N171	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N172	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N173	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
N174	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N175	11.2	13.1	16.6	19.9	22.1	24.1	24.4	24.4	24.4
N176	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
N177	11.2	13.1	16.6	19.9	22.1	24.1	24.4	24.4	24.4
N178	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N179	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N180	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
N181	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N182	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N183	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
N184	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N185	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
N186	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
N187	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N188	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
N189	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
N190	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N191	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N192	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
N193	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N194	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N195	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
N196	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N197	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
N198	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N199	10.6	12.5	16.0	19.3	21.5	23.5	23.8	23.8	23.8
N200	11.2	13.1	16.6	19.9	22.1	24.1	24.4	24.4	24.4
N201	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N202	10.6	12.5	16.0	19.3	21.5	23.5	23.8	23.8	23.8
N203	10.4	12.3	15.8	19.1	21.3	23.3	23.6	23.6	23.6
N204	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N205	11.0	12.9	16.4	19.7	21.9	23.9	24.2	24.2	24.2
N206	11.1	13.0	16.5	19.8	22.0	24.0	24.3	24.3	24.3
N207	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N208	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N209	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N210	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N211	10.6	12.5	16.0	19.3	21.5	23.5	23.8	23.8	23.8
N212	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N213	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N214	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N215	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N216	10.7	12.6	16.1	19.4	21.6	23.6	23.9	23.9	23.9
N217	10.5	12.4	15.9	19.2	21.4	23.4	23.7	23.7	23.7
N218	10.9	12.8	16.3	19.6	21.8	23.8	24.1	24.1	24.1
N219	10.8	12.7	16.2	19.5	21.7	23.7	24.0	24.0	24.0
N220	10.6	12.5	16.0	19.3	21.5	23.5	23.8	23.8	23.8
N221	10.4	12.3	15.8	19.1	21.3	23.3	23.6	23.6	23.6
Involved receivers									
H01	21.9	23.8	27.3	30.6	32.8	34.8	35.1	35.1	35.1
H02	26.0	27.9	31.4	34.7	36.9	38.9	39.2	39.2	39.2
H03	25.4	27.3	30.8	34.1	36.3	38.3	38.6	38.6	38.6
H04	20.4	22.3	25.8	29.1	31.3	33.3	33.6	33.6	33.6
H05	31.0	32.9	36.4	39.7	41.9	43.9	44.2	44.2	44.2

Receiver	Hub-height wind speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
H06	24.8	26.7	30.2	33.5	35.7	37.7	38.0	38.0	38.0
H07	29.8	31.7	35.2	38.5	40.7	42.7	43.0	43.0	43.0
H10	26.1	28.0	31.5	34.8	37.0	39.0	39.3	39.3	39.3
H11	26.1	28.0	31.5	34.8	37.0	39.0	39.3	39.3	39.3
H12	23.5	25.4	28.9	32.2	34.4	36.4	36.7	36.7	36.7
Synergy properties									
H08	29.3	31.2	34.7	38.0	40.2	42.2	42.5	42.5	42.5
H09	33.4	35.3	38.8	42.1	44.3	46.3	46.6	46.6	46.6

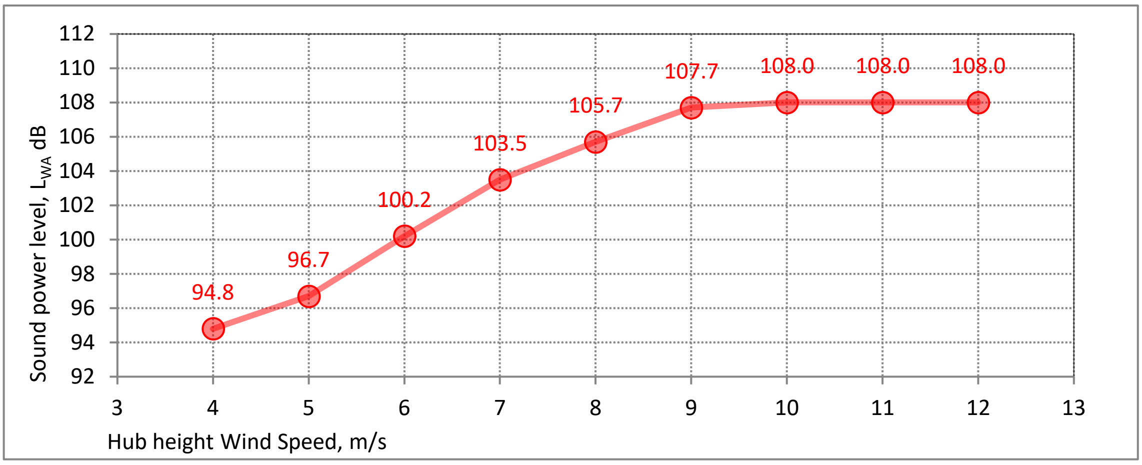
APPENDIX I NZS 6808 DOCUMENTATION

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

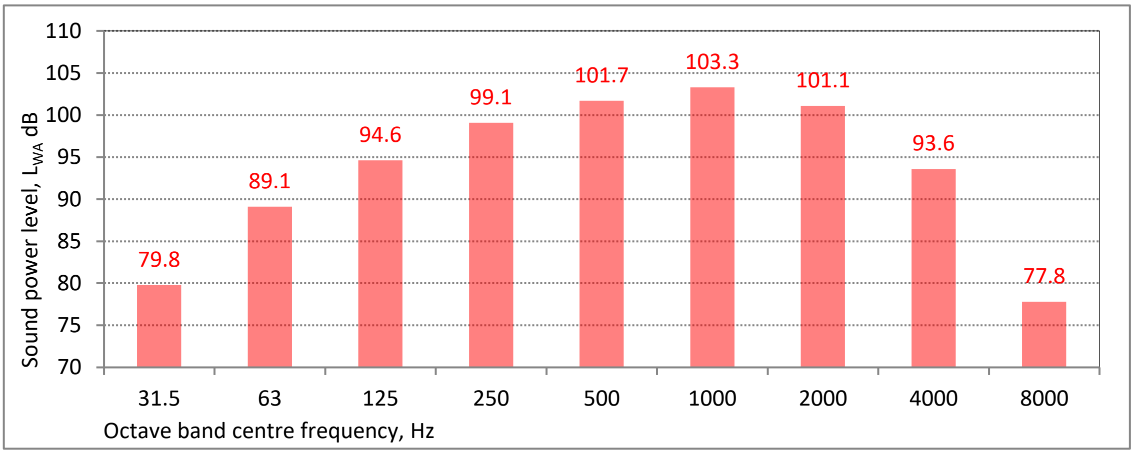
(b) Noise sensitive locations: See Section 2.0 and Appendix C

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

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



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



(d) Wind turbine model: See Table 3 of 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 F)

(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.