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WATTA WELLA RENEWABLE ENERGY PROJECT
ENVIRONMENTAL NOISE ASSESSMENT

Rp 001 R02 20230659 | 30 June 2025

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Project:	**Watta Wella Renewable Energy Project Environmental Noise Assessment**
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Report No.:	**Rp 001 R02 20230659**

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Document Control

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GLOSSARY OF KEY ABBREVATIONS

Term	Abbreviation
Battery energy storage system	BESS
Bulgana Green Power Hub	BGPH
Environment effects statement	EES
Environment Protection Act 2017	EP Act
Environment Protection Authority Victoria	EPA
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
EPA Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline*	Technical Guideline
Environment Protection Regulations 2021	EP Regulations
Environment Reference Standard	ERS
General environmental duty	GED
ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*	ISO 9613-2
New Zealand Standard 6808:2010 *Acoustics – Wind farm noise*	NZS 6808
Noise management plan	NMP
Planning permit application	PPA
RES Australia Pty Ltd	proponent
Victoria Planning Provisions	VPP
Victorian Department of Environment, Land, Water and Planning	DELWP
Victorian Department of Transport and Planning	DTP
Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities*	Victorian Wind Energy Guidelines
Watta Wella Renewable Energy Project	Project

EXECUTIVE SUMMARY

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

The assessment is based on the proposed renewable energy project consisting of a co-located wind farm and battery energy storage facility (BESS), with 2 associated electrical substations.

This report has been prepared to inform the planning permit application (PPA) for the Project which will be submitted for determination by the Victorian Minister for Planning.

The wind farm component of the Project consists of 45 multi-megawatt wind turbines and the planning application seeks permission to develop wind turbines with a maximum tip height of 255 m. The actual wind turbine model for use at the site would be determined at a later stage, 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 applicable noise limits at surrounding noise sensitive locations (receivers). In advance of a final selection, the assessment considers a candidate wind turbine model that is representative of the size and type of wind turbines which could be used at the site. For this purpose, the Nordex N175 6.x with a nominal hub height of 160 m and rotor diameter of 175 m, has been nominated by the proponent for this assessment.

Operational noise from the proposed wind turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the *Environment Protection Regulations 2021* and the Victorian Department of Transport, Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023, and EPA-DTP Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline* dated 20 December 2024.

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

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

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

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

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

The assessment has also considered operational noise associated with the 2 electrical substations and the BESS which are proposed to be located to the southeast of the site. Noise levels from the substations and BESS have been assessed in accordance with EPA Publication 1826.2 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol). The assessment demonstrates that the substations and BESS can be designed and operated to achieve the noise limits determined in accordance with the Noise Protocol.

The assessment also considered the cumulative noise levels of the substations, BESS and other surrounding industry comprising the existing Bulgana Terminal Station and BESS, and the proposed Joel Joel BESS adjacent to the Bulgana Terminal Station. The results demonstrate that cumulative noise levels are predicted to comply with the noise limits.

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

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TABLE OF CONTENTS

1.0 INTRODUCTION

RES Australia Pty Ltd (proponent) is proposing to develop the Watta Wella Renewable Energy Project (Project) within the Victorian local government area of the Northern Grampians Shire Council.

The proposed Project comprises a wind farm, battery energy storage system (BESS), substations and related infrastructure.

An Environment Effects Act 1978 (EE Act) referral was lodged with the Victorian Department of Environment, Land, Water and Planning (DELWP) in August 2022. The Minister for Planning subsequently decided that an environment effects statement (EES) is not required for the Project, subject to a set of conditions primarily related to ecology, which would be assessed via an Environment Report process.[1] The scope of the Environment Report did not include any noise or amenity related matters.

This report presents an assessment of environmental noise associated with operation of the Project's wind turbines, BESS and substations. This report was prepared to accompany the planning permit application (PPA) for the Project, and addresses the environmental noise assessment requirements of the:

- Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023 (Victorian Wind Energy Guidelines)
- *Environment Protection Act 2017* (EP Act)
- *Environment Protection Regulations 2021* (EP Regulations)
- EPA-DTP Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline* dated 20 December 2024 (Technical Guideline).

Environmental noise levels are assessed at sensitive locations for people comprising:

- building and facility locations considered as noise sensitive areas or noise sensitive locations under the EP Regulations, collectively referred to as receivers and typically concerns dwellings in a wind farm context
- parks and reserves which may be considered natural areas for the purposes of the Environment Reference Standard under the EP Act and collectively referred to as natural areas in this report.

The assessment considers the environmental noise associated with operation of the Project both in isolation and cumulatively with other developments in the surrounding area.

[1] See *Reasons for decision under Environment Effects Act 1978 (referral number 2022-R05)* dated 22 October 2022 through this weblink

The noise assessment presented in this report is based on:

- a survey of background noise levels at a selection of receivers around the Project
- the minimum (base) wind turbine noise limits determined in accordance with New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the EP Regulations and Victorian Wind Energy Guidelines
- BESS and substation noise limits determined 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* (Noise Protocol)
- predicted wind turbine noise levels associated with the Project, 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 PPA seeks consent for
- predicted BESS and substation noise levels based on empirical noise emission data
- predicted noise levels from the operational Bulgana Green Power Hub, adjacent to the south of the Project, to assess potential cumulative noise levels
- a comparison of the predicted noise levels with the applicable base noise limits determined in accordance with NZS 6808 and the noise limits defined by the Noise Protocol
- an evaluation of noise management measures for the Project accounting for the general environmental duty under the EP Act to minimise the risk of harm to people and the environment so far as reasonably practicable.

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

2.0 PROJECT DESCRIPTION

The proposed Watta Wella Renewable Energy Project consists of a co-located wind farm, BESS and substations. The proposed location of the Project is approximately 16 km northeast of Stawell and 15 km west of Landsborough, as shown in Figure 1.

The wind farm component of the Project consists of 45 multi-megawatt wind turbines, with a maximum capacity of up to 360 MW. The proposed wind turbine layout is illustrated in Figure 2 and the coordinates are tabulated in Appendix B.

The proponent is seeking consent for wind turbines with a maximum tip height of 255 m. The Nordex N175 6.x MW, with a rotor diameter of 175 m and a power output of 6.8 MW, was nominated by the proponent as the candidate wind turbine model for this assessment. Further details of the candidate wind turbine model are presented in Section 7.2.

The BESS component of the Project is proposed to be rated to 400 MW/1,600 MWh and located toward the southeast of the site, with an associated substation. A second substation, associated with the wind farm component of the Project is proposed to consist of two high voltage transformers and associated ancillary electrical infrastructure, and is also located at the southeast of the site. The BESS and substations are illustrated in Figure 2.

Other Project related infrastructure on the site would include access tracks, underground cable reticulation, overhead power transmission lines and site offices.

Details of the study area and surrounding receivers are addressed subsequently in Section 5.0.

Figure 1: Project location

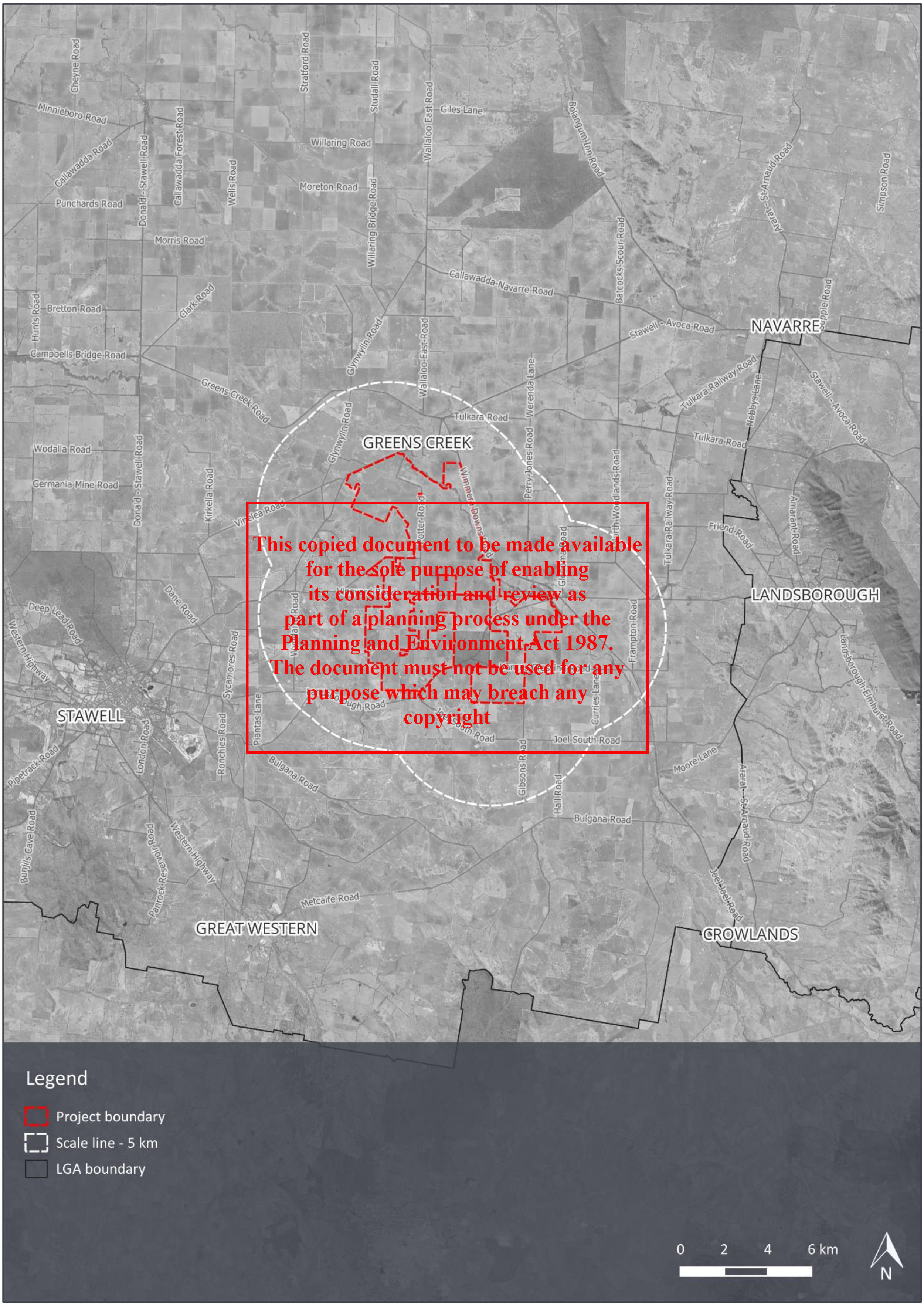

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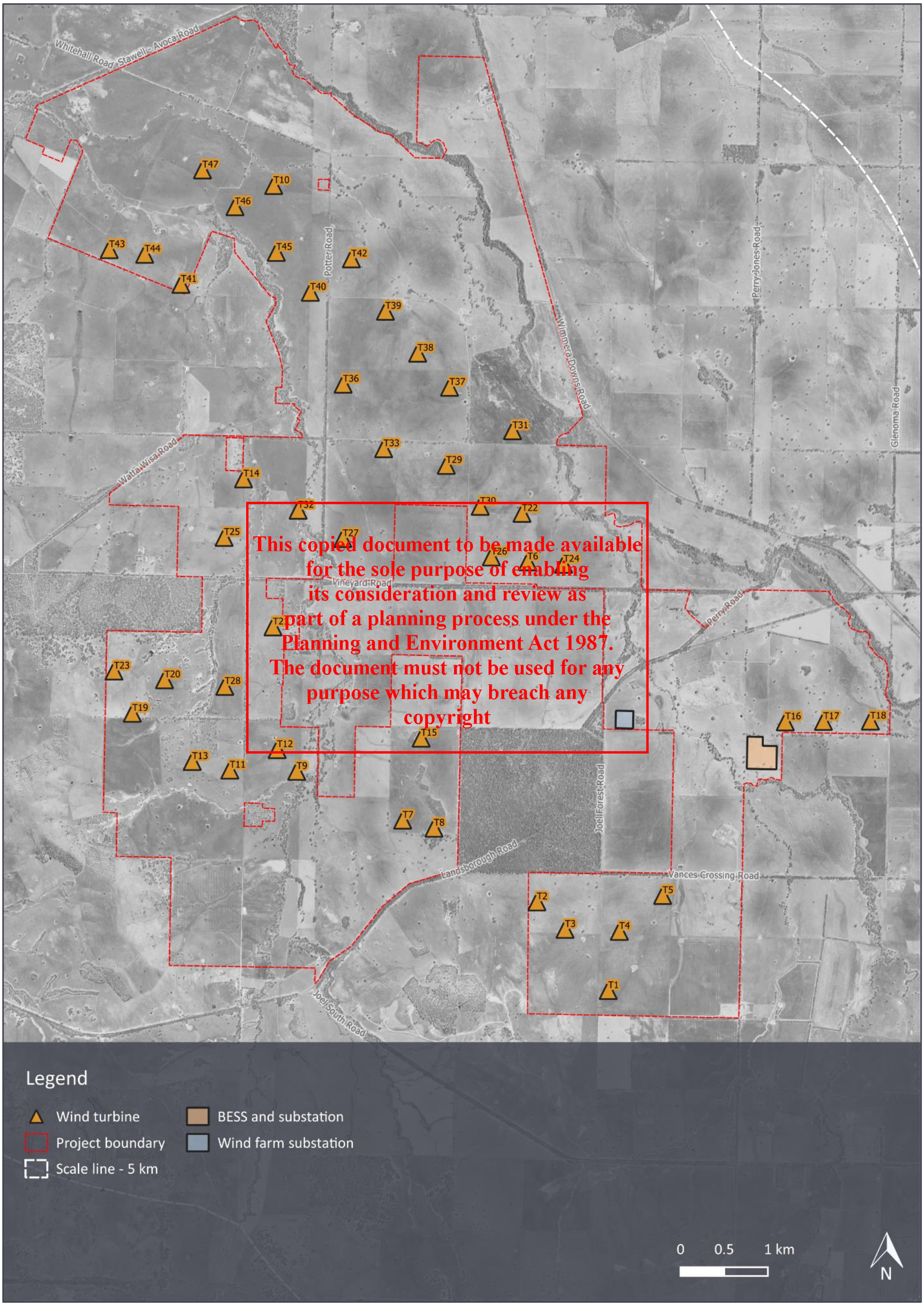
Figure 2: Project site layout – proposed wind turbines, BESS and substation locations



3.0 LEGISLATION AND GUIDELINES

The environmental noise assessment requirements for the Project are defined by the following:

- *Environment Protection Act 2017*
- *Environment Protection Regulations 2021*
- *Environment Reference Standard* published 25 May 2021, as amended by *Environment Reference Standard No. S158 Gazette* dated 29 March 2022
- *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023
- 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
- NZS 6808:2010 *Acoustics – Wind farm noise*.

The requirements of these documents are summarised below. Additional details and extracts from these documents are provided in Appendix C.

Victorian guidelines that are relevant to the assessment are also briefly outlined below.

3.1 Environment Protection Act 2017

The *Environment Protection Act 2017* (EP Act) provides the overarching legislated protection of the environment in Victoria and establishes mandatory requirements for the control of environmental noise. The following key obligations apply under the EP Act:

- A person who is engaging in an activity that may give rise to risks of harm to human health or the environment has a general environmental duty (GED) to minimise the risk of harm, so far as reasonably practicable.
- A person must not, from a place or premises that are not residential premises, emit unreasonable noise or permit unreasonable noise to be emitted.

The risk of harm under the EP Act includes both health and amenity related noise impacts. The EP Act defines environmental noise as unreasonable if it is:

- prescribed to be unreasonable from an assessment against mandatory noise limits (see Sections 3.2, Section 3.5 and Section 3.7); or
- assessed to be unreasonable according to the following factors defined in the EP Act:
  - noise volume, intensity or duration
  - noise character
  - the time, place and other circumstances in which the noise is emitted
  - how often the noise is emitted
  - any prescribed factors relating to the noise (frequency spectrum being a prescribed factor).

3.2 Environment Protection Regulations 2021

The *Environment Protection Regulations 2021* (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. The EP Regulations also define the types of noise sensitive areas where these requirements apply and the hours of different assessment time periods (i.e. day, evening and night).

The relevant elements of the EP Regulations are the requirements for the:

- operational noise from commercial, industrial and trade premises (industry)
- operational wind turbine noise of a wind farm.

The EP Regulations specify that the prediction, measurement, analysis and assessment of operational industry 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 the noise limit determined in accordance with the Noise Protocol.

In relation to wind turbine noise, the EP Regulations specify a range of requirements for the assessment, verification and ongoing management of operational wind turbine noise. Under the EP Regulations, the relevant standard specified for the assessment of wind turbine noise is NZS 6808 (see Section 3.7).

An important element of the EP Regulations with respect to wind turbine noise is the Act compliance note, which provides clarity on how a wind energy facility operator can satisfy the GED under the EP Act.[2] The Act compliance note means that demonstrating compliance with the EP Regulations also demonstrates compliance with the GED under the EP Act.

3.3 Environment Reference Standard

The *Environment Reference Standard* (ERS) was introduced under the EP Act and sets out environmental and human health outcomes that are sought to be achieved and maintained in Victoria. The outcomes are described by the ERS in terms of a collection of environmental values, indicators and objectives.

The environmental values of the ambient sound environment defined by the ERS relate to conditions that are conducive to domestic activities (conversation, recreation and sleep), learning, and appreciation and enjoyment of tranquillity in natural areas. The environmental values in most settings are defined using a quantitative indicator, and the objective for these indicators are defined according to the land use and planning zone. However, for natural areas, the indicator is qualitative and is based on an appraisal of sound quality that is conducive to human tranquillity and enjoyment of natural soundscapes.

Indicators and objectives for the ambient sound in different settings are defined to provide a basis for assessing actual and potential risks to the environment. They also provide a benchmark for comparing the state of the environment, or potential changes to the environment, to desired outcomes. However, the ERS is not a compliance standard. The primary function of the ERS is to provide an environmental assessment reporting benchmark which can be used as a reference point for decision makers to consider whether a proposal or activity is consistent with the environmental values identified in the ERS.

[2] Regulation 6 to the EP Regulations states that if a note at the foot of a provision of the regulations states 'Act compliance' followed by a reference to a section number, the regulation provision sets out the way in which a person's duty or obligation under that section of the EP Act is to be performed in relation to the matters and the extent set out in the regulation provision.

3.4 Planning Guidelines for Development of Wind Energy Facilities

The Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023 (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 advice includes detailed guidance on consistent methods for the assessment of wind turbine noise at the planning stage of a project. In particular, the Victorian Wind Energy Guidelines specifies that potential operational noise levels associated with proposed wind farm developments are to be assessed in accordance with NZS 6808 (see Section 3.7). Guidance is also provided on how NZS 6808 should be considered in the Victorian regulatory framework.

3.5 EPA Publication 1826.4 (Noise Protocol)

The EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* dated May 2021 (Noise Protocol) defines a procedure for setting noise limits that apply to the operation of industry premises and entertainment venues in Victoria. The noise limits are applicable to the operational stage of the Project. Compliance with the noise limits is mandatory.

