MARSHALL DAY Acoustics

HEXHAM WIND FARM
ENVIRONMENTAL NOISE & VIBRATION ASSESSMENT

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Project:	**Hexham Wind Farm** **Environmental Noise & Vibration Assessment**
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GLOSSARY OF ABBREVATIONS

Term	Abbreviation
Battery energy storage system	BESS
Construction noise and vibration management plan	CNVMP
Environment effects statement	EES
Environment Protection Act 2017	EP Act
Environment Protection Authority Victoria	EPA
EPA Publication 1826.5 *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
EPA webpage *Wind Energy Facility Turbine Noise Regulation Guidelines*	EPA web guide
Environment Protection Regulations 2021	EP Regulations
Environment Reference Standard	ERS
General environmental duty	GED
Hexham Wind Farm	The project
Marshall Day Acoustics Pty Ltd	MDA
Mineral Resources (Sustainable Development) Act 1990	MRSD Act
NSW Department of Environment and Conservation	NSW DEC
NSW Roads and Maritime Service	NSW RMS
Hexham Wind Farm Pty Ltd	The proponent
Noise management plan	NMP
Planning and Environment Act 1987	PE Act
Road Management Act 2004	RM Act
Scoping Requirements Hexham Wind Farm Environment Effects Statement	Scoping requirements
Victoria Planning Provisions	VPP
Victorian Department of Transport and Planning	DTP

EXECUTIVE SUMMARY

This report provides an assessment of the potential noise and vibration levels associated with the construction, operation and decommissioning of the Hexham Wind Farm (the project) that is proposed to be developed by Hexham Wind Farm Pty Ltd (the proponent).

The assessment is based on the proposed renewable energy project comprising up to 106 wind turbines, and related infrastructure which includes an on-site terminal station and a battery energy storage system.

Context

Construction of a renewable energy project would generate noise and vibration as a result of activities occurring both on and off the site of the proposed development. On-site works include a range of activities such as construction of access tracks, connection infrastructure, turbine foundations and erection of the wind turbines. Off-site noise generating activities primarily relate to heavy goods vehicle movements to and from the site. Construction of a renewable energy project mostly occurs at relatively large separating distances from noise sensitive receivers and, as proposed for the project, the majority of the work would be limited to normal working hours. The only exceptions are for unavoidable works or low-noise managed-works. Unavoidable works outside of normal working hours are expected to comprise the delivery of oversized turbine components at times selected to minimise traffic disruption associated with intersection closures, and potentially turbine installation activities that are sensitive to weather conditions (e.g. installation of rotors, turbine foundation pour, etc.).

For the above reasons, noise and vibration associated with the construction of a renewable energy project can usually be satisfactorily addressed using considerate equipment selections, working practices and maintenance protocols. The objective of these measures is to minimise the risk of harm as a result of noise and vibration so far as reasonably practicable, in accordance with the general environmental duty (GED) under the *Environment Protection Act 2017* (EP Act). These measures are normally documented in a construction environmental management plan for the project along with broader protocols for noise management (e.g. complaint handling and response protocols) and continual improvement. Decommissioning of a renewable energy project generally involves comparable or less intensive activities, and can therefore be acceptably managed in a similar manner to construction.

In addition to the activities directly associated with construction of a renewable energy project, noise would also be generated by an on-site quarry for construction rock and a number of concrete batching plants that are proposed to be located on the project site for the construction stage of the project. The key noise generating activities associated with the proposed on-site quarry include excavation (mechanical extraction processes), rock crushing, material handling operations and heavy goods vehicle movements. For the batching plants, the key sources of noise emissions are the fixed items of batching plant, pumps, and concrete mixing trucks. The on-site quarry and concrete batching plants would only be used during construction of the project. However, as a conservative approach, the noise of these facilities is assessed against requirements which apply to permanent operations. The main methods of managing noise levels from the on-site quarry and concrete batching plants are based on considerate site selection, restriction of operations to normal working hours, and targeted mitigation measures, where appropriate, such as screening and the selection of lower noise emission plant.

