MARSHALL DAY Acoustics

NAVARRE GREEN POWER HUB
WIND TURBINE NOISE ASSESSMENT

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SUMMARY

A preliminary assessment of operational noise associated with the wind turbines of the proposed Navarre Green Power Hub Project has been carried out. The purpose of this assessment was to inform the referral process and approval pathway for the Project.

The assessment is based on a wind farm layout comprising up to 102 multi-megawatt wind turbines. Operational noise associated with the proposed wind turbines has been assessed in accordance with New Zealand Standard 6808:2010 *Acoustics – Wind farm noise*, as required by the *Environment Protection Regulations 2021* and the Victorian Wind Energy Guidelines.

Noise modelling was carried out based on a candidate wind turbine model (Vestas V172-7.2) 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 noise assessment supports that operational noise associated with the wind energy facility component of the Navarre Wind Farm Project can be designed and developed to achieve Victorian policy requirements concerning operational wind turbine noise. However, the predicted noise levels are sufficient to indicate that operational noise associated with the wind turbines would warrant further assessment. This is recommended to be addressed as part of the ongoing design and approval process, and include:

- an assessment of the latest wind turbine selection and layout, demonstrating compliance with the applicable noise limits at surrounding receivers can be achieved;
- background noise monitoring at surrounding receivers and natural areas, if required;
- an assessment of operational noise associated with ancillary infrastructure demonstrating compliance with the applicable noise limits.

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1.0 INTRODUCTION

Neoen Australia Pty Ltd (the Proponent) is proposing to develop the Navarre Green Power Hub (the Project) in the Shire of Northern Grampians and Pyrenees Shire Council local government areas, approximately 5 km north of the township of Navarre in western Victoria.

The Project would be a combined 600 MW wind energy facility and 600 MW/1200 MWh Battery Energy Storage System (BESS). The wind energy facility would incorporate a total of 102 wind turbines.

This report presents the results a preliminary assessment of operational noise associated with the wind energy facility component, specifically the wind turbines of the Project in accordance with relevant legislation and guidelines. The purpose of this assessment has been to inform the referral process and approval pathway for the Project, such as to accompany a referral under the *Environment Effects Act 1978*.

The noise assessment presented in this report is based on:

- Operational wind farm noise limits 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 for which approval may be sought; and
- A comparison of the predicted noise levels with the applicable base noise limits.

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

2.0 PROJECT DESCRIPTION

The 600 MW wind energy facility component of the Project would incorporate a total of 102 wind turbines, across two (2) areas referred to as the Eastern Layout, consisting of 50 wind turbines, and the Western Layout, consisting of 52 wind turbines. The coordinates of the proposed wind turbines are tabulated in Appendix B.

The Proponent is seeking consent for a wind energy facility comprising wind turbines extending to a tip height of up to 270 m. The Vestas V172-7.2, with a power output of 7.2 MW and a rotor diameter of 172 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 5.2.

A total of 110 noise sensitive locations (generally referred to as receivers herein) located within five (5) km of the proposed wind turbines have been considered in this assessment. This includes nine (9) 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 Project layout and receivers is provided in Appendix D.

3.0 VICTORIAN LEGISLATION & GUIDELINES

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

- *Environment Protection Act 2017*
- *Environment Protection Regulations 2021*
- *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines* dated November 2021, by then Department of Environment, Land, Water and Planning
- 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.
- *Environment Reference Standard* (ERS), 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 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 New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (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 *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines,* dated November 2021 (Victorian Wind Energy Guidelines) provides 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.*

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*

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

- *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 New Zealand Standard 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 Standard specifically defines the noise sensitive locations where limits apply as locations that are outside the wind farm boundary.

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.

Ancillary infrastructure, such as the proposed BESS or substations are considered a ‘commercial, industrial and trade premises’ under the EP Act, and would therefore require an assessment in accordance with the Noise Protocol. However, the Noise Protocol excludes noise from wind turbines.

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. Also, in rural areas only, noise sensitive areas include:

that part of the land within the boundary of—

(i) a tourist establishment; or

(ii) a campground; or

(iii) a caravan park;

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.

3.6 Environment Reference Standard

The *Environment Reference Standard* (ERS) is a legislative instrument made under the EP Act which sets out environmental values for ambient sound that are sought to be achieved and maintained in Victoria and standards to support those values. The indicators and objectives within the standard provide a benchmark for comparing desired outcomes to the actual state of the environment, and a basis for assessing actual and potential risks to the environmental values.

The ERS is an environmental benchmark. It brings together a collection of environmental values, indicators and objectives that describe environmental and human health outcomes to be achieved or maintained in the whole or in parts of Victoria. These values, indicators and objectives are used to assess and report on changing environmental conditions by providing a reference point for decision makers to consider whether a proposal or activity is consistent with the environmental values identified in the ERS. The ERS also allows decision makers to evaluate potential impacts on human health and the environment that may result from a proposal or activity. The ERS does not specify requirements that must be met by environmental managers or other duty holders.

The ERS is primarily relevant for aspects of the environment that are not the subject of prescriptive regulation. These aspects include the noise from commercial premises and construction activities in natural areas, or the additional noise from public roads as a result of traffic associated with commercial activities.

Further, in the situations where the ERS is a relevant consideration, it is important to note that the ERS is not a compliance standard. Specifically, the values listed within the ERS are not prescribed noise limits, nor are they design criteria for proposed development.

Indicators and objectives within the ERS are generally not relevant considerations where they relate to an aspect of the environment that is the subject of prescriptive regulation. For example, the ambient sound indicators and objectives will not be relevant when considering noise from wind turbines and commercial, industrial and trade premises at noise sensitive areas, as defined in the EP Regulations. This is because noise in these circumstances is regulated by specific provisions and noise limits in the EP Regulations and the associated Noise Protocol and NZS 6808.