The Noise Protocol defines noise limits that are used to assess whether a noise is prescribed to be unreasonable in accordance with the EP Regulations and the EP Act.

The noise limits apply at a 'noise sensitive area', which is defined by the EP Regulations as being *within 10 metres of the outside of the external walls* of buildings including dwellings, hotels, and schools. In rural areas, noise sensitive areas also include land within the boundary of campgrounds, caravan parks and certain types of tourist establishments.

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. Separate noise limits are defined for the day, evening and night periods.

3.6 EPA Publication 1843.1

EPA Publication 1834.1 provides an overview of the duties which apply under the EP Act and describes measures for managing noise and vibration from construction and decommissioning of a project. The guidance addresses scheduling of works, community consultation, managing noise and vibration at the source, and managing noise using offsite controls.

EPA Publication 1834.1 states that noise and vibration is to be minimised at all times, and that project developers should aim to constrain works to normal working hours, defined as 0700 to 1800 hrs Monday to Friday and 0700 to 1300 hrs on Saturdays (public holidays excluded).

Restricting construction activities to normal working hours is one of the key measures for controlling construction noise. However, where necessary, and subject to the approval of the relevant authority, construction activities outside normal working hours may occur for:

- low-noise impact works: inherently quiet or unobtrusive activities that do not have intrusive noise characteristics
- managed-impact works: activities where the noise emissions are managed through actions specified in a noise and vibration management plan, and which do not have intrusive noise characteristics
- unavoidable works: activities that need to occur outside of normal working hours due to risks to life or property, potential traffic hazards (e.g. oversized deliveries), or certain types of construction work that cannot be stopped midway through the process (concrete pours and tunnelling works are cited as examples).

EPA 1834.1 does not define requirements in terms of objective noise criteria for work conducted during normal working hours. Objective criteria are normally reserved for works conducted outside of normal working hours. However, noise criteria for evening and night works are not intended as the basis for determining whether works outside of normal working hours is justified.

3.7 NZS 6808

NZS 6808:2010 *Acoustics – Wind farm noise* (NZS 6808) defines a method for assessing operational wind turbine noise levels, including procedures for:

- measuring background noise levels prior to construction of a wind farm
- deriving noise criteria from measured background noise levels
- conducting post-construction measurements of wind farm noise
- assessing the character of the noise produced by the wind farm noise
- assessing post-construction noise measurements to determine compliance with the standard.

The noise criteria defined by NZS 6808 are a combination of a base (minimum) noise limit and noise limits which vary with wind speed and background noise levels. The base limit is a fixed value that is used for conditions when the background noise is low. The noise limit at each integer wind speed is then defined as the base limit or the background level plus 5 dB, whichever value is higher. The limits apply to wind turbine noise levels in the vicinity of noise sensitive locations.

The character of the wind farm sound is also assessed to determine whether adjustments should be applied to account for sounds referred to by the standard as special audible characteristics (SACs). These SACs are defined as tonality, impulsiveness and amplitude modulation. The noise level of the wind farm, adjusted where necessary for the presence of SACs, is then compared with the noise limits at each wind speed to determine the wind farm's compliance.

3.8 Related Victorian guidelines

To support the application the legislation and guidance summarised in the preceding sections, a range of Victorian publications provide additional advice on matters of interpretation and technical procedures. These publications include:

- EPA Publication 1992 *Guide to the Environment Reference Standard,* dated June 2021
- EPA Publication 1996 *Noise guideline – assessing low frequency noise,* dated June 2021
- EPA Publication 1997 *Technical guide: Measuring and analysing industry noise and music noise,* dated June 2021
- EPA Publication 2061 *Wind Energy Facility Turbine Noise Regulation Guidelines*[3]
- EPA-DTP Publication 3011 *Wind Energy Facility Turbine Noise* – Technical Guideline.

These guidelines are non-statutory documents which provide detailed advice for a broad range of technical considerations. Relevant aspects of these guidelines are referenced where appropriate in this assessment.

[3] At the date of preparation of this report, EPA Publication 2061 is not available as a version controlled formal document. This report is based on the EPA webpage version of this publication, last updated on 26 January 2024.

4.0 ASSESSMENT METHOD

4.1 Overview

Based on the policies and guidelines outlined in Section 3.0, assessing the operational noise levels of a proposed renewable energy project (comprising wind turbines, BESS and substations) involves:

- identifying receivers and ERS natural areas within a 5 km study area (see Section 5.0) from the Project infrastructure
- reviewing the existing noise environment in the Project area and assessing background noise levels at key receivers and ERS natural areas around the Project
- establishing suitable noise limits accounting for background noise levels and land zoning
- predicting noise levels associated with the Project, accounting for the inherent and proposed noise controls as appropriate
- assessing compliance with mandatory noise limits, where applicable
- assessing the potential for cumulative noise as a result of the Project and other existing and known developments in the surrounding area
- defining noise management measures consistent with the GED to minimise the risk of harm from Project operational noise so far as reasonably practicable.

4.2 Existing noise environment

Background noise level information is used to:

- set operational noise limits for wind turbines
- set operational noise limits for the BESS and substations
- consider the existing noise environment in natural areas where relevant.

However, in rural areas where wind farms are typically developed, the background noise level data is generally most important 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. Further, in rural areas, the land zoning is usually the decisive factor when setting noise limits for sources such as the BESS and substations.

Based on the above, the wind turbine noise component of the assessment, and therefore the assessment requirements of NZS 6808, are the key consideration when establishing existing noise levels.

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 an NZS 6808 assessment 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 monitoring is 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 the 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 would operate. At the wind speeds when the value of the background noise is above 35 dB L_{A90} (or 30 dB L_{A90} in special circumstances where high amenity limits apply), the background noise levels are used to set the noise limits for the wind farm.

4.3 Noise predictions

Operational noise levels from the Project are predicted using:

- noise emission data for the relevant equipment (e.g. wind turbines, transformers, and inverters)
- a 3D digital model of the site and the surrounding environment
- international standards used for the calculation of environmental sound propagation.

The method selected to predict noise levels is ISO 9613-2.[4] The prediction method is consistent with the guidance provided by NZS 6808 and has been shown to provide a reliable method of predicting the typical upper levels of the wind turbine noise expected to occur in practice. The method is also referenced in the Technical Guideline.

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

Further discussion of the method and the calculation choices is provided in Appendix D.

4 ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*

4.4 Cumulative noise

The potential for cumulative noise from the Project and other noise sources is evaluated by:

- identifying other existing and proposed developments in the area around the Project (including those in operation and approved at the time of assessment)
- identifying receivers where there is the potential for cumulative noise from the Project and other developments
- predicting noise levels from other existing and potential developments, where relevant and suitable information is available
- assessing cumulative wind turbine noise levels at the identified receivers to determine whether:
  - the Project could contribute to total wind turbine noise levels above the limits in the vicinity of other exiting wind farms
  - there is a margin below the noise limits to accommodate other potential wind farm developments, where relevant
- assessing cumulative industry noise levels at the identified receivers to determine whether:
  - the Project would contribute to total industry noise levels above the limits in the vicinity of other existing commercial, industry and trade premises
  - there is a margin below the noise limits to accommodate other potential developments, where relevant.

Specific cumulative noise study areas are not defined by the legislation and guidelines set out in Section 3.0. MDA has adopted 10 km as the study area for wind turbine noise and 5 km for substation and BESS noise. This is technically appropriate based on propagation distances associated with each noise source type. More detail is provided in Section 5.0.

5.0 STUDY AREA

The study area for the noise assessment extends to 5 km from the proposed locations of the Project wind turbines, BESS and substations. This is a nominal distance selected to enable a complete account of operational and potential cumulative noise considerations associated with the Project.

The study area is predominantly rural with the nearest township more than 10 km from the Project. The land in the study area is mainly designated as Farming Zone (see zoning map in Appendix E).

The types of locations within the study area where noise and vibration are assessed includes:

- noise sensitive receivers, which is any discrete location such as a residential dwelling where an assessment of noise or vibration is required
- natural areas which are considered under the ERS.

The locations of noise sensitive receivers and natural areas are identified and discussed within this section. This section also identifies the location of other potential or existing projects in or near the study area which may be relevant to the assessment of cumulative noise.

5.1 Receivers

The term *noise sensitive receiver* (receiver) is used throughout this report when referring to any building or facility where an assessment of noise is required. However, the details and types of receivers which must be considered are specific to the source of noise being assessed.

The EP Regulations specify noise requirements such as assessment procedures, the types of receivers to be assessed and different time periods which must be accounted for in the assessment. Importantly, the requirements of the EP Regulations are specific to the type of noise generating activity being assessed. For example, the types of receivers which must be considered when assessing commercial and industrial noise sources are called *noise sensitive areas*. Conversely, the procedure specified in the EP Regulations for assessing wind turbine noise requires consideration of receivers called *noise sensitive locations*. While noise sensitive areas and noise sensitive locations are broadly similar, there are slight differences between the two which relate to the types of receivers which must be considered and the specific locations where the noise limits apply.

The study area for this assessment includes all receivers identified by the proponent within 5 km of the proposed wind turbines, BESS and substations.

An important distinction when assessing wind turbine noise levels is whether the receivers are within the Project boundary, or a noise agreement is in place with the receiver landowners. In particular, NZS 6808 requires that the wind turbine noise assessment be undertaken at all receivers in the vicinity of the proposed wind farm which it defines as follows:

> *The location of a noise sensitive activity, associated with a habitable space or education space in a building not on the wind farm site. […]*
>
> *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.*

Further, based on the above definitions and statutory context of NZS 6808 discussed in Appendix C5, the noise limits specified in NZS 6808 only apply to the assessment of wind turbine noise levels at receivers where a noise agreement is not in place. This is also reflected in the EP Regulations which defines different noise limits for receivers located outside the Project boundary where noise agreements are in place.

Based on the above, receivers located within the Project boundary, or those located outside the Project boundary where a noise agreement is in place, are collectively referred to as involved receivers.

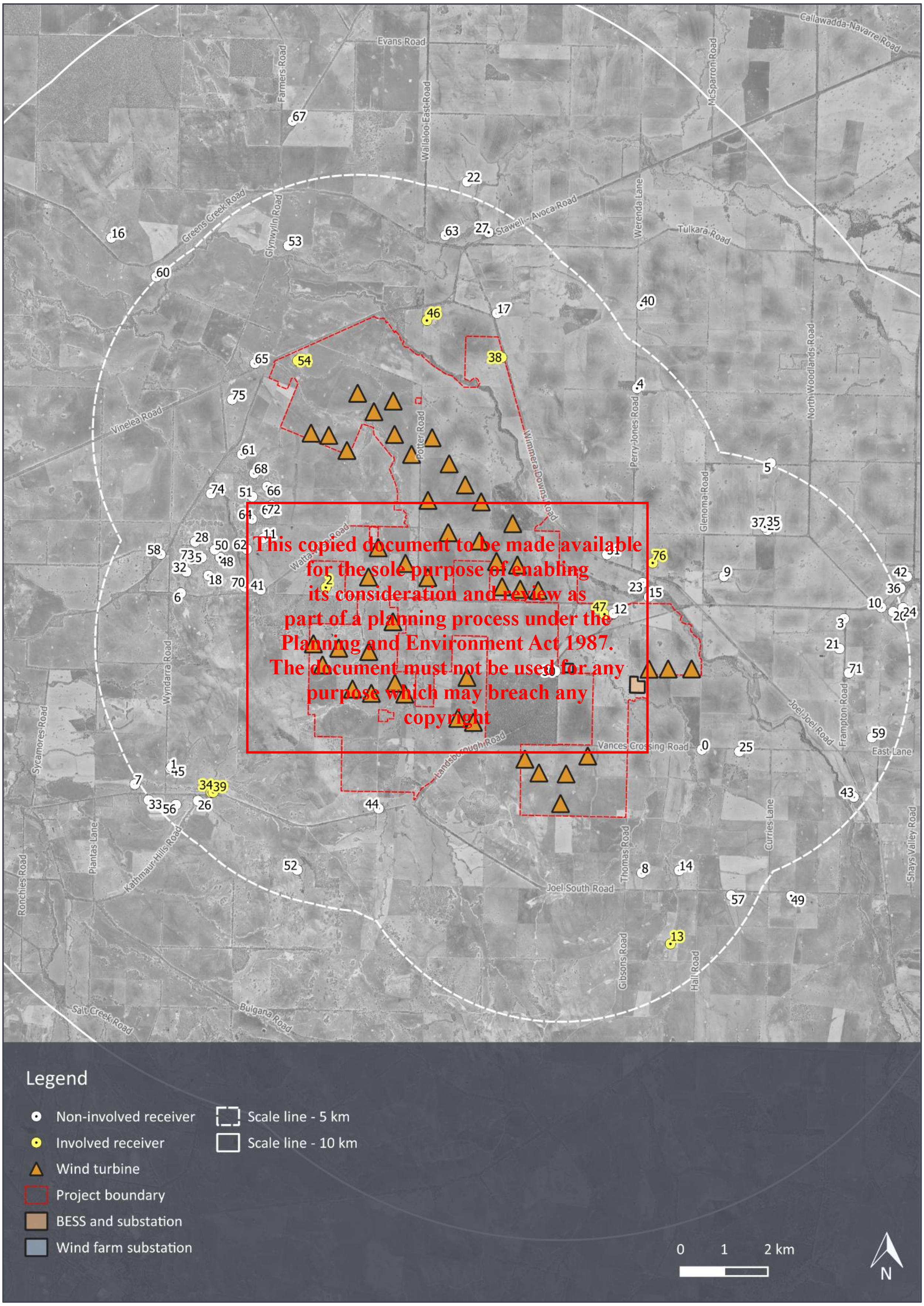
A total of 65 receivers were identified by the proponent within 5 km of the proposed wind turbines, comprising:

- 56 non-involved receivers on properties that are not associated with the Project
- 9 involved receivers including:
  - 2 receivers within the Project boundary
  - 7 receivers outside the Project boundary where a noise agreement is proposed between the landowner and the proponent.

The coordinates of all assessed receivers within 5 km of the proposed wind turbines are provided in Appendix F.

A site layout plan illustrating the wind turbine layout, BESS, substations and receivers is provided in Figure 3.

Figure 3: Site map of proposed wind turbines, BESS, substations and receivers



5.2 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, wildlife reserves and environmentally significant areas and landscapes outside metropolitan Melbourne that are identified in a planning scheme.*

Data from the Parks and Conservation Reserves state mapping (PARKRES) has been used to identify the following natural areas within the Project study area:[5]

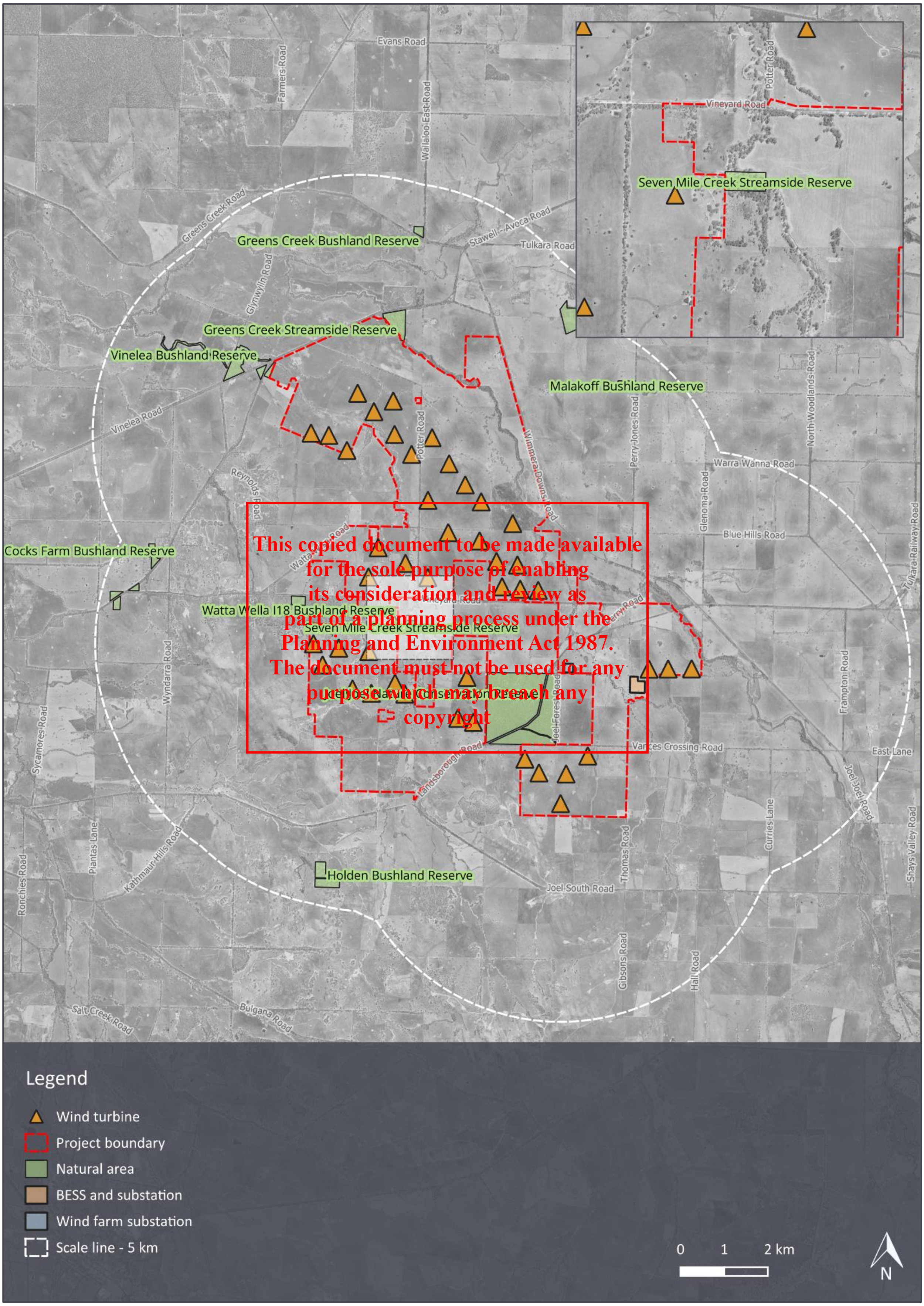
- Vinelea Bushland Reserve
- Greens Creek Streamside Reserve
- Greens Creek Bushland Reserve
- Greens Creek Swamp Wildlife Reserve (hunting)
- Malakoff Bushland Reserve
- Landsborough West School Historic Reserve
- Joel Joel Nature Conservation Reserve
- Holden Bushland Reserve
- Seven Mile Creek Streamside Reserve
- Watta Wella H21 Bushland Reserve
- Cocks Farm Bushland Reserve.

The natural areas listed above are shown in Figure 5.