The main environmental noise consideration for a renewable energy project is the operational stage of the project, with the key source of operational noise being the wind turbines. The noise of a modern wind turbine mainly relates to aerodynamic noise that is produced as the blades pass through the air. The mechanical components such as gearboxes within the turbine's nacelle can also be a source of noise, however modern turbines generally include specific design and construction measures to effectively suppress this type of noise. Mechanical noise is therefore not a normal characteristic of a correctly functioning modern wind farm at typical receiver distances.

The proposed on-site terminal station and the battery energy storage system (BESS) are a secondary source of operational noise comprising the power transformers, inverters, and batteries. Other potential sources of operational noise include maintenance activities and overhead power lines/ these are generally considered low risk noise sources for a renewable energy project and are not formally assessed. However, the GED still applies to these types of sources and the associated operational noise would need to comply with the limits which apply under the *Environment Protection Regulations 2021* (EP Regulations).

At the planning stage of a renewable energy project, operational wind turbine noise is addressed using a combination of wind turbine selection and layout design. The objective of these measures is to achieve acceptable noise levels as defined by Victorian legislation and guidelines. In terms of the on-site terminal station and BESS, planning stage noise controls are based on considerate site selection and targeted mitigation measures, where appropriate, such as screening and the selection of lower noise emission plant.

Assessment requirements

The *Scoping Requirements Hexham Wind Farm Environment Effects Statement* (scoping requirements) dated September 2024 set out the matters to be investigated and documented in the environment effects statement (EES), and specify the EES evaluation objectives. In accordance with the scoping requirements and the current legislative framework, the following methods have been used to assess noise and vibration associated with the project:

- Construction noise has been assessed in accordance with EPA Publication 1834.2 *Civil construction, building and demolition guide* (EPA Publication 1834.2) dated September 2025, and having regard to the environmental values for ambient sound defined in the *Environmental Reference Standard* (ERS) established under the EP Act.
- Construction vibration has been assessed in accordance with the NSW Roads and Maritime Service's publication *Construction Noise and Vibration Guideline* dated August 2016 (NSW RMS Construction Noise & Vibration Guideline), in lieu of detailed Victorian guidance.
- Operational wind turbine noise has been assessed in accordance with NZS 6808:2010 *Acoustics – Wind farm noise* (NZS 6808), as required by the Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities* dated September 2023 (Victorian Wind Energy Guidelines) and the EP Regulations.

  The assessment is supplemented by both EPA webpage *Wind Energy Facility Turbine Noise Regulation Guidelines* dated 2 May 2025 and EPA-DTP Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline* dated 20 December 2024, and having regard to the environmental values for ambient sound defined in the ERS.
- Operational noise associated with the on-site terminal station and BESS has been assessed in accordance with the EP Act, the EP Regulations and the EPA Publication 1826.5 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol) and having regard to the environmental values for ambient sound defined in the ERS.

Noise and vibration assessment

The EES evaluation objective for the project with respect to noise and vibration is to manage potential adverse effects for noise sensitive receivers, having regard to construction, operation and decommissioning of the project.

A number of measures are to be used to control the potential adverse effects of noise and vibration at noise sensitive receivers, and address regulatory requirements. With these measures in place, the noise assessment has determined the following:

- Noise generated by construction of the project can be controlled in accordance with relevant Victorian guidelines provided by EPA Publication 1834.2, using a combination of restricted working hours and good practice working measures. Dedicated controls are also warranted to address the noise of off-site construction traffic. The preferred option for the project includes the development of an on-site quarry to limit off-site vehicle movements associated with material sourcing. A restriction on the times when these movements can occur on the surrounding road network has also been recommended.
- The predicted operational noise levels from the on-site quarry and concrete batching plants proposed to operate during the construction phase of the project are below the applicable noise limits determined in accordance with the Noise Protocol.
- The predicted operational wind turbine noise levels are below the noise limits determined in accordance with NZS 6808.
- The predicted operational noise levels from the project's on-site terminal station and BESS are below the noise limits determined in accordance with the Noise Protocol.
- The noise generated by decommissioning of the project can be controlled using similar measures to those implemented for the construction of the project.
- Consideration was also given to the general environmental duty (GED), as required by the EP Act, by evaluating standard forms of engineering control such as selection of equipment with low sound power levels, appropriate site selection, and localised acoustic barriers.