The environmental values presented in the ERS and a description of each is provided in Table 1.

Table 1: Environmental values of the ambient sound environment

Environmental value	Description of environmental value
Sleep during the night	An ambient sound environment that supports sleep during the night
Domestic and recreational activities	An ambient sound environment that supports recreational and domestic activities in a residential setting
Normal conversation	An ambient sound environment that allows for normal conversation indoors without the need to raise voices
Child learning and development	An ambient sound environment that supports cognitive development and learning in children
Human tranquillity and enjoyment outdoors in natural areas	An ambient sound environment that allows for the appreciation and enjoyment of the environment for its natural condition and the restorative benefits of tranquil soundscapes in natural areas
Musical entertainment	An ambient sound environment that recognises the community's demand for a wide range of musical entertainment.

The ERS land use categories and their descriptions are provided in Table 2.

Table 2: Land use categories for the ambient sound environment

Land use category	General description	Planning zones
Category I	An urban form with distinctive features or characteristics of taller buildings, high commercial and residential intensity and high site coverage.	Industrial Zone 1 (IN1Z) Industrial Zone 2 (IN2Z) Port Zone (PZ) Road 1 Zone (RDZ1) Capital City Zone (CCZ) Docklands Zone (DZ)
Category II	Medium rise building form with a strong urban or commercial character. Typically contains mixed land uses including activity centres and larger consolidated sites, and an active public realm.	Industrial Zone 3 (IN3Z) Commercial 1 Zone (C1Z) Commercial 2 Zone (C2Z) Commercial 3 Zone (C3Z) Activity Centre Zone (ACZ) Mixed Use Zone (MUZ) Road 2 Zone (RDZ2)
Category III	Lower rise building form including lower density residential development and detached housing typical of suburban residential settings or in towns of district or regional significance.	Residential Growth Zone (RGZ) General Residential Zone (GRZ) Neighbourhood Residential Zone (NRZ) Urban Floodway Zone (UFZ) Public Park and Recreation Zone (PPRZ) Urban Growth Zone (UGZ)

Land use category	General description	Planning zones
Category IV	Lower density or sparse populations with settlements that include smaller hamlets, villages and small towns that are generally unsuited for further expansion. Land uses include primary industry and farming.	Low Density Residential Zone (LDRZ) Township Zone (TZ) Rural Living Zone (RLZ) Green Wedge A Zone (GWAZ) Rural Conservation Zone (RCZ) Public Conservation and Resource Zone (PCRZ) Green Wedge Zone (GWZ) Farming Zone (FZ) Rural Activity Zone (RAZ)
Category V	Unique combinations of landscape, biodiversity and geodiversity. These natural areas typically provide undisturbed species habitat and enable people to see and interact with native vegetation and wildlife.	Natural areas are classified as land within Category V irrespective of the planning zones that apply to that land.
Category I, II, III or IV depending on surrounding land uses and the intent of the specific planning zone (which may have a diversity of uses) as specified in a schedule to the planning zone		Comprehensive Development Zone (CDZ) Priority Development Zone (PDZ) Special Use Zone (SUZ) Public Use Zone (PUZ)

Note: Urban Growth Zone (UGZ) is a Category III land use until the relevant precinct structure plan is adopted, at which time the approved land uses will determine the land use category.

The ERS indicators and objectives relevant to each land use category are described in Table 3.

Table 3: Indicators and objectives for the ambient sound environment

Land use category	Indicators	Objectives
Category I	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	55 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	60 dB L_{Aeq}
Category II	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	50 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	55 dB L_{Aeq}
Category III	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	40 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	50 dB L_{Aeq}
Category IV	Outdoor $L_{Aeq,8h}$ from 2200 hrs to 0600 hrs	35 dB L_{Aeq}
	Outdoor $L_{Aeq,16hr}$ from 0600 hrs to 2200 hrs	40 dB L_{Aeq}
Category V	Qualitative	A sound quality that is conducive to human tranquillity and enjoyment, having regard to the ambient natural soundscape

4.0 ASSESSMENT METHOD

4.1 Overview

Assessing noise levels for the Project generally involves:

- establishing background noise levels at noise sensitive locations around the wind farm;
- assessing the land zoning of the Project Area and surrounding areas;
- determining suitable noise limits accounting for background noise levels and land zoning;
- predicting the level of noise expected to occur as a result of the Project;
- 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 may be used to inform the setting of limits for operational noise associated with the Project. 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 may be used for setting noise limits for the wind energy facility component of the 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 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 Project, 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. At this stage in the Project, background noise monitoring has not been conducted, and the assessment has adopted the base (minimum) applicable noise limits.

4.3 Noise predictions

Operational noise levels associated with the proposed wind energy facility is predicted using:

- Noise emission data for the wind turbines;
- 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 demonstrated 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 4. Further discussion of the method and the calculation choices is provided in Appendix G.

Table 4: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLANnoise 9.0.
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 based on 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 SoundPLANnoise modelling software and relate to the influence of terrain screening and ground effects on sound propagation.
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 Project, the following specific procedures are noted: Calculations of wind turbine to receiver distances and average sound propagation heights are made based on the point source being located at the position of the hub of the wind turbine. Calculations of terrain related screening are made based on 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	1 m resolution within the site and surrounds, provided by the Proponent.

Detail	Description
Terrain effects (wind turbine-specific procedures)	Adjustments for the effects of terrain are determined and applied based on the UK Institute of Acoustics guidance and research outlined in Appendix G. Valley effects: +3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the wind turbine and calculation point is 50 % greater than would occur if the ground were flat. Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the wind turbine and the calculation point. The value of the screening effect is limited to a maximum value of -2 dB. The western part of the Project is in a relatively flat area, while the eastern part is within a relatively hilly area characterised by variations in ground elevation between the wind turbines and surrounding receivers. The topography of the site is depicted in the elevation map provided in Appendix E.
Ground conditions	Ground factor of G = 0.5 based on the UK Institute of Acoustics guidance and research outlined in Appendix G. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10°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 (rate of change in the speed of sound with increasing height above ground) 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.