[5] Data Vic webpage

MARSHALL DAY Acoustics

Figure 4: Site map of proposed wind turbines, BESS, substations and surrounding natural areas



5.3 Other projects

The approved and operating projects identified within 15 km of the Project are the:[6]

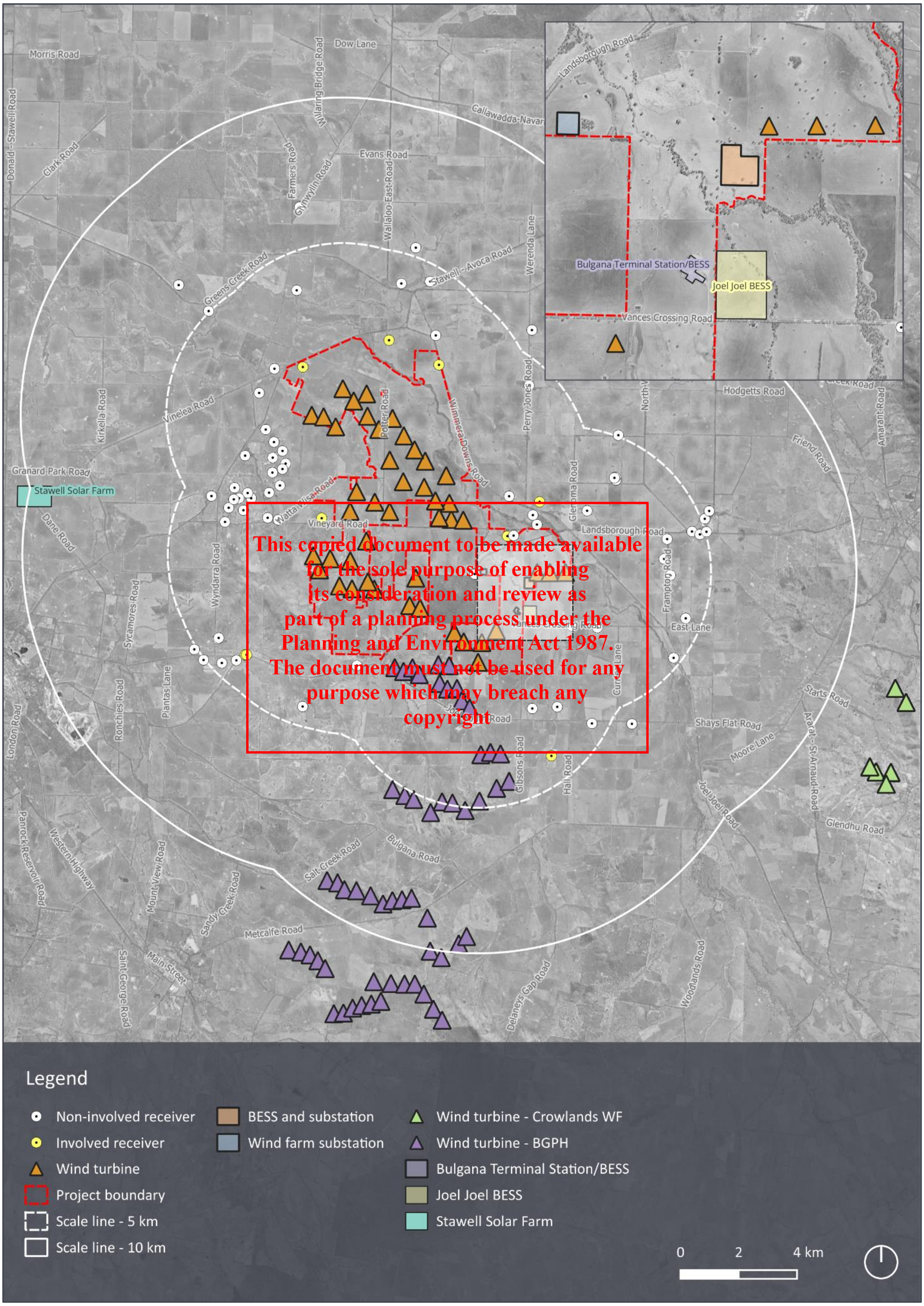
- operational Bulgana Green Power Hub, located adjacent to the Project boundary to the south.
- operational Crowlands Wind Farm, located approximately 12.5 km to the east
- operational Bulgana Terminal Station/BESS, located within the Project boundary in the southeast sector of the site.
- approved Stawell Solar Farm, located approximately 10 km to the west.
- approved Joel Joel BESS, adjacent to the Bulgana Terminal Station, comprising a 350 MW BESS.[7]

These other projects are presented relative to the Project infrastructure and study area in Figure 5.

The listing detailed above is provided for completeness. However, the Crowlands Wind Farm and Stawell Solar Farm are located 10 km or more from the Project. At these separating distances, cumulative operational noise is not a relevant consideration. The assessment of potential cumulative noise is therefore limited to the infrastructure associated with Bulgana Green Power Hub for cumulative wind turbine noise assessment, and Bulgana Terminal Station/BESS and the Joel Joel BESS for cumulative BESS and substation noise assessment.

6 Based on aerial imagery and the Department of Transport and Planning *Renewable Energy Projects Victoria* webpage
7 PA2402945

Figure 5: Project area and other projects



6.0 EXISTING NOISE ENVIRONMENT

Preliminary noise modelling of the site was conducted at the beginning of the development of the Project in 2021, based on the Project layout and candidate wind turbine applicable at that time. The results indicated only one receiver where predicted noise levels were higher than 35 dB L_{A90}, being the involved receiver 2 (identified as receiver 376 at that time). In accordance with NZS 6808, background noise monitoring was therefore not required to be undertaken.

However, the proponent elected to commission a survey of background noise levels at a broader range of locations than was strictly required by NZS 6808. The objective of the noise monitoring was to obtain data that would assist with providing context to the predicted noise levels of the proposed wind farm. Accordingly, monitoring was undertaken between 15 July to 20 September 2021 at 4 locations, with the background noise levels determined in accordance with NZS 6808 for the all-time and night-time periods respectively. The noise monitoring locations can be seen in relation to the Project layout in Figure 6.

The noise monitoring, analysis procedures and results are detailed in the Background Noise Report.[8] The Background Noise Report also includes noise contours associated with the 2021 preliminary noise modelling. Table 1 and Table 2 provide a summary of the background noise levels. The Background Noise Report should be reviewed for further detail.

If the Project is approved, the background noise data should be re-evaluated prior to commencement of construction to determine whether any additional or updated background monitoring is required, accounting for the recommendations of the Technical Guideline.

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

Table 1: Background noise levels, dB L_{A90} - all-time period

Receiver ID	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
2 [2]	28.0	28.6	29.4	30.2	31.1	32.0	33.0	34.1	35.1	36.2	37.2	38.3	39.3
12	30.6	31.5	32.4	33.2	34.0	34.7	35.3	36.0	36.6	37.1	37.6	38.1	38.5
30	29.2	29.4	29.8	30.3	30.8	31.5	32.2	33.0	33.8	34.6	35.5	36.4	37.3
19 [3]	26.3	27.3	28.2	29.2	30.2	31.2	32.2	33.1	33.9	34.7	35.4	35.9	36.3

1 166 m above ground level at 672,316 E, 5,904,979 N (MGA 94 Zone 54)

2 Involved receiver

3 Since preparation of the Background Noise Report additional ground truthing has indicated that 19 is not a dwelling and is therefore no longer considered a receiver

8 MDA Report Rp 002 20200098 *Watta Wella Renewable Energy Project - Background noise monitoring*, dated 8 July 2022

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

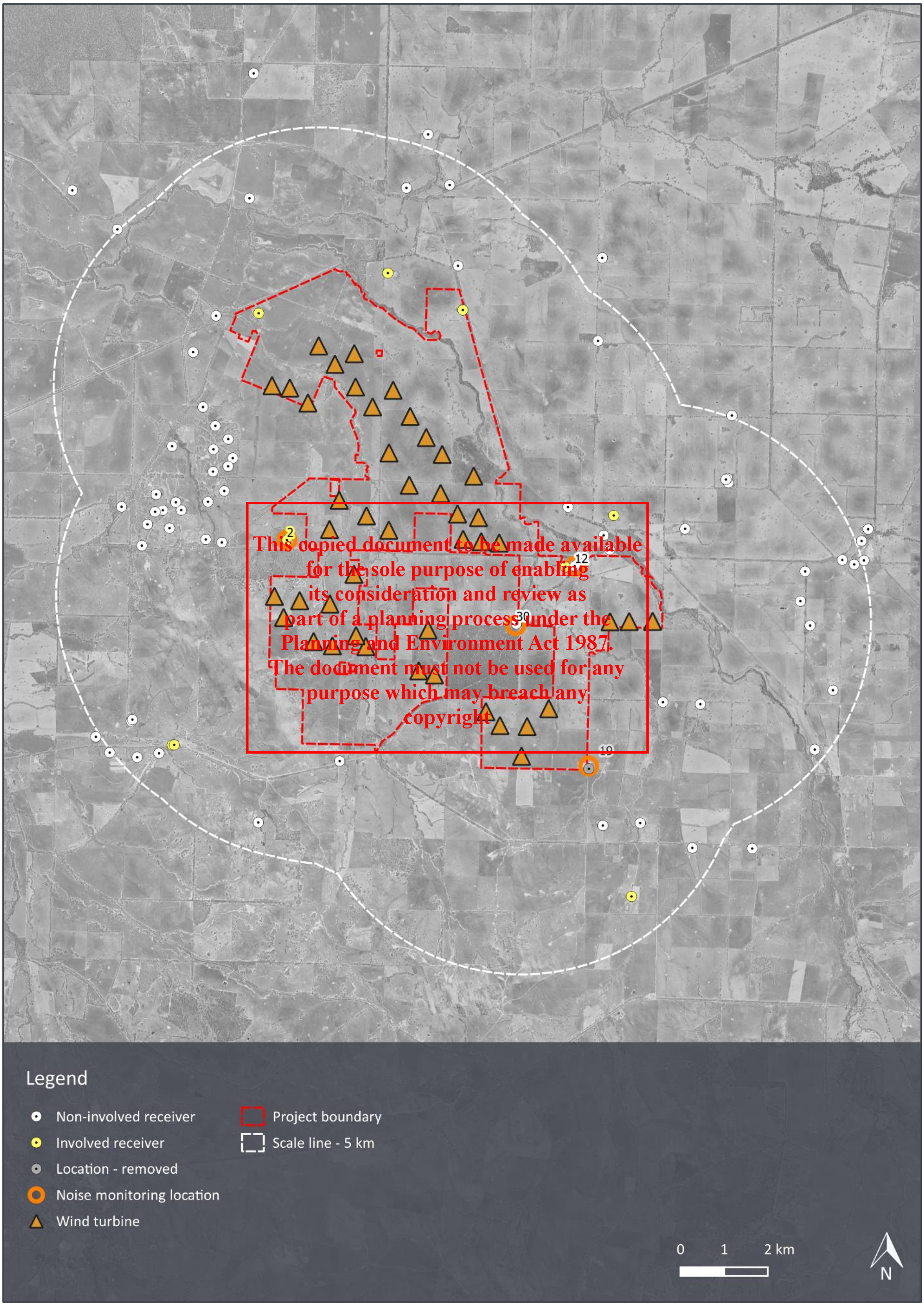
Receiver ID	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
2 [2]	25.1	25.7	26.3	27.0	27.8	28.6	29.5	30.5	31.5	32.7	33.9	35.1	36.5
12	29.2	29.6	29.9	30.2	30.5	30.9	31.3	31.7	32.2	32.7	33.4	34.1	34.9
30	28.5	28.1	27.8	27.7	27.7	27.9	28.2	28.7	29.4	30.2	31.2	32.3	33.7
19 [3]	23.6	24.9	26.0	27.0	27.8	28.6	29.3	30.0	30.6	31.1	31.6	32.1	32.6

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

2 Involved receiver

3 Since preparation of the Background Noise Report additional ground truthing has indicated that 19 is not a dwelling and is therefore no longer considered a receiver

Figure 6: Background noise monitoring locations



7.0 WIND TURBINE NOISE ASSESSMENT

This section presents an assessment of environmental noise associated with operation of the proposed wind turbines, including the cumulative noise of the Project and the existing Bulgana Green Power Hub.

7.1 Assessment criteria

The assessment criteria detailed in NZS 6808 apply to noise levels at noise sensitive locations and consist of a combination of base limits (i.e. fixed value limits irrespective of wind speed) and relative limits which are defined by an allowable margin above the background noise (i.e. limits which vary with wind speed). The value of the base limit depends on whether there are high amenity areas near the Project and whether there are receivers involved with the Project. These factors are discussed in the following subsections.

7.1.1 High amenity areas

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. This is based on a two-step approach:

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 of NZS 6808.

Based on the predicted noise level contours presented subsequently in Section 7.4, and the zoning map for the area presented in Appendix E, the area within the predicted 35 dB L_{A90} contour is designated as Farming Zone.

Consistent with the guidance from EPA Publication 2061, Section 5.2 of the Technical Guideline states that the high amenity limit in Victoria should:

- apply to a dwelling located in the following zones predominantly intended for residential development: Low Density Residential Zone (LDRZ), Township Zone (TZ), Rural Living Zone (RLZ), and Green Wedge A Zone (GWAZ).
- not apply to dwellings in the Farming Zone (FZ).
- not be applied in any location where background sound levels are already affected by other specific sources such as road traffic noise, based on Section 5.3.1 of NZS 6808.
- only apply for WEF wind speeds up to and including 6 m/s during evening and night-times.
- be applicable only when there is no agreement made in accordance with regulation 131A.

Based on the above, the high amenity noise limit is not justified for the proposed Watta Wella Renewable Energy Project as all receivers within the 35 dB L_{A90} noise contour are within a Farming Zone (FZ).

7.1.2 Involved receivers

Involved receivers consist of receivers within the Project boundary and receivers outside the Project boundary where noise agreements are in place.

The noise limits defined in NZS 6808 do not apply at involved receivers (see earlier discussion in Section 5.1 and further information in Appendix C5). However, consistent with the Victorian Wind Energy Guidelines, regulation 131BA of the EP Regulations states that receivers with a noise agreement is in place are subject to a noise limit of:

- the noise limit specified in the agreement, where a noise agreement between the owner or operator of a wind energy facility and a landowner is made before 1 November 2021
- 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.

The proponent has advised that noise agreements are currently in place or proposed between the landowners and the proponent at 7 receivers outside the Project boundary, as presented in Section 5.1. The noise agreements set a limit of 45 dB or background + 5dB, whichever is higher.

Further, consistent with the Victorian Wind Energy Guidelines, it is recommended that operational wind turbine noise levels not exceed a reference level of 45 dB L_{A90} or background noise (L_{A90}) +5 dB at the 2 involved receivers within the Project boundary.

7.1.3 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 3.

Table 3: 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 receiver located outside the Project boundary with a noise agreement	45 dB or background L_{A90} + 5 dB, whichever is the greater
Involved receiver within the Project boundary	Not applicable Reference level of 45 dB or background L_{A90} + 5 dB, whichever is the greater

The applicable noise limits based on the background noise levels presented in Section 5.0 are summarised in Table 4 and Table 5.

Table 4: Operational wind farm noise limits, dB L_{A90} – all-time period

Location	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
2 [2]	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
12	40.0	40.0	40.0	40.0	40.0	40.0	40.3	41.0	41.6	42.1	42.6	43.1	43.5
30	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.5	41.4	42.3

1 166 m above ground level at 672,316 E, 5,904,979 N (MGA 94 Zone 54)

2 Involved receiver

Table 5: Operational wind farm noise limits, dB L_{A90} – night period

Location	Hub height wind speed, m/s [1]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
2 [2]	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
12	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
30	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0

1 166 m above ground level at 672,316 E, 5,904,979 N (MGA 94 Zone 5

2 Involved receiver

7.2 Candidate 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 the planning permit noise limits at surrounding receivers.

Accordingly, to assess the proposed wind turbines at this stage in the Project, it is necessary to consider a candidate 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 Nordex N175 6.x MW 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 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 unconstrained modes 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

Detail	N175 6.x
Make	Nordex
Rotor diameter	175 m
Hub height	160 m
Operating mode	Mode 0 [1]
Serrated trailing edge	Yes
Rated power	6.8 MW
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	12 m/s
Cut-out wind speed (hub height)	24 m/s

1 'Mode 0' is a manufacturer designation which indicates an unconstrained mode of operation to achieve a power output of 6.8 MW (i.e. without noise curtailment)

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

The final wind turbine hub height would be used for updated pre-construction noise modelling once the wind turbine layout has been finalised and the final wind turbine model selected (pre-construction noise modelling would be included in the noise management plan prepared in accordance with the EP Regulations).

7.3 Wind turbine noise emissions

7.3.1 Sound power levels

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

Sound power level data for the candidate wind turbine models, including sound frequency characteristics, has been sourced from Nordex document F008_278_A17_EN *Third octave sound power levels – Nordex n175/6.X*, dated 24 April 2024.

Based on the data sourced from the manufacturer's specification, the noise modelling for this assessment involved:

- conversion of standardised wind speed (10 m above ground level) to hub height wind speed as per the method specified in IEC 61400-11[9]
- conversion of third octave band level to octave band levels
- adjustment by addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The overall A-weighted sound power levels (including the +1 dB addition for uncertainty) as a function of hub height wind speed are presented in Table 7 with the octave band values presented in Table 8. These represent the total noise emissions of the wind turbine, including the secondary contribution of ancillary plant associated with each turbine (e.g. cooling fans).

Table 7: Sound power levels versus hub height wind speed, dB L_{WA}

	Hub height wind speed, m/s								
Wind turbine	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
N175 6.x	96.8	97.8	99.8	102.9	106.1	107.9	107.9	107.9	107.9

Table 8: Octave band sound power levels, dB L_{WA} [1]

	Octave band centre frequency, Hz									
Wind turbine	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**Total**
N175 6.x	82.8	90.7	97.5	100.9	101.4	102.3	100.2	90.9	74.4	107.9

1 Based on one-third octave band levels at a hub height wind speed of 10 m/s

These sound power levels are also illustrated in Appendix I.

9 IEC 61400-11 *Wind turbines – part 11: Acoustic noise measurement techniques* dated June 2018

Industry research conducted with reference to sound power data for a range of wind turbine models has shown that there is not a clear relationship between wind turbine size, or power output, and the noise emission characteristics of a given wind turbine model.[10] 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).

7.3.2 Special audible characteristics

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

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

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

Given the above, adjustments for special audible characteristics have not been applied to the predicted noise levels presented in this assessment. This is consistent with the recommendations of the Technical Guideline which states that it is not necessary to apply a penalty for special audible characteristics during the prediction of wind farm noise levels.

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.

7.4 Predicted noise levels

7.4.1 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 7.3.1 for the selected candidate wind turbine model. The predicted noise levels are summarised in Table 9 for for the wind speeds which result in the highest predicted noise levels (hub height wind speeds ≥ 10 m/s). Results are presented for receivers where the highest predicted noise levels are greater than or equal to 30 dB L_{A90}.

[10] Van den Berg, Frits & Koppen, Erik & Boon, Jaap & Ekelschot-Smink, Madelon. - *Sound power of onshore wind turbines and its spectral distribution. Sound & Vibration. 59* - 2025

The locations of the predicted 30, 35, 40 and 45 dB L_{A90} noise contours are illustrated in Figure 7, for the wind speed that results in the highest predicted noise levels.