The findings of the noise assessment therefore demonstrate that the project can comply with the requirements of the applicable Victorian legislation and guidelines. As such, the project is expected to achieve the EES evaluation objective.

Mitigation measures

Based on the assessment findings, mitigation measures are recommended for the control of noise and vibration associated with construction and operation of the project. The mitigation measures are summarised as follows.

Mitigation measure	Description
EMM-NV01	Establishes a requirement to prepare a construction noise and vibration management plan, including measures relating to both on-site activities and off-site construction traffic.
EMM-NV02	Establishes noise requirements for the design and operation of the on-site quarry during construction of the project.
EMM-NV03	Establishes noise requirements for the design and operation of all on-site concrete batching plants during construction of the project.
EMM-NV04	Establishes a requirement for a pre-construction assessment of operational noise associated with the project's wind turbines, based on the final wind turbine layout and model selection. Results of the pre-construction assessment would be documented in the NMP prepared under EMM-NV06.
EMM-NV05	Establishes a requirement to conduct early testing of a representative selection of turbines to verify that the noise emissions (sound power levels) of the installed turbines are consistent with the pre-construction noise assessment prepared under EMM-NV04.
EMM-NV06	Establishes a requirement to prepare the noise management plan (NMP) for operational wind turbine noise, as required under the EP Regulations, prior to commencement of operation of the facility.
EMM-NV07	Establishes a requirement for a pre-construction assessment of operational noise associated with the project's on-site terminal station and BESS.
EMM-NV08	Establishes a requirement to prepare a decommissioning noise and vibration management plan, including measures relating to both on-site activities and off-site traffic associated with decommissioning.

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1.0 INTRODUCTION

1.1 Purpose of the report

This report has been prepared to address the environmental noise and vibration assessment requirements of the:

- *Scoping Requirements Hexham Wind Farm Environment Effects Statement* published by Minister for Transport and Planning in September 2024 (scoping requirements)
- Victorian Department of Transport and Planning (DTP) 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).

This report assesses the potential noise and vibration impacts associated with the construction and operation of the Hexham Wind Farm (the project), and identifies mitigation measures to address these impacts together with consideration for the general environmental duty (GED), as required by the EP Act. Specifically, the assessment considers:

- construction noise and vibration from on-site activities including the proposed quarry and batching plants (excluding blasting which is addressed in a separate technical study which is included and considered in the draft quarry work plan)
- construction noise associated with off-site vehicle movements
- operational wind turbine noise
- operational noise from the proposed terminal station and battery energy storage system (BESS).

Decommissioning of a renewable energy project generally involves comparable or less intensive activities, and can therefore be acceptably managed in a similar manner to construction. A separate assessment of decommissioning is therefore not warranted at this stage of the project.

Potential sources of operational noise also include maintenance activities and overhead power lines. While these noise sources are subject to the same obligations as the proposed terminal station and BESS, they are generally considered low risk noise sources for a renewable energy project and are not usually subject to formal assessment at planning stage. These sources are therefore not formally addressed in this study.

The assessment is based on determining whether the noise and vibration impact of the project would be acceptable in planning terms, based on criteria provided by relevant Victorian regulations and guidelines which are intended to provide a balance between protecting the amenity of neighbouring noise sensitive receivers and enabling the development of new infrastructure. It is important to note that, beyond compliance with noise limits, the GED requires the risk of harm be minimised, so far as reasonably practicable.

The assessment considers noise and vibration levels which may be experienced by people at receivers (as detailed in Section 5.1) and natural areas (as defined in the *Environment Reference Standard* and detailed in Section 5.2) around the project. The potential effects of noise from the project on fauna are addressed in separate specialist studies (the Hexham Wind Farm Flora and Fauna Assessment and Hexham Wind Farm Brolga Assessment).

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

General information about the definition of sound and the ways that different sound characteristics are described is also presented in Appendix B.