5.0 WIND ENERGY FACILITY NOISE ASSESSMENT

5.1 Noise limits

5.1.1 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 5.3, and the zoning map for the area presented in Appendix F, the area within the predicted 35 dB LA90 contour is zoned 'Farming,' with portions zoned 'Public Conservation And Resource,' albeit where no receivers are located.

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 considered warranted for noise associated with the proposed wind energy facility.

5.1.2 Involved receivers

The definition of noise sensitive locations in NZS 6808 specifically excludes dwellings located within the wind farm project areas. 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 Project Area 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.

5.1.3 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 5.

Table 5: 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, noise from the wind energy facility has been assessed using the relevant base (minimum) noise limits presented above.

5.2 Wind turbine noise emissions

5.2.1 Candidate 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 energy facility 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 Vestas V172-7.2 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 6.

Table 6: Selected candidate wind turbine model

Item	Detail
Make	Vestas
Model	V172-7.2
Rotor diameter	172 m
Hub height	174.5 m
Rated power	7.2 MW
Cut-in wind speed (hub height)	3 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. 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 need to be considered once the wind turbine layout has been finalised and the final wind turbine model selected.

5.2.2 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.

The highest (maximum) overall sound power level data for the candidate wind turbine model has been obtained from the manufacturer's website, https://www.vestas.com/en/products/enventus-platform/V172-7-2-MW. This indicates an overall A-weighted sound power level of 106.9 dB L_{WA}.

In the absence of available sound frequency characteristics, the Proponent has advised that third octave band level data available for Vestas V162 would be considered representative. This data has therefore been sourced from document *Third octave noise emission EnVentus™ V162-6.2MW, 0105-5200_00*, dated 21 April 2021.

The noise modelling undertaken for this assessment involved conversion of the V162 third octave band levels to octave band levels, and adjusted to highest (maximum) overall sound power level for the Vestas V172-7.2. An addition of +1.0 dB has also been applied to provide a margin for typical values of test uncertainty.

The highest (maximum) overall A-weighted sound power levels (including the +1.0 dB addition) is 107.9 dB LWA, with the octave band values presented in Table 7. These represent the total noise emissions of the wind turbine, including the secondary contribution of ancillary plant associated with each wind turbine (e.g. cooling fans).

Table 7: A-weighted 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}	78.7	89.2	96.7	101.3	103.0	101.9	97.8	90.9	81.0	107.9

Note: Based on one-third octave band levels at 10 m/s

A 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.

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. This is 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.

5.2.3 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.

5.3 Predicted noise levels

This section of the report presents the predicted noise levels associated with the wind turbines 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 turbines have been predicted using the sound power level data detailed in Section 5.2.2 for the candidate wind turbine model and are summarised in Table 8, at receivers where the predicted noise level (for the hub height wind speed which results in the highest predicted noise level) is 35 dB L_{A90} or above.

The locations of the predicted 35 dB and 40 dB L_{A90} noise contours are illustrated in Figure 1, corresponding to 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 35 dB L_{A90}.

Table 8: Highest predicted noise level at receivers with predicted levels 35 dB L_{A90} or above

Receiver	Predicted level, dB L_{A90}	Receiver	Predicted level, dB L_{A90}
94 (1)	44.4	8 (1)	37.0
9 (1)	41.9	88	37.0
96 (1)	41.4	91	37.0
6 (1)	39.3	17	36.3
87 (1)	39.3	5	36.2
93	38.1	112	36.1
98 (1)	37.7	107	35.5
111	37.6	95	35.2
92	37.4	102	35.1
97 (1)	37.2	82	35.0

Note: (1) Involved receiver with noise agreement in place

The results in Table 8 indicate:

- Predicted noise levels at all non-involved locations are below the base (minimum) applicable limit of 40 dB L_{A90}; and
- Predicted noise levels at all involved locations are below the base (minimum) applicable limit of 45 dB L_{A90} as specified in the EP Regulations.

The results therefore support that the Project can be designed and developed to achieve Victorian policy requirements concerning operational wind turbine noise. However, the predicted noise levels are sufficient to indicate that operational noise associated with the wind turbines will need to be addressed as part of the ongoing design and approval process.