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

Table 9: Highest predicted noise level at receivers with predicted levels over 30 dB L_{A90}

Receiver	Highest predicted noise level, dB L_{A90}
Non-involved receivers	
0	33.1
8	30.3
9	31.0
11	34.0
12	36.3
15	35.0
17	30.7
18	31.2
23	34.3
25	30.9
28	30.3
30	37.2
31	35.4
41	34.7
44	32.9
48	31.7
50	31.3
51	33.8
55	30.7
61	33.9
62	33.1
64	33.4
65	32.5
66	35.3
68	34.7
69	35.0
70	33.6
72	34.5

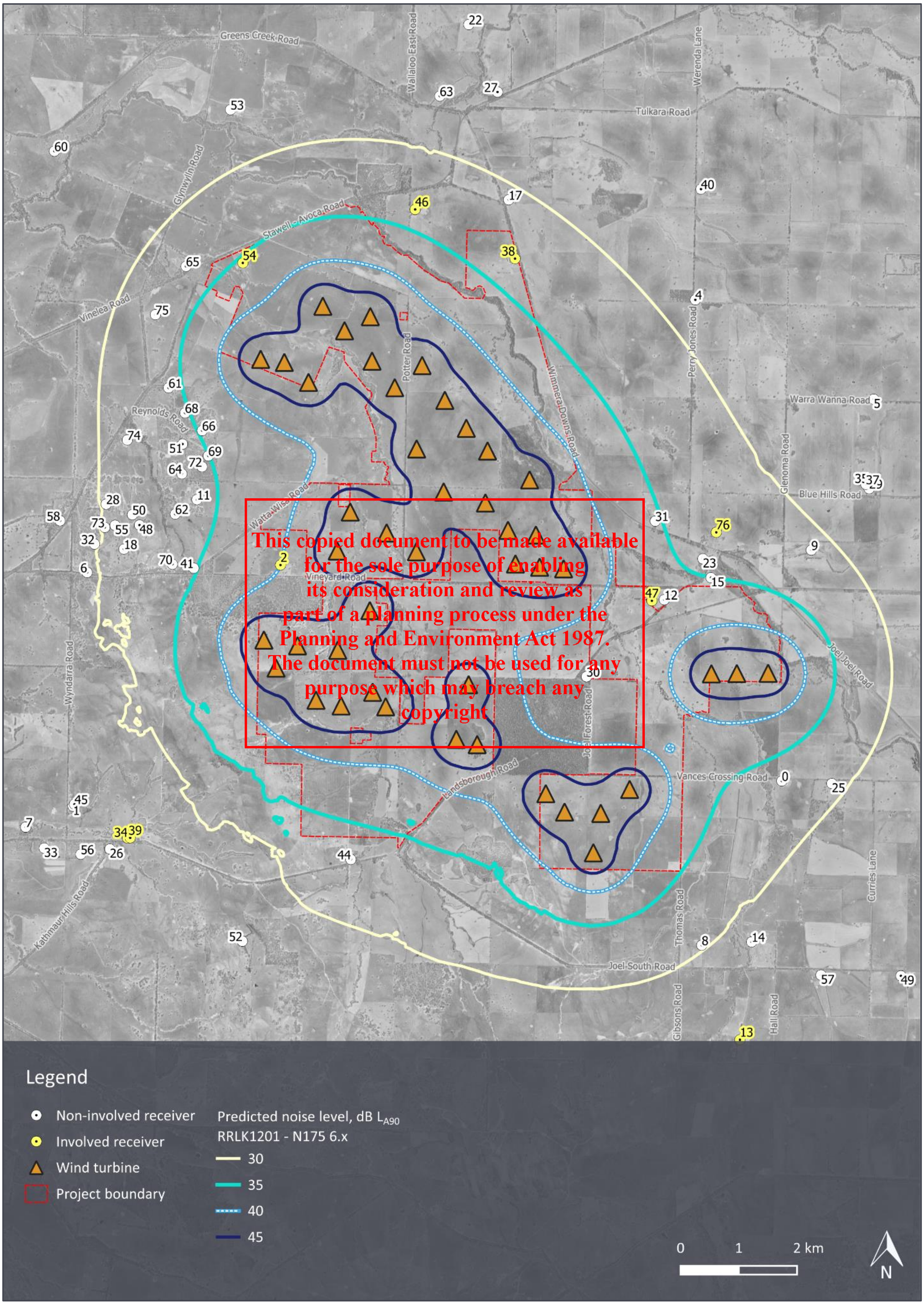
Receiver	Highest predicted noise level, dB L_{A90}
73	30.3
74	31.2
75	32.3
Involved receiver outside the Project boundary	
2	40.0
46	33.5
47	36.6
76	33.0
Involved receiver within the Project boundary	
38	33.0
54	35.5

The results presented in Table 9 demonstrate that wind turbine noise levels associated with the Project are predicted to comply with the noise limits for all receivers.

Specifically, the predicted operational wind turbine noise levels are:

- below the applicable base noise limit of 40 dB L_{A90} by at least 2.8 dB at all non-involved receivers
- below the applicable base noise limit of 45 dB L_{A90}, by at least 5.0 dB at all involved receivers outside the Project boundary
- below the reference base noise level of 45 dB L_{A90} by at least 9.5 dB at all involved receivers within the Project boundary.

Figure 7: Highest predicted noise level contours, dB L_{A90}



7.4.2 Natural areas

Wind turbine noise levels in natural areas that are associated with the operation of the Project are likely to be audible on some occasions at locations where the predicted wind turbine noise levels are between 30 and 40 dB L_{A90}. At locations where predicted wind turbine noise levels are higher than 40 dB L_{A90}, the Project is expected to be regularly audible when the wind turbines are operating. At locations where the predicted noise levels are approaching, or greater than 45 dB $L_{A90,}$ wind turbine noise levels would be clearly audible when the wind farm is operating.

Conversely, where the predicted noise levels are below 30 dB L_{A90}, wind turbine noise may still be audible at times, but it would be very dependent on wind conditions and the characteristics of the background environment. At levels below 30 dB L_{A90}, instances of audible wind turbine noise would usually be difficult to distinguish from the ambient sound environment. As a point of context, while the background noise monitoring was conducted at receivers rather than natural areas, the data presented in Section 6.0 provides a general indication of the range of background noise levels in the surrounding area. At wind speeds of around 7-8 m/s when the turbines are producing sound power levels approaching their maximum noise emissions, the background noise levels are typically comparable to or higher than 30 dB L_{A90}.

As an indication, wind turbine noise levels above 30 dB L_{A90} are predicted to occur in areas within approximately 2 km of the Project's wind turbines.

The distribution of wind turbine noise levels in the identified natural areas is presented in Figure 8. The noise modelling indicates that the natural areas most likely to experience regular wind turbine noise are (in order of highest to lowest predicted noise levels):

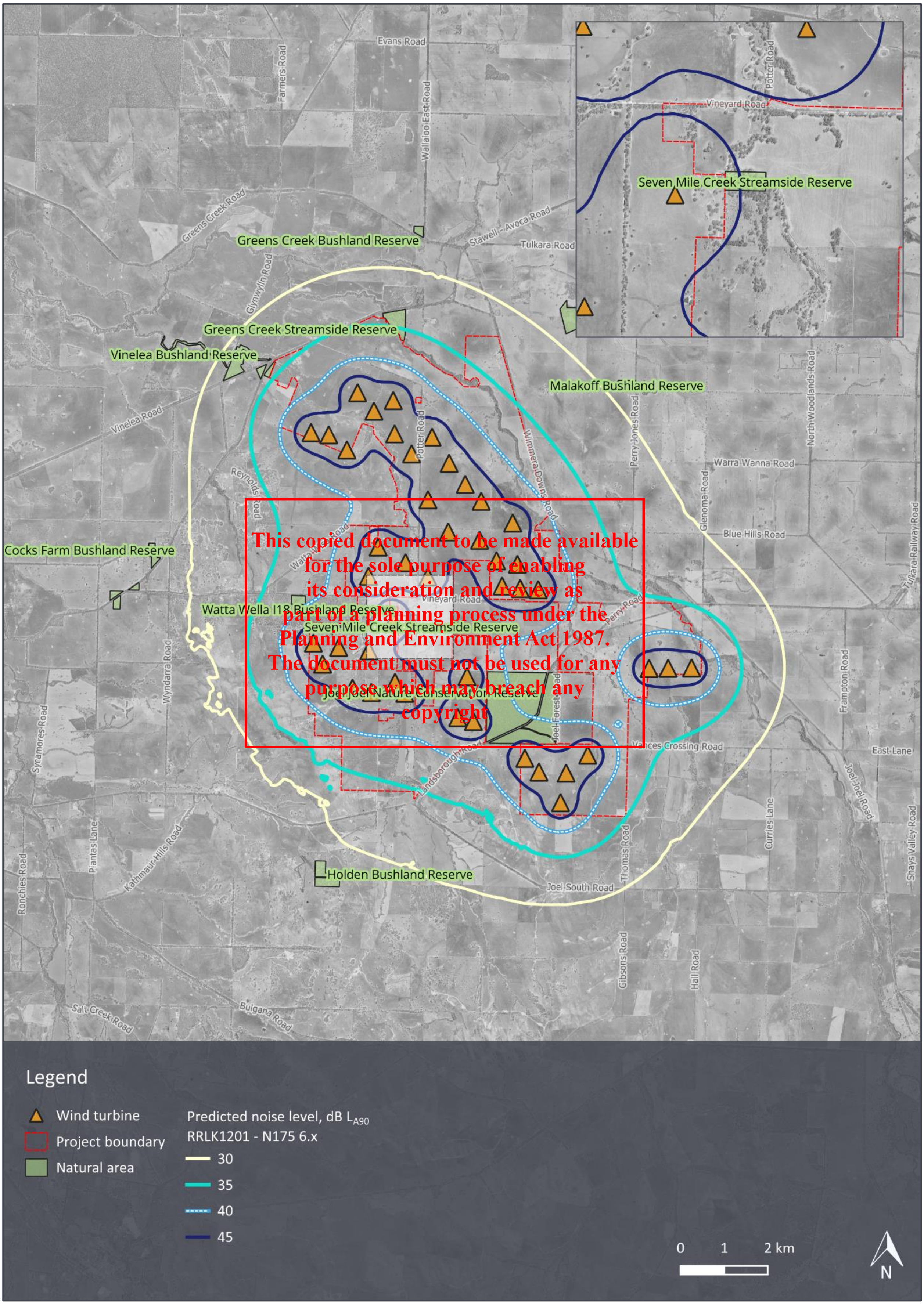
- Joel Joel Nature Conservation Reserve, where the majority of the reserve is predicted to experience wind turbine noise levels above 40 dB L_{A90}, with small areas to the west and south predicted to experience noise levels above 45 dB L_{A90}
- Seven Mile Creek Streamside Reserve, which is located between the 40 and 45 dB L_{A90} contours
- Watta Wella I18 Bushland Reserve, where the predicted noise levels are just below 40 dB L_{A90}
- Greens Creek Streamside Reserve, where the predicted noise levels are below 35 dB L_{A90} at most locations
- Vinelea Bushland Reserve, which is located between the 30 and 35 dB L_{A90} contours.

These results indicate that the soundscape in these reserves would be influenced to varying degrees by wind turbine noise.

To consider the potential effects of audible wind turbine noise, the Parks Victoria website for each of these reserves was reviewed to obtain an indication of their potential use. The review did not indicate listed trails, park amenities or other visitor attractions which would suggest these reserves are specifically sought out for their natural soundscape. Similarly, a review of online aerial and street imagery did not provide any indication of whether these reserves are likely to be frequented by visitors seeking natural soundscapes and that some reserves may have limited, or no public access.

Based on the available data the assessment indicates that it is unlikely that wind turbine noise in these reserves would be relevant to the ERS environmental value for natural areas (i.e. a value which solely relates to the experiences of people visiting these reserves).

Figure 8: Predicted operational wind turbine noise levels and identified natural areas



7.5 Cumulative assessment

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

Information relating to other developments in the area around the Project is presented in Section 5.3 The Bulgana Green Power Hub (BGPH) was identified as a relevant site to consider with respect to cumulative wind turbine noise.

The BGPH began operating mid-2021 and comprises 56 Siemens Gamesa SG3.4-132 wind turbines with a hub height of 114 m.[11] The coordinates of the wind turbines were provided by the proponent on 22 November 2020.

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

The predicted cumulative wind turbine noise of the Project and the BGPH is illustrated as noise contours in Figure 9 for the wind speeds which give rise to the highest noise emissions from each site respectively. The results demonstrate that the predicted cumulative wind turbine noise levels are below the minimum applicable base limit of 40 dB L_{A90} at all receivers and therefore no change is predicted in the compliance outcomes.

Further receiver-specific information on cumulative noise levels is provided in Table 10 for the receivers that are located within 3 km of wind turbines of both projects (to allow a sufficient account of potential cumulative noise considerations). As per the noise contours, the predicted noise level data is provided for the wind speeds which give rise to the highest noise emissions from each site respectively.

Table 10: Cumulative wind turbine noise assessment for receivers within 3 km of both projects

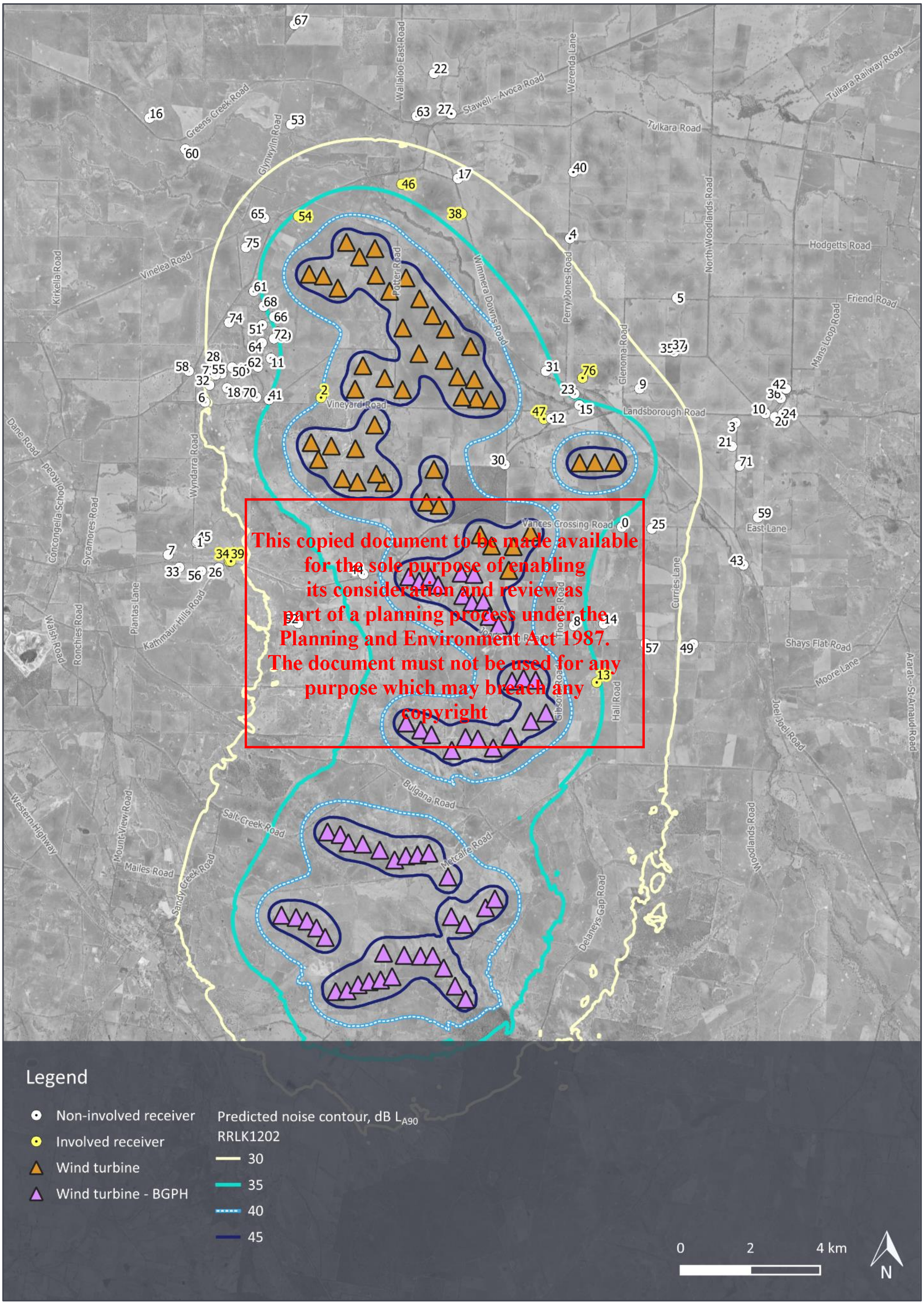
Receiver ID	Predicted noise level, dB L_{A90} Watta Wella only	BGPH only	Cumulative	Change in compliance outcome due to cumulative effects
44	32.9	35.4	37.3	No
8	30.3	34.6	36.0	No

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

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

11 See BGPH information at this weblink

Figure 9: Cumulative wind turbine noise contours from the Project and the BGPH



8.0 SUBSTATION AND BESS NOISE ASSESSMENT

This section presents an assessment of operational noise from the Project's substations and BESS, including potential cumulative noise considerations.

As part of the design development work for the substations and BESS, environmental noise was identified as a key consideration with respect to plant layouts, equipment selection and noise mitigating structures. In accordance with the GED, noise control options were reviewed and developed with the objective of minimising the risk of harm as a result of operational noise from the plant. The noise controls factored in the concept layout and this assessment include:

- positioning of the equipment to increase the separating distance where possible
- selection of low noise emission plant
- noise barriers in the vicinity of the substation.

These risk controls are discussed in further detail in this section.

8.1 Assessment criteria

The following obligations apply under the EP Act and EP Regulations:

- Operation of the substation and BESS must not cause noise that is prescribed to be unreasonable or assessed to be unreasonable according to the listed factors set out in the EP Act.
- The risk of harm from noise associated with the substation and BESS must be minimised so far as reasonably practicable, in accordance with the GED under the EP Act.
- Frequency spectrum is a prescribed factor under the EP Regulations and, as a result, an objective assessment of low frequency may inform an assessment of whether the noise is unreasonable.

In terms of assessment requirements, the EP Regulations specify that the prediction, measurement, assessment and analysis of noise for commercial, industrial and trade premises must be conducted in accordance with the Noise Protocol.

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

In rural areas, applicable noise limits are generally based on zone levels determined 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.

Adjustments for 'background relevant areas' are not warranted in this instance, as the background noise levels during the relevant assessment conditions for the Project's substation and BESS (i.e. low wind speeds) are low.

The Victorian Planning Provisions include the following in its definition of a utility installation:

> *Land used* [...] *to transmit, distribute or store power, including battery storage*

As such, and considering the BESS and substations are located on land designated as Farming Zone (FZ) (see land zoning map in Appendix E), the noise limits applicable at the nearest receivers are summarised in Table 11.

Table 11: Noise Protocol time periods and noise limits

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

The substations and BESS have the potential to operate at any time in a 24 hour day and across 7 days a week. Meeting the applicable night-time noise limit of 34 dB ENL infers meeting the noise limits during all other time periods.