1.2 Project description

The project involves the establishment of a renewable energy project which would include a wind energy facility (wind farm), an on-site terminal station and a BESS. The project would be mostly located in agricultural land in southwest Victoria, between the townships of Hexham, Caramut and Ellerslie, within the local government area of the Moyne Shire Council.

Permanent infrastructure to be constructed as part of the project would include:

- a wind farm with up to 106 wind turbines, each with a capacity of 6 to 8 MW, tip height of up to 260 m, rotor diameter of up to 190 m and minimum distance of rotor tip above ground level of 40 m
- an on-site terminal station to facilitate connection to the existing Moorabool to Heywood 500 kV transmission line located within the southern part of the project site, owned and operated by Ausnet Services
- a battery energy storage system (BESS) with a nameplate capacity of 200 MW
- an on-site quarry and 7 concrete batching plants
- on-site powerline connections between the wind turbines and the new on-site terminal station
- access roads, including creation or improvement of up to 11 access points from public roads
- up to 5 meteorological monitoring masts within the wind farm site
- a temporary hardstand area
- permanent hardstand areas at each turbine location
- temporary infrastructure including construction compounds and wind turbine component laydown areas
- an operations and maintenance facility to provide office, storage and maintenance facilities.

2.0 SCOPING REQUIREMENTS

This section reproduces the noise related elements of the scoping requirements which specify the Environment Effects Statement (EES) evaluation objectives and set out the matters to be investigated and documented in the EES.

Section 4.4 of the scoping requirements is relevant to amenity and includes the desired outcomes in relation to the potential noise and vibration effects of the project.

The scoping requirements relating to noise and vibration are reproduced in Table 1.

Table 1: Scoping requirements related to noise and vibration

Aspect	Detail	Report reference
Evaluation objective	To minimise and manage adverse air quality and noise and vibration effects on residents and local communities as far as practicable during construction, operation and decommissioning having regard to applicable limits, targets or standards.	-
Key issues	Potential for adverse effects on noise and vibration amenity at sensitive receptors during construction, operation and decommissioning (including for the potential on-site quarry).	-
Existing environment	Characterise the ambient noise environment in adjacent established residential, farming zone, commercial and open space areas and at other sensitive land use locations. Identify sensitive receptors that may be subject to effects to amenity from the project including, but not limited to, all dwellings within 3 km of wind turbines, associated infrastructure and potential on-site quarry.	See Section 6.0
Likely effects	Assess the potential dust, noise and vibration impacts from the potential on-site quarry in accordance with the requirements of EPA Publication 1823.1 *Mining and quarrying: Guide to preventing harm to people and the environment*. Assess the potential effects of the project on noise and vibration amenity at sensitive receptors, including information that addresses	
	• how the noise associated with construction of the wind farm and project infrastructure will be managed in accordance with relevant guidelines, such as EPA Publication 1820.1: *Construction – Guide to preventing harm to people and the environment*, EPA Publication 1834: *Civil Construction, Building and Demolition guide*, EPA Publication 1695 *Assessing and controlling risk: a guide for business* [a], and having regard to the environmental values for ambient sound defined in the *Environment Reference Standard* (ERS) established under the *Environment Protection Act 2017*;	See Section 7.0
	• how the operational wind turbine noise will be managed in accordance with Division 5 of Part 5.3 of the *Environment Protection Regulations 2021* and relevant guidelines, including DELWP *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria* (2021) [b], EPA *Wind Energy Facility Turbine Noise Regulation Guideline* [c] and NZS 6808:2010 *Acoustics – Wind Farm Noise* for the turbines	See Section 9.0