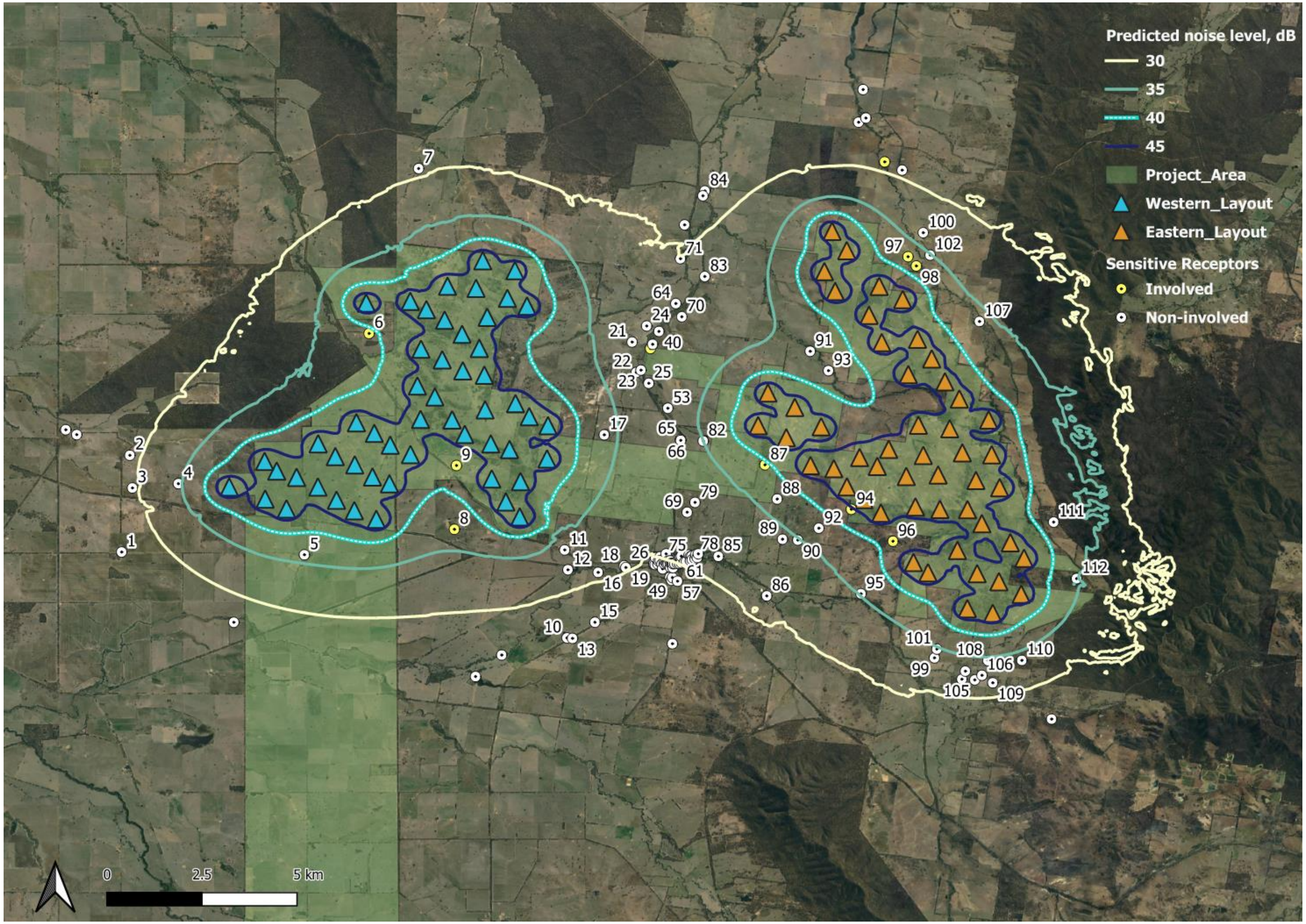
5.4 Cumulative assessment

No approved or operating wind farms are known to occur within a 10 km radius of the proposed Project Area.

From a review of the area surrounding the Project, the nearest approved and/or operating wind farm is the Bulgana Green Power Hub (approximately 15 km south west).

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

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



6.0 ENVIRONMENTAL REFERENCE STANDARD

The Environmental Reference Standard (ERS) is a relevant consideration for natural areas located in the vicinity of the Project and is addressed in this section.

6.1 Identified natural areas

Natural areas are a land-use category for which the ERS details desired outcomes in terms of noise level to be achieved or maintained in Victoria. The ERS defines natural areas as national parks, state parks, state forests, nature conservation reserves and wildlife reserves.

To provide an indication of the proximity of natural areas to the Project, reference has been made to the land zoning of the surrounding area. Specifically, areas zoned as PCRZ and PPRZ, have been identified, where the ERS may be relevant. For this Project, the nearest identified natural areas include:

- Kara Kara National Park, east of the Project;
- Big Tottington Nature Conservation Reserve, Mount Bolangum Nature Conservation Reserve and Little Tollington State Forest, north of the Project; and
- Mori Mori Nature Conservation Reserve, west of the Project.

6.2 Guidance on noise in natural areas

Clause 7 of the ERS sets out the environmental values for the ambient sound environment that are to be achieved or maintained in Victoria. The ERS also sets out the indicators and objectives to support those values. The environmental value relevant to natural areas and the indicator to support this value is contained in Table 9.

Table 9: Environmental values of the ambient sound environment

Environmental value	Description of environmental value
Human tranquillity and enjoyment outdoors in natural areas	An ambient sound environment that allows for the appreciation and enjoyment of the environment for its natural condition and the restorative benefits of tranquil soundscapes in natural areas

6.3 Project noise levels in natural areas

The potential for the environmental value of *human tranquillity and enjoyment outdoors in natural areas* to be affected by noise is dependent on the audibility of the noise. Audibility of the Project in the identified natural areas will be highly dependent on a range of factors, including:

- Proximity and scale of the Project;
- Extent of the identified natural areas;
- Natural background noise sources (e.g., vegetation, fauna, etc.);
- Anthropogenic background noise sources (e.g., road traffic, farming and forestry activities); and
- Wind conditions (e.g., wind speed and wind direction).

The distribution of operational noise from proposed wind turbines in the identified natural areas is presented in Figure 1 and Appendix F. These indicate predicted operational wind turbines noise levels between 35-40 dB L_{A90} at boundary locations within identified natural areas, and therefore likely to be audible and require further consideration.

7.0 RECOMMENDATIONS

Further assessments are recommended as part of subsequent stages of the approval process of the Project, addressing:

- the latest wind turbine selection and layout, demonstrating compliance with the applicable noise limits at surrounding receivers can be achieved;
- background noise monitoring at surrounding receivers and natural areas, if required;
- assessment of operational noise associated with ancillary infrastructure demonstrating compliance with the applicable noise limits

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 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 *Eastern_Layout* and *Western_Layout*, supplied by Aurecon 2 March 2023).