8.2 Noise emissions

8.2.1 Wind farm substation

The high voltage (HV) transformer and any associated cooling equipment would be the main sources of noise located within the wind farm substation.

At this stage in the Project, specific details of the transformer make and model are yet to be determined. However, the proponent has indicated that 2 transformers, each with a rating of 200 MVA, would be representative. A summary of the relevant information is shown in Table 12.

Table 12: Substation equipment details

Equipment item	Quantity
HV transformer (200 MVA)	2

8.2.2 BESS and BESS substation

At this stage of the Project, a detailed BESS design has not been established. However, for the purposes of the noise assessment a representative design concept with a capacity of 400 MW / 1,600 MWh has been developed by the proponent. This includes HV transformers within a dedicated BESS substation.

The concept comprises a layout of separate inverters, medium voltage (MV) transformers, HV transformers and batteries. The concept layout, indicating the number and position of each equipment item alongside the substation HV transformers, is shown in Figure 10. A summary of the relevant information is shown in Table 13.

Table 13: BESS and BESS substation equipment details

Equipment item	Quantity
BESS	
Battery	396
Inverter	132
MV transformer (4.2 MVA)	132
BESS substation	
HV transformer (225 MVA)	2

8.2.3 Sound power level data

Sound power levels for individual equipment items used in the noise model are detailed in Table 14. The data is un-weighted (linear) octave band spectra and A-weighted overall sound power level.

Table 14: Sound power levels for each individual equipment item, dB L_W

Item	Octave band centre frequency, Hz							
	63	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**Total**
Wind farm substation								
HV transformer (200 MVA)	93	95	90	90	84	79	74	90
BESS								
Battery	83	76	69	64	63	57	47	68
Inverter	87	89	92	80	77	78	80	88
MV transformer (4.2 MVA)	69	71	66	66	60	55	50	66
BESS substation								
HV transformer (225 MVA)	94	96	91	91	85	80	75	91

Table 15: Sound power level data description

Item	Description
Wind farm substation	
HV transformer	At this stage of the Project, specific details of the transformer makes and models are yet to be finalised. Based on information provided by the proponent, it is understood that 2 HV transformers are proposed for the Project's wind farm substation, each expected to be rated at 200 MVA. In the absence of sound power level data for a specific transformer model, sound power levels have been estimated based on the nominated power rating, using the method for deriving the 'reduced maximum' described in Annex ZA of AS 60076-10:2009. [12] An octave band spectrum for each transformer was then estimated by applying Bies & Hansen corrections from Table 11.27, (*Location 1a for outdoor transformer noise*) to the determined overall 'reduced maximum' sound power level. [13]

[12] AS 60076-10:2009 *Power transformers – Part 10: Determination of sound levels*

[13] *Bies, D. H. & Hansen, C. H. (2009). Engineering noise control: theory and practice (Fourth edition.). p. 601*

Item	Description
BESS	
Battery	Third octave band sound power levels for the containerised battery system were provided by the proponent for this assessment. The subject datasheet did not define the standard adopted by the manufacturer for deriving the sound power level, however the noise data aligns with 100 % operation of the battery, i.e. worst-case sound power level. Noise data associated with the selected battery unit represents the lowest end of the range of sound power levels exhibited on the market.
Inverter	Manufacturer third octave band sound power levels measured in accordance with ISO 3744:2010 were provided by the proponent . [14] Extensive specific operating conditions for the equipment were described in the supplied datasheet, including operation with and without a manufacturer designed and provided attenuation kit. For the purposes of this assessment noise data associated with 80 % fan speed including the manufacturer's attenuation kit has been adopted, being the sound power level of greatest magnitude in the provided datasheet, with the attenuation kit applied. Based on information provided by the manufacturer it is understood that 100 % apparent power is feasible with fan speeds of 80 % up to a temperature of 40°C.
MV transformer	At this stage of the Project, specific details of the transformer makes and models are yet to be finalised. Based on information provided by the proponent, it is understood that the MV transformers proposed for the Project's BESS are expected to be rated at approximately 4.2 MVA, respectively. In the absence of sound power level data for a specific transformer model, sound power levels have been estimated based on the nominated power rating, using the method for deriving the 'reduced maximum' described in Annex ZA of AS 60076-10:2009. An octave band spectrum for each transformer was then estimated by applying Bies & Hansen corrections from Table 11.27, (*Location 1a for outdoor transformer noise*) to the determined overall 'reduced maximum' sound power level.
BESS substation	
HV transformer	At this stage of the Project, specific details of the transformer makes and models are yet to be finalised. Based on information provided by the proponent, it is understood that the HV transformers proposed for the Project's BESS substation are expected to be rated at approximately 225 MVA. In the absence of sound power level data for a specific transformer model, sound power levels have been estimated based on the nominated power rating, using the method for deriving the 'reduced maximum' described in Annex ZA of AS 60076-10:2009. An octave band spectrum for each transformer was then estimated by applying Bies & Hansen corrections from Table 11.27, (*Location 1a for outdoor transformer noise*) to the determined overall 'reduced maximum' sound power level.

Due to commercial sensitivities specific manufacturers and models are not detailed in this report. However, the proponent has confirmed the equipment to be representative of the specification required for the Project.

[14] ISO 3744:2010 *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

8.3 Tonality

Noise associated with the operation of inverters and transformers has the potential to be tonal in nature.

Section 3.4 of the Noise Protocol provides a mechanism by which the characteristics of a noise source, such as tonality, may attract the application of a modifying factor adjustment if deemed to meet the prescribed criteria. The Noise Protocol states that:

> *The following adjustments apply –*
>
> *a. when the tonal character of the noise is just detectable then* A_{tone} *= +2 dB;*
>
> *b. when the tonal character of the noise is prominent then* A_{tone} *= +5 dB.*
>
> *When a tone is present, but observations do not provide certainty with regards to the value to apply for the tonal adjustment, the adjustment may be determined using the objective tonal method in accordance with Annex C.*

Tonality has been evaluated by reviewing the predicted third-octave band noise levels at the receivers in the context of the objective method detailed in Annex C of the Noise Protocol. This method indicates that a tonality adjustment, A_{tone}, of +2 dB is appropriate for predicted noise levels for the Project at the relevant receivers.

8.4 Required noise controls

As part of the design development work for the wind farm substation, BESS, and BESS substation, environmental noise was identified as a key consideration. This has resulted in the following noise controls being included within the Project design:

- installation of a manufacturer designed noise control kit to the inverters located at the BESS
- specification of the reduced maximum noise level for the HV transformers located at both the wind farm substation and the BESS substation
- nearfield barriers adjacent to the HV transformers located at the wind farm substation.

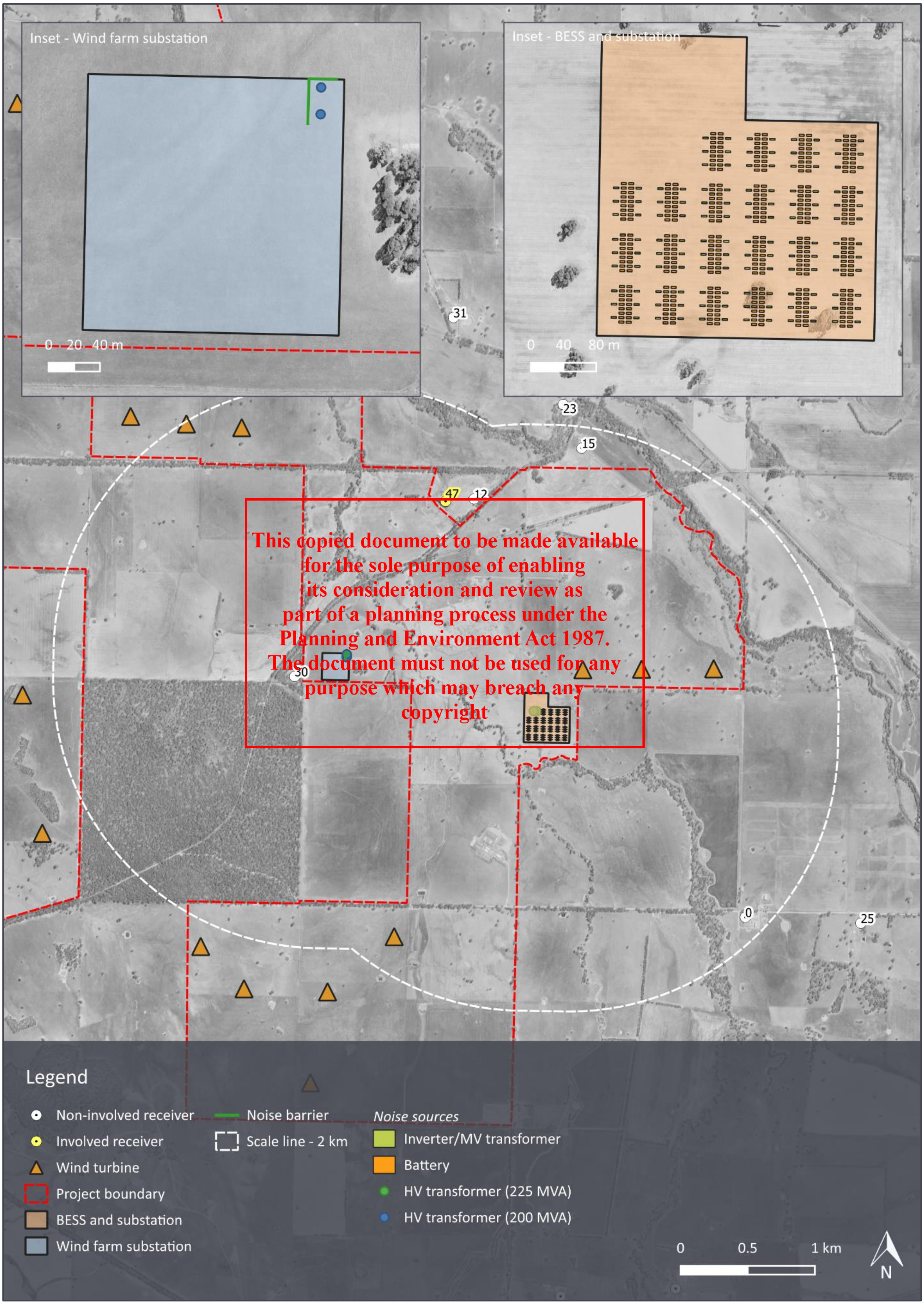
It is noted that the noise assessment and design of noise controls for the wind farm substation is currently based on a design concept, indicating the general area of the substation and potential locations of the HV transformers. On this basis, the specific design and extent of the noise barriers will need to be determined a part of a detailed design, however a design concept is shown in Figure 10.

The noise barriers would be required to be:

- designed such that they are a minimum of 2 m above the top of the HV transformers
- constructed of a material with a surface density of at least 20 kg/m^2
- free from holes and gaps, particularly during penetrations for access and at the interface with the ground.

These requirements will need to be coordinated with other disciplines during detailed design.

Figure 10: Wind farm substation, BESS, and BESS substation concept noise source layouts



8.5 Predicted noise levels

The predicted effective noise levels in this section relate to total A-weighted noise levels with an A_{tone} noise character adjustment of +2 dB for tonality.

Given that frequency spectrum is a prescribed factor, an objective assessment of low frequency may also be applicable to the assessment of unreasonable noise. However, low frequency noise emission data for the plant is presently unavailable. Further, noise emission data is not typically available at a frequency resolution (one third octave bands) that is appropriate for indicative modelling and assessment of low frequency noise. Accordingly, at this stage of the Project, the assessment is primarily based on A-weighted noise levels. Low frequency noise would need to be addressed during the detailed design stage of the Project, accounting for actual plant selections and detailed noise emission data. Requirements for the assessment of low frequency are therefore included in the recommended mitigation measures discussed subsequently in Section 10.0.

8.5.1 Receivers

Predicted effective noise levels at all receivers within 2 km of the proposed wind farm substation, BESS and BESS substation are detailed in Table 16. These results include the attenuation provided by the noise control measures specified in Section 8.4.

Table 16: Predicted noise levels from wind farm substation, BESS and BESS substation at receivers within 2 km

Receiver	Wind farm substation dB L_{Aeq}	BESS substation dB L_{Aeq}	BESS dB L_{Aeq}	Cumulative dB ENL [1]
Non-involved receivers				
0	< 10	13	27	29
12	15	10	23	26
15	11	8	21	24
30	23	15	27	31
Involved receivers outside the Project boundary				
47	15	10	23	26

1 Includes +2 dB adjustment for tonality

The predicted effective noise levels in Table 16 are predicted below the applicable night-time noise limit set out in Table 11 of Section 8.1 by at least 3 dB at all receivers

The following contextual notes are provided:

- The predicted effective noise levels conservatively assume concurrent worst-case operation of the wind farm substation, BESS and BESS substation (i.e. 100% power output). In practice this is unlikely to occur, particularly during the night period.
- Effective noise levels associated with reduced operational conditions would result in lower noise levels than that shown in Table 16.

- A +2 dB adjustment for tonality has been assumed at all receivers in order to provide a conservative assessment. For most of the receivers with 2 km, the predicted effective noise levels are low and comparable to the background noise levels. The adjustment for tonality may therefore not be applicable if the tonal character of the substations and BESS is not detectable at the receiver.
- Conversely, in the unlikely event that the character of the noise warranted a larger adjustment of +5 dB (the maximum potential adjustment, which would only be triggered in the event that the selected transformers were tonal and the tonal character was audible and prominent at the receiver), the predicted noise levels would still be at or below the noise limit at all receivers. However, in the interest of minimising the risk of harm, additional noise control options would need to be reviewed to determine if the tonality could be reduced or eliminated.

These results indicate that the proposed substations and BESS associated with the Project are capable of being designed and operated such that the applicable noise limits are achieved.

Notwithstanding the above, the predicted noise levels should be updated as the design of the Project progresses, accounting for actual equipment numbers, the final plant layout and manufacturer noise emission data. This may include consideration of representative operational conditions in respective time periods (in lieu of the conservative 100% power output adopted herein) and discrete assessment of tonality on a receiver by receiver basis.

8.5.2 Natural areas

Noise associated with the operation of the substations and BESS is a relevant consideration for natural areas throughout the life of the Project.

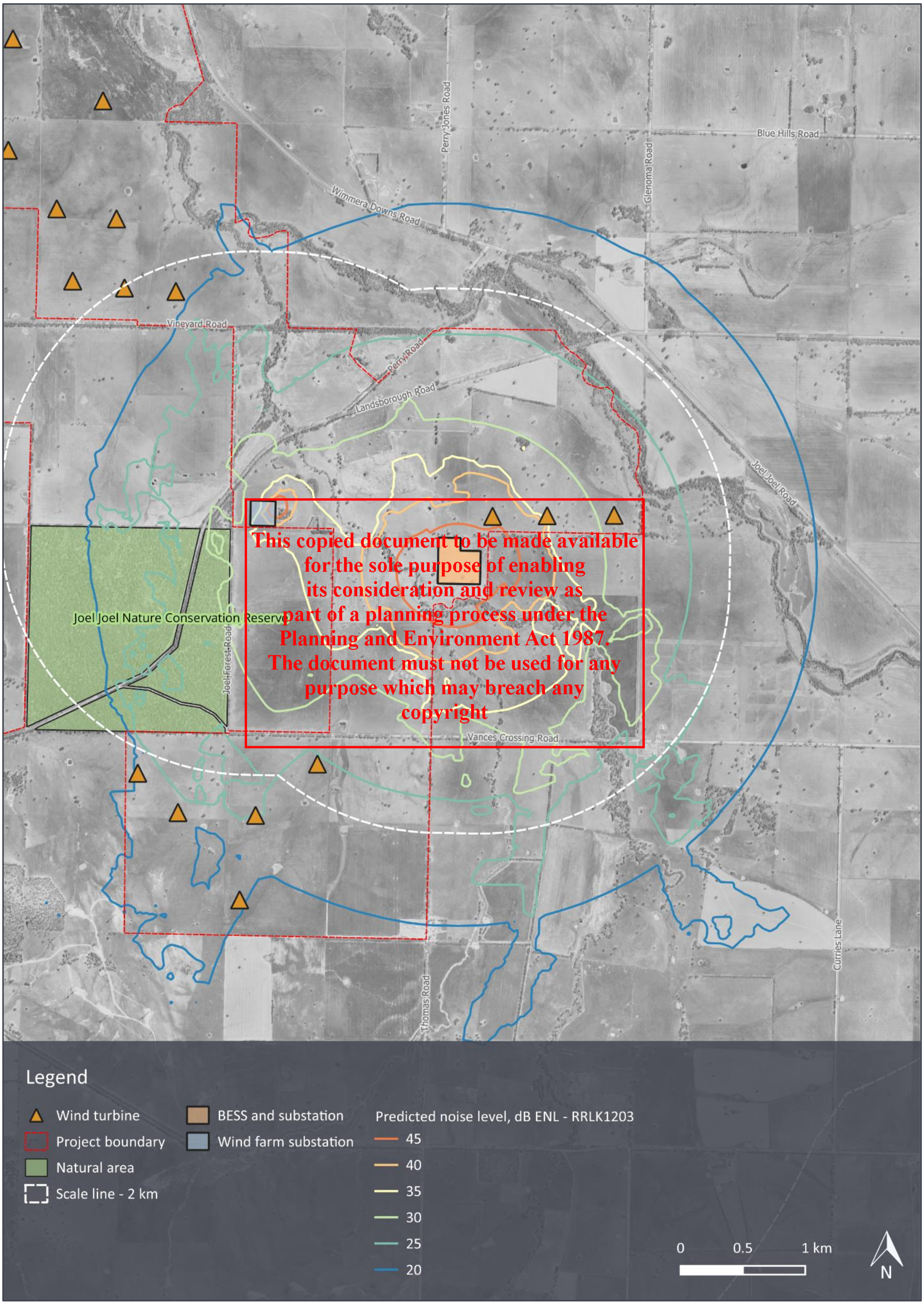
Due to the nature of the operation of these components of the Project, the extent of the areas in which the noise could be audible has the potential to be highly variable. However, natural areas where predicted noise levels are lower than 20 dB L_{Aeq} are not likely to experience audible noise from these noise sources even when daytime background noise levels are low and conditions favour the propagation of sound from the substation and BESS locations.

Predicted noise contours are presented in Figure 11 and provide an indication of the extent of the areas in which cumulative effective noise level from the BESS and both substations may be audible at natural areas.

The noise modelling indicates that the natural area most likely to experience operational noise from the substations and BESS is Joel Joel Nature Conservation Reserve, where the majority of the reserve is predicted to experience noise levels above 20 dB ENL. The remainder of the reserve (predominantly to the west) is predicted to experience noise levels below 20 dB ENL.

Further to the discussion in Section 7.4.2, based on the available information, the use of the Joel Joel Nature Conservation Reserve would not qualify as a sensitive receiver. On this basis it is unlikely that noise from the substation and BESS at this reserve would materially compromise the ERS environmental values for natural areas (i.e. values that solely relate to the experiences of people visiting these reserves).

Figure 11: Predicted substation and BESS effective noise level contours, dB ENL



8.6 Cumulative noise

EPA Publication 1997 states that noise limits determined in accordance with the Noise Protocol:

> *apply to the cumulative noise from all industry impacting on noise sensitive areas (Regulation 119)*

and:

> *each industry must take all reasonable steps, including working with other industries to reduce their emissions, to ensure that the contribution from each of the premises, when combined, does not exceed the noise limit for the noise sensitive area.*

The following commentary is also provided:

> *In other words, the noise limit must be 'shared' between all premises contributing to the noise within the noise sensitive area. To achieve this, the noise emissions of each individual industry should be controlled to meet noise levels lower than the noise limits.*

The EPA Publication 1997 then further defines the equal sharing principle:

> *When assessing the emissions of a single premises within several industry premises, the noise level to meet is reduced by an amount calculated from the number of premises contributing to the noise, where N is the total number of industry premises.*
>
> *A value of 10 x log10(N) is subtracted from the noise limit to establish the assessment criteria that applies to each individual premises.*

With respect to cumulative noise assessment, the Project teams identified the following existing or proposed commercial, industrial and trade (CIT) premises close to the Project:

- Bulgana Terminal Station and BESS – an existing electrical facility related to the nearby Bulgana Green Power Hub.
- Joel Joel BESS – a proposed BESS project to be located adjacent to Bulgana Terminal Station.

Figure 5 in Section 5.3 details the relative location of the Project, and the 2 other projects listed above, with respect to noise sensitive receivers.

Based on the equal sharing principle, the following adjusted noise limits have been developed, applying to each of the 2 projects above and the Project:

- Day 40 dB ENL
- Evening 34 dB ENL
- Night 29 dB ENL.

The equal sharing principle presents a number of practical challenges, specifically:

- Where existing or proposed CIT premises use a disproportionate amount of the noise budget
- How the noise emissions of proposed nearby CIT premises can be controlled where they are consented or approved but not yet constructed
- How the equitable sharing concept is practically applied to existing premises that have been designed and operated based on legacy noise policy which has been superseded by the requirements of the EP Act, EP Regulations, Noise Protocol and supporting publications.

EPA Publication 1997 recognises these challenges and states:

The equal sharing principle may be too simplistic in complex situations where the amount of noise each individual premises contributes to the cumulative noise within sensitive areas varies to a large degree. This can be the case if, for example,

- *there is a large diversity in the size or nature of the industries affecting noise sensitive areas,*
- *the distance from each individual premises to the noise sensitive area varies greatly, or*
- *the practicability of noise control varies greatly between the different premises.*

Rather than applying the equal sharing principle, noise reductions achievable from each site need to be investigated to obtain a suitable outcome. It may then be relevant to adopt individual criteria that give regard to the circumstances of each premises.

These projects, and their consideration in the context of cumulative noise assessment for the Project, are discussed in the following sections.

8.6.1 Bulgana Terminal Station and BESS

Bulgana Terminal Station and BESS (BTS) is an existing facility located close to the Project.

Noise assessment documentation for the BTS could not be publicly sourced. A review of information available online indicated that the main noise generating equipment related to BTS is likely to be:

- One 225 MVA HV transformer
- Ten blocks of Tesla Powerpacks comprising 5 units per block.

In order to determine noise levels that are likely to be associated with BTS, noise from the above equipment was modelled, adopting the general noise assessment method set out in Section 4.3.

Source noise levels for transformers have been developed adopting the 'standard maximum' described in Annex ZA of AS 60076-10:2009 and applying Bies & Hansen corrections from Table 11.27, *(Location 1a for outdoor transformer noise)*. This aligns with the general method adopted for transformers within the Project.

Source noise levels for the Tesla Powerpack (a legacy Tesla model no longer produced by the company) were taken from publicly available documentation (assuming the units running at 100% fan speed).

Based on the above, noise levels from operation of the BTS were predicted at nearby noise sensitive receivers for inclusion in the cumulative noise assessment, as shown in Table 17.

The BTS noise predictions conservatively assume that the project could run at 100% operational capacity at any time of the day, evening or night. On this basis, the same predicted noise levels would apply for all assessment time periods.

8.6.2 Joel Joel BESS

Joel Joel BESS (JJB) was granted a Ministerial permit on 8 August 2024 (PA2402945) and is currently in development.

As part of the planning permit application a noise assessment was completed by a third-party acoustic consultant (JJB Noise Assessment). [15]

The cumulative assessment presented in in Table 17 relies on predicted noise levels set out in the JJB Noise Assessment. The JJB Noise Assessment indicates the same predicted noise levels for the day, evening and night assessment time periods.

8.6.3 Cumulative noise assessment

Cumulative CIT noise levels at nearby noise sensitive receivers have been calculated based on the predicted noise levels for the Project set out in Section 8.5.1, the noise modelling of BTS (as described in Section 8.6.1), and the predicted noise levels detailed in the JJB Noise Assessment (Section 8.6.2). The results are shown in Table 17.

Table 17: Cumulative CIT predicted noise levels

Receiver	Project, dB L_{Aeq} [1]	BTS, dB L_{Aeq}	JJB, dB L_{Aeq}	Cumulative, dB ENL [2]
Non-involved receivers				
0	27	28	28	34
12	24	30	23	33
15	22	22	- [3]	25
30	29	28	25	34
Involved receivers outside the Project boundary				
47	24	30	22	33

1 Includes noise from the Project's substation HV transformer

2 Includes A_{tone} of +2 dB to reflect potential tonality associated with the Project, BTS and JJB

3 Receiver 15 is not included in the JJB Noise Assessment

Based on the results shown in Table 17, cumulative effective noise levels are at or below the most stringent night-time noise limit of 34 dB ENL. This is based on the conservative assumption of all 3 projects operating at 100% operational capacity (i.e. all equipment and associated cooling systems operating at 100%). Such operational conditions are unlikely to occur in practice, particularly during the night-time period.

15 Watson, Moss Growcott Acoustics document 13158-1jg Revision 2 *Joel Joel BESS Acoustic Report – Environmental Noise Emission Assessment*, dated 12 April 2024.

9.0 CONSTRUCTION NOISE

Construction of the Project will generate noise and vibration as a result of activities occurring both on and off the site of the proposed development.

Off-site noise generating activities primarily relate to heavy goods vehicle movements to and from the site. On-site works typically include a range of activities such as the construction of access tracks, connection infrastructure, wind turbine foundations, and erection of the wind turbines.

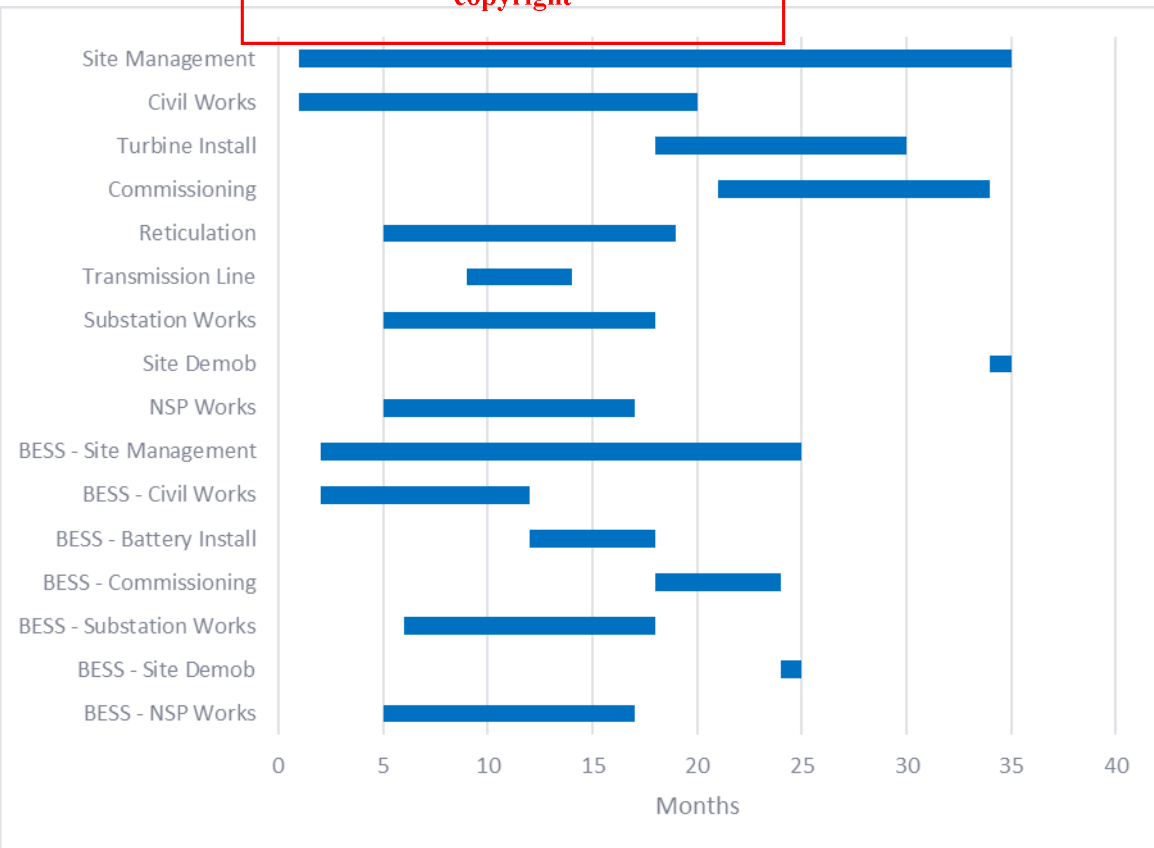
Construction of a wind farm mostly occurs at relatively large separating distances from receivers and as proposed for the Project, the majority of the work is limited to normal working hours. The only exceptions are for unavoidable works or low-noise managed works. Unavoidable works outside of normal hours are expected to comprise the delivery of oversized turbine components at times selected to minimise traffic disruption associated with intersection closures, concrete pours, and potentially turbine installation activities that are sensitive to weather conditions (e.g. installation of rotors). For these reasons, and consistent with the EPA Publication 1834.1, noise associated with the construction of a wind farm can usually be satisfactorily addressed by the adoption of good practice and considerate working practices. These measures are normally documented and agreed to in a Construction Environmental Management Plan (CEMP) which is prepared for review and approval by the responsible authority prior to commencing the work. This section therefore provides general information about the types of activities that are expected to be associated with the construction of the wind farm and reference data that should be considered as part of the preparation of a CEMP for the Project.

9.1 Construction program

The construction stage of the Project is likely to occur over a period of up to 32 months.

A simplified graphical summary of the indicative construction program provided by the Proponent is shown in Figure 12.

Figure 12: Indicative construction program



9.2 Typical construction plant & noise emissions

The types of equipment involved at different stages of construction include excavation plant, pneumatic equipment and lifting equipment. Based on typical groupings of construction equipment expected to be associated with the construction phases shown in Figure 12, total aggregated sound power levels are expected to be in the order of 115 to 125 dB L_{WA}.

The construction activity that would typically occur nearest to a receiver is access road construction. This activity involves a brief period of elevated noise while work is carried out to improve existing roads (where required), create new intersections at site access points, and initiate site access tracks. During these initial works, construction noise levels in the order of 70 to 75 dB L_{Aeq} could be expected for brief periods when road and access work is carried out at distances less than 100 m from a receiver. These noise levels are comparable to, and typical of, noise levels produced by general road works and maintenance activity.

Once the initial work for access road construction is complete, the majority of the work occurs in proximity to the turbine locations, substations and BESS locations, and on-site cabling routes. These works therefore typically occur at much larger separating distances. As a result, construction noise levels are then significantly lower. For example, at distances comparable to 1,000 m, worst-case construction noise levels in the order of 50 to 55 dB L_{Aeq} would be expected for receivers located downwind of the work.

However, depending on background noise levels and wind directions, construction noise associated with more distant works may still be audible at surrounding receiver locations at time. In particular, given the low background noise levels that can occur in rural environments at low wind speeds, construction noise could be significantly higher than the background noise levels on some occasions.

It is for this reason that the majority of works would need to be restricted to normal working hours (as defined in Section 3.6), as is proposed for the Project. Any general construction work that occurred outside of these hours would need to adhere to limits determined on the basis of background noise levels. For example, if general works needed to occur on Saturday afternoons (a period considered outside of normal working hours according to EPA Publication 1834.1) construction works would need to achieve a level of not more than 5 to 10 dB above the background noise level, depending on the actual duration of the construction program. This means that any work outside of normal hours would need to be limited to low noise activities and/or works that are classified as unavoidable, such as timing of oversized deliveries to avoid hazardous traffic conditions, concrete pours, or some aspects of turbine assembly which must occur in still wind conditions for safety reasons.

In preparing the CEMP, it would also be prudent to consider the use of lower noise emission construction equipment, primarily for activities that generate the highest noise levels, and particularly for any plant that may be used outside of normal working hours. The CEMP should also address considerate working practices for maintenance activities, timing of the noisiest works during the least sensitive periods of normal working hours wherever possible, and community notification and communication protocols.

General experience of wind farm development has indicated that construction noise tends to represent a limited risk factor. With the above types of measures implemented, it is expected that construction noise associated with the Project can be acceptably managed.

10.0 NOISE MANAGEMENT MEASURES

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

Specifically, the operator of the facility must:

- ensure that wind turbine noise complies with NZS 6808
- 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 (NMP)
  - conducting noise compliance testing when the wind farm begins operating
  - preparing annual compliance statements
  - conducting verification wind turbine noise monitoring every 5 years.

In addition to the above, the following noise management measures are recommended:

- Development of reasonably practicable construction noise mitigation and management measures to be documented in a construction environmental management plan, prior to construction. This may include:
  - universal work practices
  - consultation and notification
  - preferential selection of plant and equipment
  - on-site controls
  - work scheduling
  - transmission path and at-receiver physical noise controls.

- A detailed noise assessment of the substation and BESS should be prepared by a qualified acoustic consultant, prior to construction, addressing:
  - updated noise modelling for the substations and BESS, based on the final equipment layouts and manufacturer noise emission data for the selected equipment
  - tonality
  - low frequency noise emissions
  - all reasonably practicable noise mitigation and management measures to be implemented to minimise the risk of harm from noise associated with the BESS and substations
  - details of post-construction noise monitoring to verify compliance with the noise limits
- The NMP required under the EP Regulation must be prepared and reviewed by an EPA appointed independent environmental auditor prior to commencement of wind turbine operations.

  The NMP should include the results of noise modelling based on the final wind turbine selection and layout and verify compliance with the applicable noise limits at surrounding receivers.

11.0 SUMMARY

An assessment of environmental noise associated with operation of the Watta Wella Renewable Energy Project's wind turbines, substations and battery energy storage system (BESS) has been carried out.

Operational noise associated with the proposed wind turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the *Environment Protection Regulations 2021* and the Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023.

Noise modelling was carried out based on the proposed 45 turbine layout and a candidate turbine model (Nordex N175 6.x) which has been selected by the proponent as being representative of the size and type of turbines which could be used at the site.

The operational wind turbine noise assessment considers base noise limits determined in accordance with NZS 6808, accounting for the land zoning of the area. The results of the noise modelling for the Project demonstrate that the predicted noise levels for the proposed wind turbine layout and candidate wind turbine model achieve the base (minimum) noise limits determined in accordance with NZS 6808 at all neighbouring receivers.

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

The assessment has also considered operational noise of the proposed substations and BESS. These noise levels have been assessed in accordance with Victorian EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol) dated May 2021.The assessment demonstrates that predicted noise levels are at least 3 dB lower than the applicable noise limit. The assessment also considered the cumulative noise levels of the substations, BESS and other surrounding industry comprising the existing Bulgana Terminal Station and BESS and the proposed Joel Joel BESS, adjacent to the Bulgana Terminal Station. The results demonstrate that cumulative noise levels are predicted to comply with the noise limits.

Consideration was also given to the general environmental duty, as required by the *Environment Protection Act 2017* and noise management measures to be addressed during subsequent stages of development have been recommended.

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

APPENDIX A GLOSSARY OF TERMINOLOGY

Term	Definition	Abbreviation
Amplitude modulation	Sound that is characterised by a rhythmic and higher than normal rise and fall in sound level at regular intervals.	-
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion below this table.
A-weighted 90th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
Decibel	The unit of sound level.	dB
Effective noise level	The effective noise level from commercial, industrial or trade premises determined in accordance EPA Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industry and trade premises and entertainment venues*. This is the L_{Aeq} noise level over a 30-minute period, adjusted for the character of the noise. Adjustments are made for tonality, intermittency and impulsiveness.	ENL
Equivalent noise level	The equivalent continuous A-weighted pressure level. Commonly referred to as the average sound level and is measured in dB.	L_{Aeq}
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 WIND TURBINE COORDINATES

The following table sets out the coordinates of the proposed wind turbine layout, as illustrated in Figure 2. Note that T34 and T35 were removed from the Project as part of design development and are therefore not included in Table 18 or shown in any graphics.

Layout reference PAUSplc098 was supplied by the proponent on 12 December 2024.

Table 18: Wind turbine coordinates – MGA2020 zone 54

Turbine	Easting, m	Northing, m	Terrain elevation, m
T1	675,123	5,897,324	247
T2	674,306	5,898,340	257
T3	674,629	5,898,024	244
T4	675,251	5,898,001	244
T5	675,747	5,898,412	225
T6	674,200	5,902,232	219
T7	672,769	5,899,275	240
T8	673,127	5,899,184	245
T9	671,555	5,899,834	223
T10	671,292	5,900,541	204
T11	670,790	5,899,848	248
T12	671,331	5,900,083	231
T13	670,359	5,899,947	255
T14	670,946	5,903,182	216
T15	672,980	5,900,214	241
T16	677,151	5,900,401	219
T17	677,588	5,900,405	228
T18	678,125	5,900,409	219
T19	669,672	5,900,499	265
T20	670,041	5,900,882	255
T21	671,284	5,901,487	235
T22	674,136	5,902,787	220
T23	669,462	5,900,982	254
T24	674,612	5,902,205	220
T25	670,724	5,902,512	225
T26	673,785	5,902,288	225
T27	672,083	5,902,499	214
T28	670,732	5,900,806	237
T29	673,269	5,903,338	225

Turbine	Easting, m	Northing, m	Terrain elevation, m
T30	673,657	5,902,868	220
T31	674,028	5,903,734	210
T32	671,572	5,902,823	210
T33	672,551	5,903,528	225
T36	672,087	5,904,267	225
T37	673,306	5,904,231	217
T38	672,941	5,904,621	215
T39	672,572	5,905,102	212
T40	671,711	5,905,319	210
T41	670,230	5,905,410	203
T42	672,182	5,905,701	210
T43	669,408	5,905,807	209
T44	669,814	5,905,754	203
T45	671,322	5,905,776	210
T46	670,849	5,906,298	210
T47	670,476	5,906,720	205

APPENDIX C VICTORIAN REGULATIONS AND GUIDELINES

The following publications are relevant to the assessment of operational noise from proposed renewable energy projects in Victoria:

- *Environment Protection Act 2017*
- *Environment Protection Regulations 2021*
- *Environment Reference Standard* published 25 May 2021, and as amended by *Environment Reference Standard No. S158 Gazette* dated 29 March 2022
- Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023
- NZS 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.