Table 10: Wind turbine coordinates – MGA 94 zone 54

Wind turbine	Easting, m	Northing, m	Wind turbine	Easting, m	Northing, m
Eastern Layout			*Western Layout*		
E.1	692725	5924876	W.1	680382	5922788
E.2	693098	5924232	W.2	681547	5922822
E.3	692493	5923558	W.3	681965	5922542
E.4	692762	5922900	W.4	682439	5922184
E.5	693928	5923039	W.5	682889	5921710
E.6	693638	5922097	W.6	683563	5922255
E.7	693953	5921194	W.7	684622	5922600
E.8	694629	5920129	W.8	684109	5922865
E.9	694538	5922595	W.9	684329	5923767
E.10	694900	5921279	W.10	683487	5924110
E.11	695259	5920626	W.11	683290	5923211
E.12	695590	5919870	W.12	682538	5923295
E.13	695957	5919295	W.13	681733	5918942
E.14	696714	5918590	W.14	681674	5920038
E.15	695681	5918325	W.15	682126	5919672
E.16	694859	5918459	W.16	682347	5920885
E.17	694056	5917686	W.17	681795	5921244
E.18	693282	5917435	W.18	682566	5918908
E.19	693742	5917133	W.19	682890	5918424
E.20	694500	5916785	W.20	683569	5918099
E.21	695341	5916815	W.21	684059	5917902
E.22	694964	5917465	W.22	684248	5919406
E.23	696769	5917447	W.23	684602	5918968
E.24	696953	5916360	W.24	685089	5918665
E.25	695996	5917526	W.25	685041	5917574
E.26	696334	5916614	W.26	683443	5919218
E.27	696089	5915663	W.27	682882	5920513
E.28	695363	5915687	W.28	683333	5921238
E.29	694717	5915782	W.29	683446	5920358

Wind turbine	Easting, m	Northing, m	Wind turbine	Easting, m	Northing, m
Eastern Layout			*Western Layout*		
E.30	693802	5915600	W.30	683925	5916184
E.31	693365	5916051	W.31	684281	5915686
E.32	692927	5916483	W.32	683570	5916948
E.33	692595	5917084	W.33	684324	5916847
E.34	691983	5917203	W.34	680040	5918867
E.35	691366	5918130	W.35	680504	5918509
E.36	690632	5918542	W.36	680915	5918114
E.37	690913	5919605	W.37	681443	5917794
E.38	691612	5919119	W.38	679017	5918198
E.39	692292	5918466	W.39	679459	5917769
E.40	696458	5915190	W.40	679967	5917486
E.41	697193	5914551	W.41	680426	5917082
E.42	697542	5914032	W.42	680868	5916845
E.43	695793	5914328	W.43	677592	5917651
E.44	694624	5913957	W.44	677905	5917324
E.45	695000	5913613	W.45	678424	5917111
E.46	696296	5913555	W.46	678981	5916780
E.47	696863	5913277	W.47	679462	5916337
E.48	696009	5912412	W.48	679924	5915983
E.49	696676	5912244	W.49	680498	5915689
E.50	697440	5912854	W.50	676642	5916829
			W.51	677581	5916414
			W.52	678137	5916078

APPENDIX C RECEIVER COORDINATES

The following table sets out the assessed receivers considered in the environmental noise assessment. (Reference *Sensitive Receptors*, supplied by Aurecon on 14 April 2023).

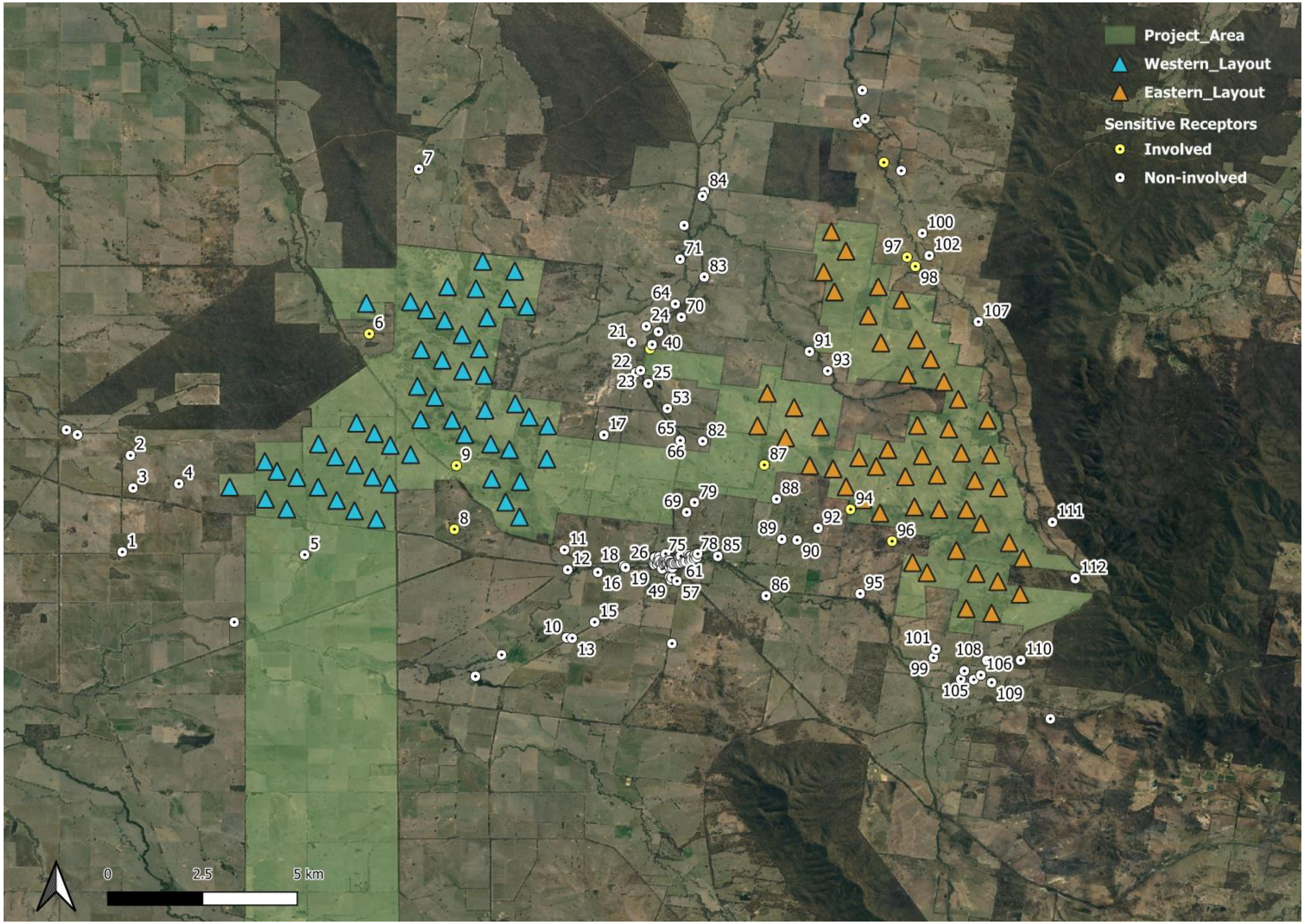
Table 11: Receivers within 5 km of the proposed wind turbines – MGA 94 zone 54

Receiver	Easting, m	Northing, m	Nearest wind turbine	Distance to nearest wind turbine, m	Receiver	Easting, m	Northing, m	Nearest wind turbine	Distance to nearest wind turbine, m
1	673763	5914753	W.50	3550	58	688406	5914067	W.31	4432
2	674043	5917922	W.50	2820	59	688459	5914063	W.31	4483
3	674089	5916849	W.50	2553	60	688469	5914254	W.31	4426
4	675303	5916965	W.50	1347	61	688500	5914172	W.31	4483
5	678577	5914563	W.52	1577	62	688507	5914083	W.31	4520
6 (1)	680436	5921788	W.1	1002	63	688511	5914303	W.31	4451
7	681859	5927171	W.10	3468	64	688549	5922595	E.37	3812
8 (1)	682549	5915314	W.30	1628	65	688573	5918136	E.36	2099
9 (1)	682648	5917407	W.32	1030	66	688579	5918103	E.36	2099
10	685439	5911687	W.31	4163	67	688587	5914103	W.31	4589
11	685441	5914575	W.31	1607	68	688640	5914122	E.34	4546
12	685513	5913921	W.31	2152	69	688697	5915741	E.36	3405
13	685584	5911668	W.31	4224	70	688698	5922157	E.37	3380
15	686186	5912184	W.31	3987	71	688704	5924063	E.3	3823
16	686307	5913818	W.31	2756	72	688716	5914337	E.34	4346
17	686567	5918329	W.24	1515	73	688748	5914281	E.34	4360
18	686999	5914022	W.31	3188	74	688749	5914156	E.34	4443
19	687040	5913962	W.31	3254	75	688785	5914292	E.34	4324
21	687368	5921357	W.7	3015	76	688797	5914180	E.34	4392
22	687456	5920357	W.24	2910	77	688873	5914213	E.34	4314
23	687582	5920430	W.24	3055	78	688893	5914342	E.34	4211
24	687764	5921876	W.7	3225	79	688911	5916059	E.36	3021
25	687778	5919994	W.24	3000	80	688930	5914248	E.34	4249
26	687783	5914068	W.31	3858	81	688959	5914369	E.34	4144
27	687814	5914041	W.31	3897	82	689172	5918068	E.36	1535
28	687829	5914283	W.31	3815	83	689333	5923465	E.3	3161
29	687831	5914266	W.31	3824	84	689398	5926273	E.1	3608
30 (1)	687850	5921134	E.37	3424	85	689487	5914275	E.34	3847
31	687889	5914060	W.31	3958	86	690733	5912949	E.44	4020
32	687907	5921270	E.37	3436	87 (1)	690783	5917250	E.35	1056