The relevant publication for the assessment of construction noise in Victoria is the EPA Publication 1834.1 *Civil construction, building and demolition guide*, dated 12 September 2023.

There is no standard or regulation that specifies criteria for the control of construction vibration levels in Victoria. In lieu of Victorian guidance for construction vibration, reference is made to NSW guidance documents.

Details of the guidance and noise criteria provided by the above publications are provided in the following sections.

C1 Environment Protection Act 2017

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

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

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

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

Under the EP Act, unreasonable noise means noise that:

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

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

C2 Environment Protection Regulations 2021

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

The following sections provide details of the requirements for wind turbine noise and industry noise.

C2.1 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 provisions and requirements.

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 landowner to modify the noise limits.

  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

  Regulation 131C establishes a duty to manage and review wind turbine noise by taking all applicable actions set in Division 5 of the EP Act.

  Regulation 131CA establishes a duty to comply with the noise limit (or the alternative monitoring point criterion if wind turbine noise is being assessed at an alternative monitoring point) determined in accordance with NZS 6808 and any applicable noise agreement.

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

Details of the types of receivers to be assessed, the noise limits and the technical procedures for assessing compliance with the noise limits are separately defined in NZS 6808 (see further information in Section C5).

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.

C2.2 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 C6). 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.

The noise limits apply at locations referred to as noise sensitive areas which are defined by the EP Regulations as:

(a) that part of the land within the boundary of a parcel of land that is—

(i) within 10 metres of the outside of the external walls of any of the following buildings—

(A) a dwelling (including a residential care facility but not including a caretaker's house);

(B) a residential building;

(C) a noise sensitive residential use[16]; or

(ii) within 10 metres of the outside of the external walls of any dormitory, ward, bedroom or living room of one or more of the following buildings—

(A) a caretaker's house;

(B) a hospital;

(C) a hotel;

(D) a residential hotel;

(E) a motel;

(F) a specialist disability accommodation;

(G) a corrective institution;

(H) a tourist establishment;

(I) a retirement village;

(J) a residential village; or

(iii) within 10 metres of the outside of the external walls of a classroom or any room in which learning occurs in the following buildings (during their operating hours)—

(A) a child care centre;

(B) a kindergarten;

(C) a primary school;

(D) a secondary school; or

(b) subject to paragraph (c), in the case of a rural area only, that part of the land within the boundary of—

(i) a tourist establishment; or

(ii) a campground; or

(iii) a caravan park; or

16 *Noise sensitive residential use* [...] *means a community care accommodation, dependent person's unit, dwelling, residential aged care facility, residential village, retirement village or rooming house*

(c) *despite paragraph (b), in the case of a rural area only, where an outdoor entertainment event or outdoor entertainment venue is being operated, that part of the land within the boundary of the following are not noise sensitive areas for the purposes of that event or venue—*

(i) a tourist establishment;

(ii) a campground;

(iii) a caravan park;

C3 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 19.

Table 19: 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 20.

Table 20: 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) [1]
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)

Land use category	General description	Planning zones
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)

1 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 21.

Table 21: 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

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, wildlife reserves and environmentally significant areas and landscapes outside metropolitan Melbourne that are identified in a planning scheme*.

C4 Victorian Wind Energy Guidelines

The Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023 (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*
- *a framework for the regulation of wind turbine noise.*

Section 4.3.2 of the Victorian Wind Energy Guidelines outlines the application requirements for a wind energy facility. Specifically, to following written reports are required to be submitted to address potential noise impacts:

- *A pre-construction (predictive) noise assessment report prepared by a suitably qualified and experienced acoustician that:*
  - *reports on a pre-construction (predictive) noise assessment conducted following New Zealand Standard NZS6808:2010, Acoustics – Wind Farm Noise*
  - *provides an assessment of whether the proposed wind energy facility will comply with the noise limit for that facility*
  - *where the proposed wind energy facility will be the subject of a wind turbine noise agreement under the Environment Protection Regulations 2021, specifies the premises of the relevant landowner (including any particular buildings) to which the agreement relates and provides an assessment of whether the proposed wind energy facility will comply with the modified noise limit for that facility specified in the agreement*
  - *is prepared on the basis that the relevant noise standard will be the New Zealand Standard NZS6808:2010, Acoustics – Wind Farm Noise and includes an assessment of whether a high amenity noise limit is applicable under Section 5.3 of the standard.*
- *A report prepared by an environmental auditor appointed under Part 8.3 of the Environment Protection Act 2017 that verifies whether or not the pre-construction (predictive) noise assessment was conducted under New Zealand Standard NZS6808:2010, Acoustics – Wind Farm 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[17].

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.

It is noted that although the Victorian Wind Energy Guidelines specifically refer to receivers within the Project boundary and/or with a noise agreement in place as 'stakeholder dwellings', they have been referred to as *involved receivers* within this report. This has been done at the request of the proponent to minimise the potential for misinterpretation of terminology by the reader. Similarly, receivers outside of the Project boundary and without a noise agreement have been referred to as *non-involved receivers.*

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*	• *Host farm*
• *Corrective institution*	• *Residential aged care facility*
• *Dependent person's unit*	• *Residential building*
• *Dwelling*	• *Residential village*
• *Group accommodation*	• *Retirement village*

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

[17] *Cherry Tree Wind Farm v Mitchell Shire Council* (2013)

C5 NZS 6808

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.

C5.1 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.

C5.2 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 Project boundary. However, the noise limits specified in the Standard are not applied to these locations on account of their participation with the Project.

C5.3 Noise limit

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

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

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

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

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

C5.4 High amenity

Section 5.3.1 of NZS 6808 states that the base noise limit of 40 dB L_{A90} 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, as informed by the Victorian Wind Energy Guidelines and EPA Publication 2061 *Wind Energy Facility Turbine Noise Regulation Guidelines.*[18]

[18] At the date of preparation of this report, EPA Publication 2061 is not available as a version controlled formal document. This report is based on the EPA webpage version of this publication, last updated on 26 January 2024.

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.

C5.5 Special audible characteristics

Section 5.4.2 of NZS 6808 requires the following:

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

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

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

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

C6 EPA Publication 1826.4 (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 on-site substation and BESS are 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. In rural areas only, noise sensitive areas also include land within the boundaries of tourist establishments, campgrounds, and caravan parks.

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.

APPENDIX D NOISE PREDICTION MODEL

D1 Overview

Key elements of the method used for predicting operational wind turbine noise from the Project are summarised in Table 22.

Table 22: Operational noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLANnoise version 9.0
Method	ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2:1996) Specific to wind turbine noise predictions, adjustments to the ISO 9613-2:1996 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* (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. Specific details of adjustments are noted below and are discussed below.
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 (e.g. wind turbines, transformers) is then calculated on the basis of simultaneous operation of all elements (e.g. all wind turbines, all equipment associated with quarrying activities) and summing the contribution of each. To model the wind turbine noise, the following specific procedures are noted: • Calculations of wind turbine noise levels at 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	5 m vertical resolution elevation contours, provided by the Proponent
Terrain effects (turbine-specific procedures)	Adjustments for the effects of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined below. • Valley effects: +3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the turbine and calculation point is 50 % greater than would occur if the ground were flat. • Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the turbine and the calculation point. The value of the screening effect is limited to a maximum value of -2 dB. The Project is located in a relatively flat area characterised by little variations in ground elevation between the wind turbines and surrounding receivers. Based on comparison of predicted noise levels with and without terrain elevation data included, terrain effects ranging between -1.0 dB and +0.1 dB were calculated for receivers within 5 km of the proposed wind turbines. For reference purposes, the ground elevations at the receivers and turbines are tabled in Appendix F and Appendix B, respectively. The topography of the site is depicted in the elevation map provided in Appendix H.

Detail	Description
Ground conditions	Ground factor of G = 0.5 based on the UK Institute of Acoustics guidance and research outlined below. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2:1996. 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%, and 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 which increase the propagation of sound from each turbine to each receiver, whether as a result of thermal inversions or wind directed toward each calculation point. [19]
Receiver heights	1.5 m above ground level Specific to wind turbine noise predictions, the UK Institute of Acoustics guidance refers to receiver heights of 4 m, and this guidance has subsequently been documented in international standards and, most recently, the EPA Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline* dated 20 December 2024 (Technical Guideline). The UK Institute of Acoustics guidance was written as a complete approach to the prediction of wind turbine noise in the context of the regulatory requirements in the UK. Specifically, the method is for the prediction of the L_{A90} wind turbine noise levels for short-term downwind conditions. Conceptually, this is directly relevant to a planning stage assessment of a wind farm under NZS 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as the assessment is intended to represent typical worst case L_{A90} noise levels of a wind farm. However, an important technical detail is that application of the complete method is incompatible with NZS 6808. This is because the UK Institute of Acoustics guidance specifies that the calculation should include subtraction of 2 dB to account for the difference between the equivalent noise level that the sound power level of the turbines is determined from, and the L_{A90} noise measurement metric. However, NZS 6808 specifically states that predictions based on the sound power levels, without adjustment between L_{Aeq} and L_{A90} noise levels, shall be taken as representative of the L_{A90} noise levels. As a result, adoption of a 4 m receiver height in the context of an NZS 6808 assessment would result in a significantly more conservative assessment than an assessment based on the complete prediction method outlined in the UK Institute of Acoustics guidance. For this reason, noise predictions in Australia have generally been based on a lower prediction height of 1.5 m, but without any adjustment between L_{Aeq} and L_{A90} noise levels. The difference between predicted noise levels at 1.5 m and 4 m varies between sites but is generally comparable to the 2 dB value factored in the UK Institute of Acoustics guidance. As a result, the effect of a lower receiver height is balanced out by not applying an L_{Aeq} to L_{A90} correction, resulting in similar predicted noise levels.

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

In Australia, wind turbine noise predictions are typically calculated using ISO 9613-2:1996 with a set of conservative assumptions tailored to wind farm assessment, as detailed in UK Institute of Acoustics guidance.

A revised version of the standard, ISO 9613-2:2024[20], was published earlier in 2024 based on broadly equivalent procedures to ISO 9613-2:1996, subject to refinements, clarifications, and supplementary advice for different types of sources. Notably, ISO 9613-2:2024 introduces an informative annex on wind turbine noise modelling to reflect the recommendations of the UK Institute of Acoustics guidance.

At the date of preparing this report, the revised standard has not yet been implemented in commonly used proprietary noise modelling software options. However, the core elements of the two versions (particularly with respect to wind farm noise modelling), are similar, and proprietary software options already implement the UK Institute of Acoustics guidance with respect to ISO 9613-2:1996.

On this basis ISO 9613-2:1996 continues to be used and referenced in Australia and 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, the South Australian EPA *Wind farms environmental noise guidelines* and the Queensland *Planning Guideline - State code 23: Wind farm development*.

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.

[20] ISO 9613-2:2024 *Acoustics — Attenuation of sound during propagation outdoors Part 2: Engineering method for the prediction of sound pressure levels outdoors*

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 9613-2:1996 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 9613-2:1996 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 9613-2:1996 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 9613-2:1996 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 9613-2:1996 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 9613-2:1996 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 guidance.

A range of measurement and prediction studies for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613-2:1996 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice. [21, 22, 23]

[21] 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.

[22] 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.

[23] 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.

The findings of these studies demonstrate the suitability of the ISO 9613-2:1996 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 ISO 9613-2:1996
- 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.

In addition to the choice of ground factor referred to above, adjustments to ISO 9613-2:1996 for screening and valleys effects are applied based on recommendations of the Joule Report, UK IOA 2009 joint agreement and the UK Institute of Acoustics guidance. 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 for the wind farm 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.

D2 Uncertainty

Guidance on uncertainty in wind farm noise assessment is provided in Appendix C of NZS 6808.

The guidance in Appendix C is designated as *informative*, meaning that the content is only for information and its provisions do not form part of the mandatory requirements of the standard. Notwithstanding this, Appendix C notes that it is good practice to state the uncertainty and confidence level for all sound levels.

Uncertainty in environmental noise modelling is typically addressed in one of two ways:

1. Mean predicted noise levels: selection of mean input values and modelling parameters to calculate a mean predicted noise level. The combined uncertainty relating to the inputs and prediction method is then assessed and used to consider how noise levels in practice could differ from the predicted noise levels.
2. Upper predicted noise levels: selection of conservative input values and modelling parameters to calculate the upper predicted noise levels, inherently accounting for uncertainty in the modelling. Noise levels in practice are then expected to be lower than predicted by the modelling.

NZS 6808 Appendix C notes that uncertainty should be determined in accordance with the procedures outlined in Craven and Kerry[24]. However, the procedures referenced in Craven and Kerry are primarily applicable to measurements rather than noise modelling. The procedures are also based on the calculation of uncertainty values which are more relevant when considering mean assessment values.

[24] Craven, N J, and Kerry, G. *A good practice guide on the sources and magnitude of uncertainty arising in the practical measurement of environmental noise*. University of Salford. 2001

The approach to uncertainty adopted for this assessment is based on calculation of upper predicted noise levels. This approach is consistent with the UK Institute of Acoustics guidance on wind turbine noise modelling which addresses uncertainty by describing procedures for the calculation of upper predicted noise levels based on conservative input selections. With this approach, it is not necessary to apply uncertainty margins to the predicted noise levels. Noise levels associated with operation of the wind farm when measured and assessed in accordance with NZS 6808 are expected to be lower than the predictions. This finding is supported by extensive post-construction noise compliance monitoring undertaken at wind farm sites across Australia. Further, Appendix C notes that when comparing a sound level with an applicable noise limit, the sound level should be deemed to comply if it is equal to or less than the noise limit and does not specify the addition or subtraction of uncertainties.

Notwithstanding the above, the elements of the modelling which may give rise to uncertainty can be considered in the context of the framework outlined in Craven and Kerry. Specifically, the procedures in Craven and Kerry suggest considering uncertainty in sections related to source, transmission and receiver. The source and transmission considerations are directly relevant to noise modelling and are discussed further below. The section related to receiver uncertainty in Craven and Kerry is solely concerned with measurement related uncertainties (e.g. instrumentation uncertainty and background noise influences) and is therefore not relevant to the noise modelling.

Source uncertainties (sound power levels)

The source levels of each wind turbine are characterised in terms of the sound power levels determined in accordance with IEC 61400-11. The results of sound power testing in accordance with this standard are typically characterised by an uncertainty margin of approximately ±1 dB. To reflect this, the sound power data sourced from the manufacturer's documentation has been factored in the noise modelling as follows:

- The manufacturer data has been adjusted by the addition of +1 dB at all wind speeds.
- All turbines are assumed to simultaneously emit sound power levels at the uncertainty adjusted values.

Uncertainty relating to the frequency characteristics of the wind turbine's noise emissions was also addressed by identifying the wind speed with the most unfavourable spectrum profile (i.e. the spectrum profile which would result in the highest predicted noise levels) and then applying the same profile to every wind speed.

Transmission uncertainties (prediction method)

The ISO 9613-2:1996 prediction method indicates an uncertainty margin of the order of ±3 dB in relation to calculated noise levels at distances between 100 m and 1,000 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 9613-2:1996 to greater propagation heights). However, the uncertainty margins are noted for a prediction in accordance with the inputs described in ISO 9613-2:1996. A strict application of ISO 9613-2:1996 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 9613-2:1996 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 each receiver is simultaneously downwind of every wind turbine at all times and consistent atmospheric conditions which result in minimal atmospheric absorption.

It is not possible to specify exact uncertainty margins for the conservative prediction approach adopted for the assessment. However, based on experience and the published studies referenced earlier in this appendix, the uncertainty in short term measured noise levels under downwind conditions is typically of the order of ±2 dB. This reduces to reduces to ±1 dB or less when comparing predictions with measured noise levels determined in accordance with NZS 6808 which are based on the analysis of aggregated data for a range of atmospheric conditions.

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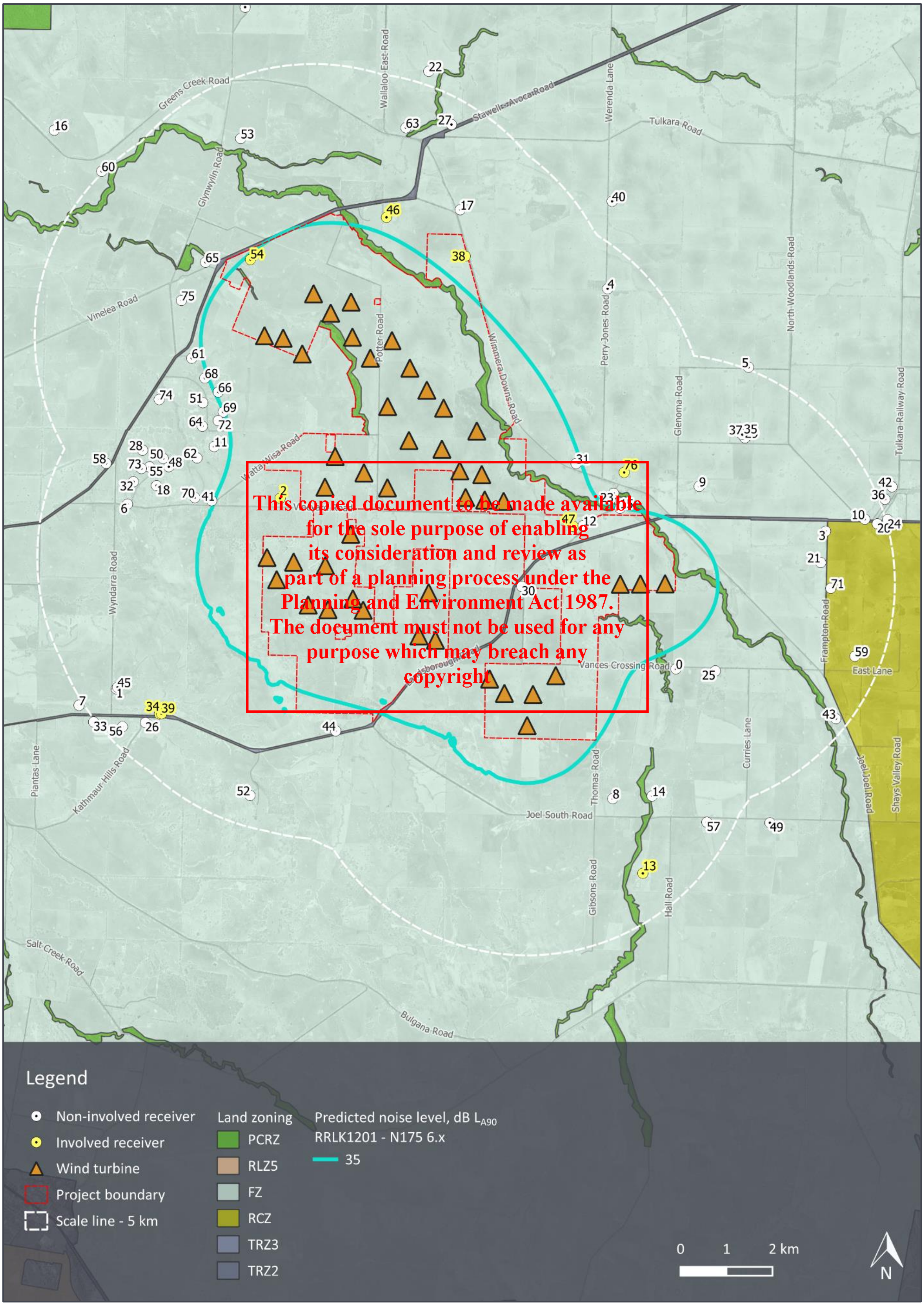
APPENDIX E ZONING MAP

Figure 13: Zoning map for the Project and surrounding area



APPENDIX F RECEIVER COORDINATES

The following table sets out the 65 assessed receivers located within 5 km of the proposed wind turbines considered in the environmental noise assessment together with their respective distance to the nearest turbine. This includes 9 involved receivers (2 within the Project boundary and 7 outside).