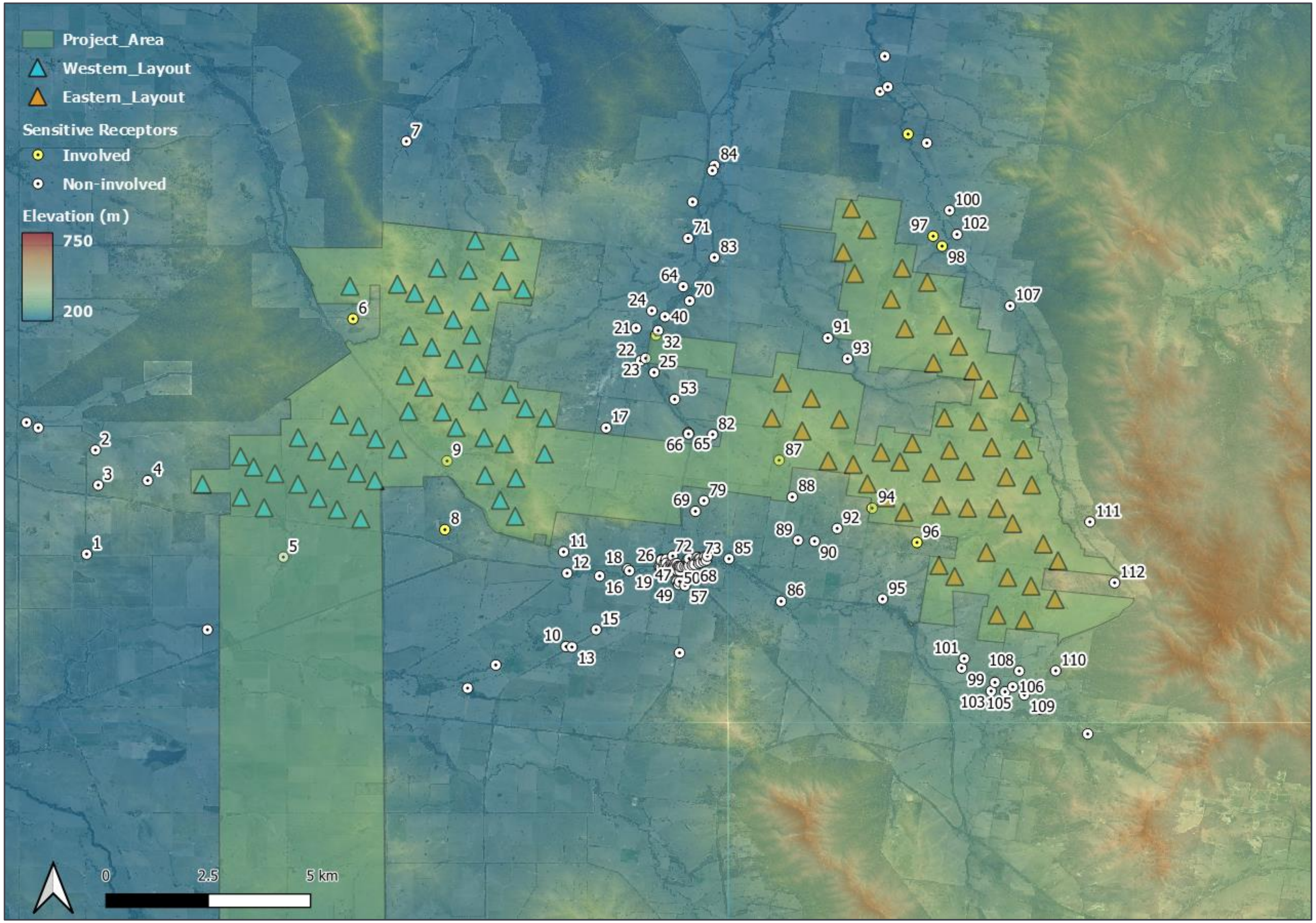
Receiver	Easting, m	Northing, m	Nearest wind turbine	Distance to nearest wind turbine, m	Receiver	Easting, m	Northing, m	Nearest wind turbine	Distance to nearest wind turbine, m
33	687908	5914161	W.31	3935	88	691079	5916121	E.34	1410
34	687950	5914291	W.31	3926	89	691190	5914799	E.32	2419
35	687950	5914169	W.31	3971	90	691594	5914761	E.32	2178
36	687994	5914054	W.31	4056	91	692059	5920948	E.37	1766
37	688007	5913899	W.31	4133	92	692157	5915139	E.31	1514
38	688061	5914067	W.31	4112	93	692527	5920303	E.38	1496
39	688066	5914164	W.31	4080	94 (1)	693027	5915739	E.31	460
40	688083	5921689	E.37	3515	95	693218	5912963	E.44	1722
41	688106	5914159	W.31	4119	96 (1)	694101	5914667	E.44	882
42	688112	5914388	W.31	4045	97 (1)	694711	5923994	E.5	1235
43	688120	5914068	W.31	4166	98 (1)	694923	5923686	E.9	1157
44	688156	5914145	W.31	4170	99	695106	5910814	E.48	1835
45	688160	5914063	W.31	4205	100	695130	5924773	E.2	2103
46	688196	5913614	W.31	4430	101	695176	5911101	E.48	1553
47	688210	5914155	W.31	4217	102	695296	5924033	E.9	1626
48	688213	5913947	W.31	4300	103	695812	5910098	E.49	2314
49	688234	5913521	W.31	4507	104	695911	5910360	E.49	2034
50	688234	5914067	W.31	4272	105	696151	5910067	E.49	2240
51	688260	5913606	W.31	4490	106	696345	5910213	E.49	2058
52	688263	5914053	W.31	4304	107	696547	5921825	E.10	1735
53	688263	5919164	E.36	2449	108	696514	5910692	E.49	1561
54	688281	5913929	W.31	4369	109	696623	5909961	E.49	2284
55	688287	5914063	W.31	4323	110	697406	5910680	E.49	1727
56	688331	5914064	W.31	4363	111	698351	5915197	E.41	1326
57	688392	5913484	W.31	4664	112	698911	5913328	E.42	1540

Note: (1) Involved receiver with noise agreement in place

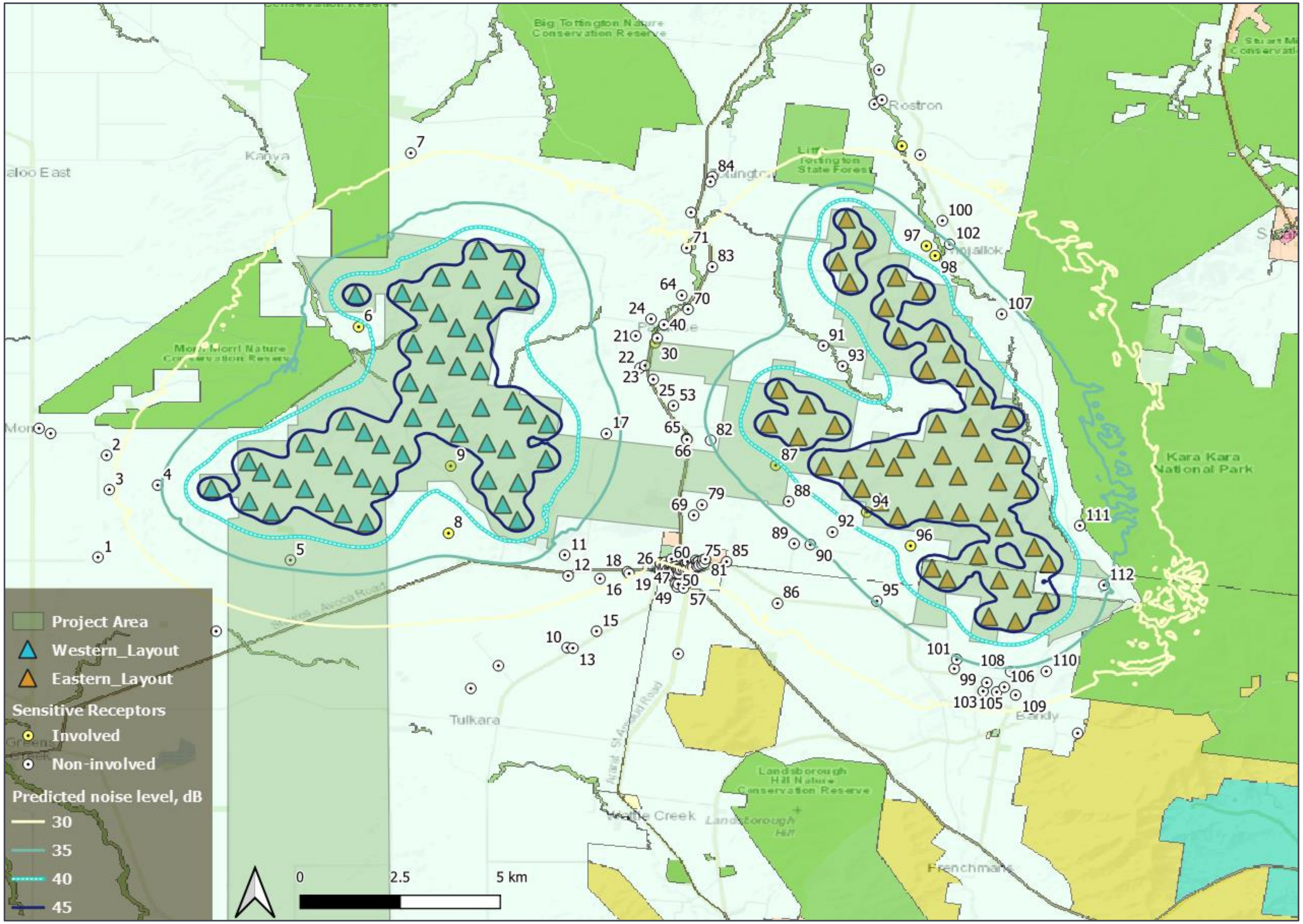
APPENDIX D SITE LAYOUT PLAN



APPENDIX E SITE TOPOGRAPHY



APPENDIX F ZONING MAP



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 Wind farms environmental 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 studies2, 3, 4 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.

[2] 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.

[3] 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.

[4] 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 SoundPLANnoise 9.0 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 12: Highest predicted noise levels, dB L_{A90}

Receiver	Predicted level, dB L_{A90}	Receiver	Predicted level, dB L_{A90}
1	27.2	58	30.0
2	29.2	59	30.0
3	29.5	60	30.2
4	34.4	61	30.2
5	36.2	62	30.1
6 (1)	39.3	63	30.3
7	29.3	64	31.4
8 (1)	37.0	65	33.6
9 (1)	41.9	66	33.6
10	27.8	67	30.1
11	32.9	68	30.2
12	31.4	69	31.8
13	27.8	70	31.8
15	28.2	71	30.3
16	30.5	72	30.3
17	36.3	73	30.4
18	30.3	74	30.3
19	30.2	75	30.3
21	32.9	76	30.3
22	33.3	77	30.4
23	33.1	78	30.4
24	32.3	79	32.2
25	33.2	80	30.3
26	29.8	81	30.5
27	29.8	82	35.0
28	30.0	83	31.2
29	30.0	84	28.3
30 (1)	32.7	85	30.9
31	29.8	86	30.8
32	32.6	87 (1)	39.3
33	29.9	88	37.0

Receiver	Predicted level, dB L_{A90}	Receiver	Predicted level, dB L_{A90}
34	30.0	89	34.0
35	29.9	90	34.8
36	29.8	91	37.0
37	29.7	92	37.4
38	29.8	93	38.1
39	29.9	94 (1)	44.4
40	32.3	95	35.2
41	29.9	96 (1)	41.4
42	30.2	97 (1)	37.2
43	29.9	98 (1)	37.7
44	30.0	99	33.4
45	29.9	100	33.5
46	29.5	101	34.7
47	30.0	102	35.1
48	29.8	103	31.7
49	29.4	104	32.7
50	29.9	105	31.7
51	29.5	106	32.3
52	29.9	107	35.5
53	33.4	108	34.4
54	29.8	109	31.3
55	29.9	110	33.7
56	29.9	111	37.6
57	29.4	112	36.1

Note: (1) Involved receiver with noise agreement in place

APPENDIX I NZS 6808 DOCUMENTATION

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

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

(c) Wind turbine sound power levels, dB $L_{WA:}$ Refer Section 5.2.2

(d) Wind turbine model: Refer Table 6, Section 5.2

(e) Wind turbine hub height: Refer Table 6, Section 5.2

(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 SoundPLANnoise 9.0: Refer Section 4.3 and Appendix G

(h) Meteorological conditions assumed: Refer Table 4, 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: 1 m resolution elevation contours provided by the Proponent: Refer Appendix E

(k) Predicted far-field wind farm sound levels: Refer Section 5.3 and Appendix H.