Data supplied by the proponent on 11 November 2023.

Table 23: Receivers within 5 km of the proposed wind turbines – MGA2020 zone 54

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine	Land zoning
Non-involved receivers						
0	678,361	5,898,558	224	1,873	T18	FZ
1	666,184	5,898,124	236	4,223	T19	FZ
3	681,618	5,901,553	230	3,679	T18	FZ
4	676,875	5,906,830	220	4,210	T31	FZ
6	666,426	5,902,143	240	3,255	T23	FZ
8	676,986	5,899,734	235	2,434	T1	FZ
9	678,868	5,902,527	215	2,250	T18	FZ
10	682,472	5,901,814	235	4,571	T18	FZ
11	668,313	5,903,395	226	2,572	T25	FZ
12	676,342	5,901,674	213	1,518	T16	FZ
14	677,842	5,895,790	230	3,126	T1	FZ
15	677,143	5,902,053	215	1,660	T16	FZ
17	673,669	5,908,549	204	3,116	T10	FZ
18	667,059	5,902,544	244	2,871	T23	FZ
20	682,743	5,901,714	238	4,801	T18	RCZ
21	681,512	5,900,871	225	3,421	T18	FZ
23	677,004	5,902,378	215	1,989	T16	FZ
25	679,220	5,898,513	235	2,195	T18	FZ
26	666,817	5,897,388	237	4,225	T19	FZ
27	673,477	5,910,402	201	4,439	T10	FZ
28	666,754	5,903,317	222	3,580	T23	FZ
29	679,862	5,903,583	227	3,622	T18	FZ
30	675,006	5,900,351	222	1,902	T24	FZ
31	676,188	5,903,025	210	1,784	T24	FZ
32	666,554	5,902,630	232	3,347	T23	FZ

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine	Land zoning
35	679,842	5,903,680	230	3,698	T18	FZ
37	679,806	5,903,657	230	3,660	T18	FZ
41	668,258	5,902,216	236	1,732	T23	FZ
43	681,840	5,897,473	221	4,738	T18	FZ
44	670,957	5,897,209	235	2,650	T11	FZ
45	666,210	5,898,158	236	4,183	T19	FZ
48	667,326	5,902,957	231	2,914	T23	FZ
50	667,204	5,903,136	224	3,126	T23	FZ
51	668,065	5,904,350	220	1,988	T43	FZ
52	669,093	5,895,803	295	4,336	T13	FZ
53	668,890	5,910,098	200	3,736	T47	FZ
55	666,906	5,902,953	231	3,233	T23	FZ
56	666,317	5,897,298	257	4,640	T19	FZ
57	679,034	5,895,221	232	4,443	T1	FZ
58	665,961	5,903,031	218	4,060	T23	FZ
59	682,256	5,898,831	229	4,425	T18	RCZ
61	667,826	5,905,316	228	1,664	T43	FZ
62	667,940	5,903,147	225	2,652	T23	FZ
63	672,485	5,910,332	204	3,978	T10	FZ
64	668,055	5,903,838	224	2,395	T43	FZ
65	668,126	5,907,406	200	2,055	T43	FZ
66	668,403	5,904,581	230	1,594	T43	FZ
68	668,109	5,904,886	230	1,601	T43	FZ
69	668,509	5,904,147	228	1,895	T43	FZ
70	667,892	5,902,284	235	2,047	T23	FZ
71	681,732	5,900,313	225	3,611	T18	RCZ
72	668,401	5,903,959	230	2,111	T43	FZ
73	666,729	5,902,917	235	3,353	T23	FZ
74	667,117	5,904,419	210	2,684	T43	FZ
75	667,600	5,906,574	210	1,970	T43	FZ

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine	Land zoning
Involved receivers outside the Project boundary						
2	669,749	5,902,271	226	1,018	T25	FZ
13	677,642	5,894,108	232	4,087	T1	FZ
34	667,120	5,897,577	235	3,883	T19	FZ
39	667,167	5,897,580	236	3,850	T19	FZ
46	672,062	5,908,384	204	2,003	T10	FZ
47	676,129	5,901,656	212	1,622	T24	FZ
76	677,235	5,902,833	230	2,439	T16	FZ
Involved receivers within the Project boundary						
38	673,777	5,907,538	205	2,438	T42	FZ
54	669,101	5,907,464	200	1,571	T47	FZ

APPENDIX G TABULATED PREDICTED NOISE LEVEL DATA

Table 24: 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									
0	22.0	23.0	25.0	28.1	31.3	33.1	33.1	33.1	33.1
1	15.2	16.2	18.2	21.3	24.5	26.3	26.3	26.3	26.3
3	15.0	16.0	18.0	21.1	24.3	26.1	26.1	26.1	26.1
4	17.7	18.7	20.7	23.8	27.0	28.8	28.8	28.8	28.8
5	15.1	16.1	18.1	21.2	24.4	26.2	26.2	26.2	26.2
6	18.4	19.4	21.4	24.5	27.7	29.5	29.5	29.5	29.5
7	13.7	14.7	16.7	19.8	23.0	24.8	24.8	24.8	24.8
8	19.2	20.2	22.2	25.3	28.5	30.3	30.3	30.3	30.3
9	19.9	20.9	22.9	26.0	29.2	31.0	31.0	31.0	31.0
10	13.5	14.5	16.5	19.6	22.8	24.6	24.6	24.6	24.6
11	22.9	23.9	25.9	29.0	32.2	34.0	34.0	34.0	34.0
12	25.2	26.2	28.2	31.3	34.5	36.3	36.3	36.3	36.3
14	17.7	18.7	20.7	23.8	27.0	28.8	28.8	28.8	28.8
15	23.9	24.9	26.9	30.0	33.2	35.0	35.0	35.0	35.0
16	12.3	13.3	15.3	18.4	21.6	23.4	23.4	23.4	23.4
17	19.6	20.6	22.6	25.7	28.9	30.7	30.7	30.7	30.7
18	20.1	21.1	23.1	26.2	29.4	31.2	31.2	31.2	31.2
20	13.1	14.1	16.1	19.2	22.4	24.2	24.2	24.2	24.2
21	15.4	16.4	18.4	21.5	24.7	26.5	26.5	26.5	26.5
22	14.4	15.4	17.4	20.5	23.7	25.5	25.5	25.5	25.5
23	23.2	24.2	26.2	29.3	32.5	34.3	34.3	34.3	34.3
24	12.8	13.8	15.8	18.9	22.1	23.9	23.9	23.9	23.9
25	19.8	20.8	22.8	25.9	29.1	30.9	30.9	30.9	30.9
26	15.2	16.2	18.2	21.3	24.5	26.3	26.3	26.3	26.3
27	16.0	17.0	19.0	22.1	25.3	27.1	27.1	27.1	27.1
28	19.2	20.2	22.2	25.3	28.5	30.3	30.3	30.3	30.3
29	16.5	17.5	19.5	22.6	25.8	27.6	27.6	27.6	27.6
30	26.1	27.1	29.1	32.2	35.4	37.2	37.2	37.2	37.2
31	24.3	25.3	27.3	30.4	33.6	35.4	35.4	35.4	35.4

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
32	18.8	19.8	21.8	24.9	28.1	29.9	29.9	29.9	29.9
33	13.9	14.9	16.9	20.0	23.2	25.0	25.0	25.0	25.0
35	16.5	17.5	19.5	22.6	25.8	27.6	27.6	27.6	27.6
36	12.7	13.7	15.7	18.8	22.0	23.8	23.8	23.8	23.8
37	16.5	17.5	19.5	22.6	25.8	27.6	27.6	27.6	27.6
40	15.4	16.4	18.4	21.5	24.7	26.5	26.5	26.5	26.5
41	23.6	24.6	26.6	29.7	32.9	34.7	34.7	34.7	34.7
42	12.5	13.5	15.5	18.6	21.8	23.6	23.6	23.6	23.6
43	13.4	14.4	16.4	19.5	22.7	24.5	24.5	24.5	24.5
44	21.8	22.8	24.8	27.9	31.1	32.9	32.9	32.9	32.9
45	15.3	16.3	18.3	21.4	24.6	26.4	26.4	26.4	26.4
48	20.6	21.6	23.6	26.7	29.9	31.7	31.7	31.7	31.7
49	13.3	14.3	16.3	19.4	22.6	24.4	24.4	24.4	24.4
50	20.2	21.2	23.2	26.3	29.5	31.3	31.3	31.3	31.3
51	22.7	23.7	25.7	28.8	32.0	33.8	33.8	33.8	33.8
52	16.5	17.5	19.5	22.6	25.8	27.6	27.6	27.6	27.6
53	16.5	17.5	19.5	22.6	25.8	27.6	27.6	27.6	27.6
55	19.6	20.6	22.6	25.7	28.9	30.7	30.7	30.7	30.7
56	14.8	15.8	17.8	20.9	24.1	25.9	25.9	25.9	25.9
57	15.0	16.0	18.0	21.1	24.3	26.1	26.1	26.1	26.1
58	17.6	18.6	20.6	23.7	26.9	28.7	28.7	28.7	28.7
59	13.6	14.6	16.6	19.7	22.9	24.7	24.7	24.7	24.7
60	14.1	15.1	17.1	20.2	23.4	25.2	25.2	25.2	25.2
61	22.8	23.8	25.8	28.9	32.1	33.9	33.9	33.9	33.9
62	22.0	23.0	25.0	28.1	31.3	33.1	33.1	33.1	33.1
63	16.7	17.7	19.7	22.8	26.0	27.8	27.8	27.8	27.8
64	22.3	23.3	25.3	28.4	31.6	33.4	33.4	33.4	33.4
65	21.4	22.4	24.4	27.5	30.7	32.5	32.5	32.5	32.5
66	24.2	25.2	27.2	30.3	33.5	35.3	35.3	35.3	35.3
67	12.2	13.2	15.2	18.3	21.5	23.3	23.3	23.3	23.3
68	23.6	24.6	26.6	29.7	32.9	34.7	34.7	34.7	34.7
69	23.9	24.9	26.9	30.0	33.2	35.0	35.0	35.0	35.0

Receiver	Hub-height wind speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**≥12**
70	22.5	23.5	25.5	28.6	31.8	33.6	33.6	33.6	33.6
71	14.9	15.9	17.9	21.0	24.2	26.0	26.0	26.0	26.0
72	23.4	24.4	26.4	29.5	32.7	34.5	34.5	34.5	34.5
73	19.2	20.2	22.2	25.3	28.5	30.3	30.3	30.3	30.3
74	20.1	21.1	23.1	26.2	29.4	31.2	31.2	31.2	31.2
75	21.2	22.2	24.2	27.3	30.5	32.3	32.3	32.3	32.3
Involved receiver outside the Project boundary									
2	28.9	29.9	31.9	35.0	38.2	40.0	40.0	40.0	40.0
13	15.0	16.0	18.0	21.1	24.3	26.1	26.1	26.1	26.1
34	15.9	16.9	18.9	22.0	25.2	27.0	27.0	27.0	27.0
39	16.0	17.0	19.0	22.1	25.3	27.1	27.1	27.1	27.1
46	22.4	23.4	25.4	28.5	31.7	33.5	33.5	33.5	33.5
47	25.5	26.5	28.5	31.6	34.8	36.6	36.6	36.6	36.6
76	21.9	22.9	24.9	28.0	31.2	33.0	33.0	33.0	33.0
Involved receiver within the Project boundary									
38	21.9	22.9	24.9	28.0	31.2	33.0	33.0	33.0	33.0
54	24.4	25.4	27.4	30.5	33.7	35.5	35.5	35.5	35.5

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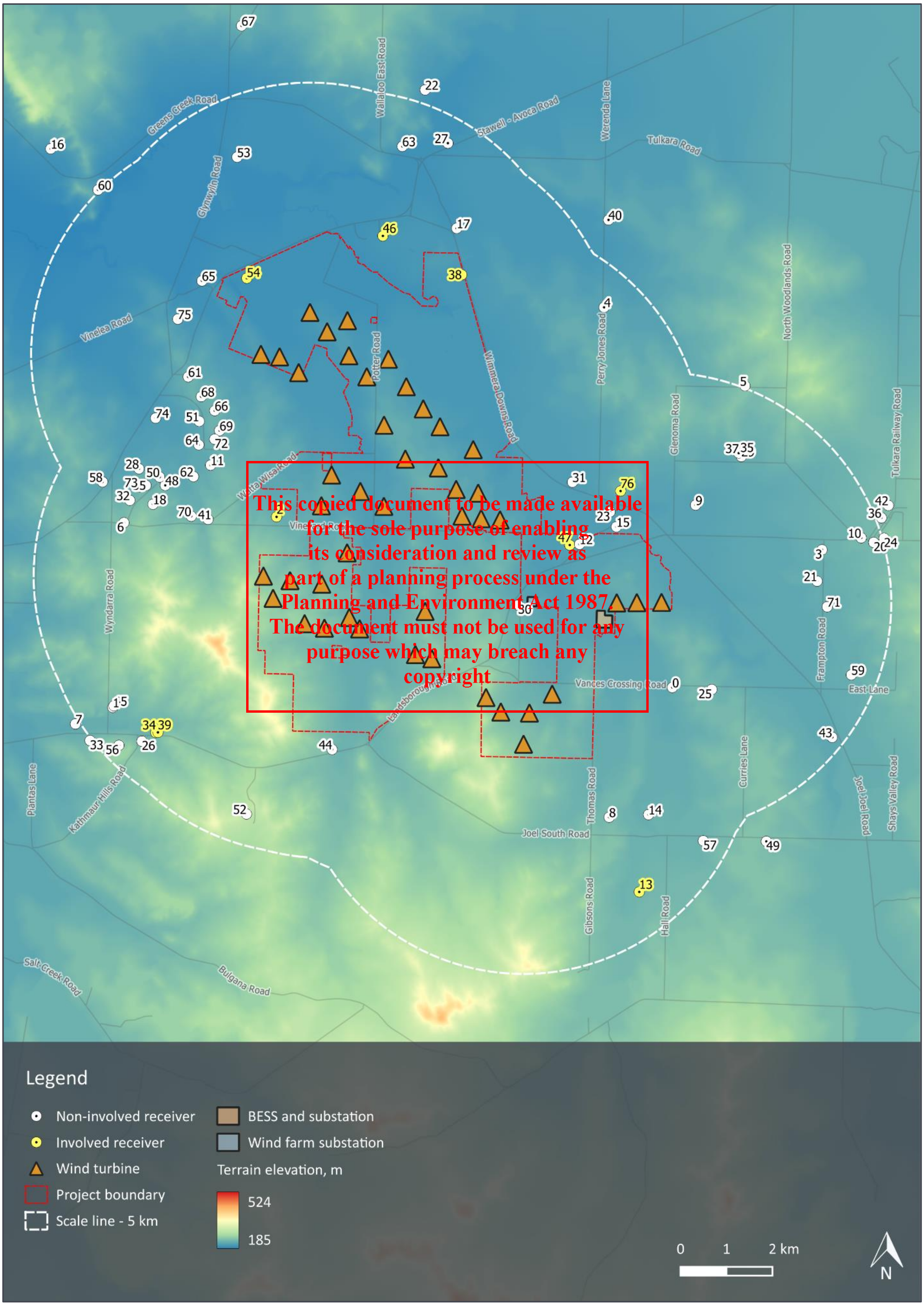
APPENDIX H SITE TOPOGRAPHY

Figure 14: Terrain elevation map for the Project and surrounding area



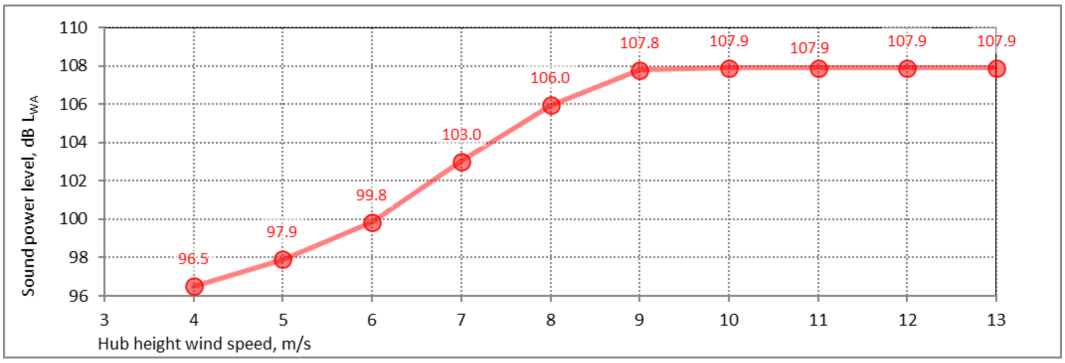
APPENDIX I NZS 6808 DOCUMENTATION

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

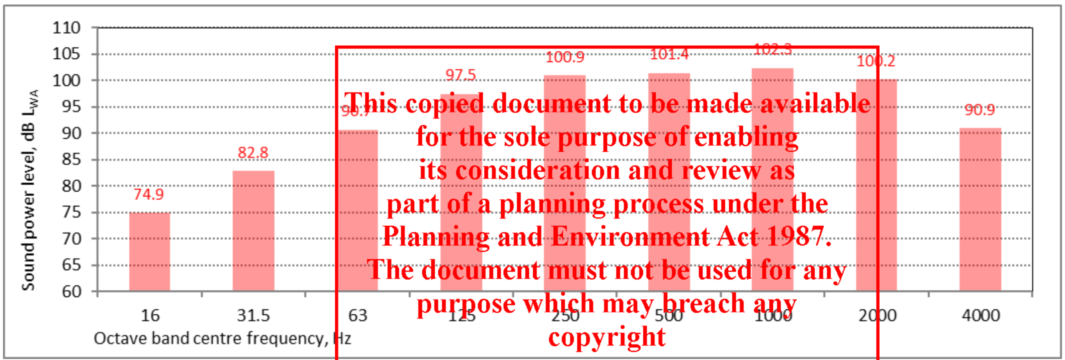
(b) Noise sensitive locations: See Section 5.1 and Appendix D

(c) Wind turbine sound power levels, dB L_{WA} (refer to Section 7.3.1)

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 6 of Section 7.2

(e) Turbine hub height: See Table 6 of Section 7.2

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

(g) Calculation procedure used: ISO 9613-2:1996 prediction algorithm as implemented in SoundPLAN v9.1 (See Section 4.3 and Appendix D)

(h) Meteorological conditions assumed:

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

(i) Air absorption parameters:

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

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

(k) Predicted far-field wind farm sound levels: See Section 7.4 and Appendix G.