Aspect	Detail	Report reference
	• how operational noise from other relevant project infrastructure such as the on-site terminal station and battery storage facility, and from other potential commercial, industrial and trade premises to be developed as part of the project such as the potential on-site quarry and potential concrete batching plants will be managed in accordance with Division 3 of Part 5.3 of the *Environment Protection Regulations 2021*, EPA Publication 1826.5: *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* as well as relevant guidelines such as EPA *Commerce Industry and Trade Noise Guidelines* and Publication 1996: *Noise guideline - Assessing low frequency noise*	See Section 10.0
	If a quarry is to be developed as part of the project, assess the potential noise and vibration (ground and airborne) effects from the proposed on-site quarry activities on sensitive receptors in accordance with guidelines, including, but not limited to, the Earth Resources *Guidelines for Ground Vibration and Airblast Limits for Blasting in Mines and Quarries*	See Section 8.0
Design and mitigation	Describe and evaluate both potential and proposed design responses and/or other mitigation measures (e.g. staging/scheduling of works) which could minimise noise and vibration during construction, operation and decommissioning.	See Section 11.0
Performance	Describe proposed measures to manage and monitor effects on amenity values and identify likely residual effects, including compliance with standards and proposed trigger levels for initiating contingency measures. Describe contingency measures for responding to unexpected impacts to amenity values resulting from the project during construction, operation and decommissioning.	See Section 11.0

a This guideline was updated in September 2025 and reissued as EPA Publication 1834.2

b This guideline was updated in September 2023 as the Victorian Department of Transport and Planning publication *Planning Guidelines for Development of Wind Energy Facilities*

c At the date of preparation of this report, this webpage is not available as a version controlled formal document. This report is based on the EPA webpage version of this publication, last updated on 2 May 2025

Where documents referenced in the scoping requirements have been superseded, the relevant documents applicable at the time of preparing this report have been used for this assessment. These are discussed in the following section.

3.0 LEGISLATION AND GUIDELINES

This section presents:

- legislation and guidelines for the assessment of environmental noise (sound)
- guidelines for the assessment of vibration (in lieu of legislated quantitative vibration criteria).

3.1 Environmental noise

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, and 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 1834.2 *Civil construction, building and demolition guide* dated September 2025
- EPA Publication 1826.5 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* dated September 2025
- NZS 6808:2010 *Acoustics – Wind farm noise*

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

In addition, related and supplementary guidance that is referenced as part of the environmental noise assessment is also summarised.

3.1.1 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 3.1.2 and 3.1.5); 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).

3.1.2 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 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 EPA Noise Protocol (see Section 3.1.5). 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 6808:2010.

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.[1] The Act compliance note means that demonstrating compliance with the EP Regulations also demonstrates compliance with the GED under the EP Act.

3.1.3 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.

[1] 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.

3.1.4 Planning Guidelines for Development of Wind Energy Facilities

The *Planning Guidelines for Development of Wind Energy Facilities* (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. Guidance is also provided on how NZS 6808 should be considered in the Victorian regulatory framework.

3.1.5 EPA Publication 1834.2

EPA Publication 1834.2 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 1834.2 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 1834.2 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.

3.1.6 EPA Publication 1826.5 (Noise Protocol)

The 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 EPA 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.

3.1.7 NZS 6808

NZS 6808 defines a methodology 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.

3.1.8 Related Victorian guidelines

To support the application and use of the legislation and guidance summarised in the preceding sections, a range of Victorian publications provide additional advice on matters of interpretation and technical assessment requirements. 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 webpage *Wind Energy Facility Turbine Noise Regulation Guidelines* (EPA web guide)[2]
- EPA-DTP Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline* dated 20 December 2024 (Technical Guideline)
- Resources Victoria online publication *Guidelines for Ground Vibration and Airblast Limits for Blasting in Mines and Quarries*[3].

The EPA also provides general online guidelines relating to noise, including:

- commerce, industry and trade noise guidelines[4]
- noise advice for businesses[5]
- unreasonable noise guidelines[6].

Broader relevant industry guidance is also provided in:

- EPA Publication 1695.1 *Assessing and controlling risk for business,* dated March 2019
- EPA Publication 1820.1 *Construction – Guide to preventing harm to people and the environment*, dated July 2021
- EPA Publication 1823.1 *Mining and quarrying: Guide to preventing harm to people and the environment*, dated July 2021
- EPA Publication 1856 *Reasonably practicable,* dated September 2020
- Resources Victoria publication (authorised by the former Department of Jobs, Precincts and Regions) *Preparation of Work Plans and Work Plan Variations - Guidelines for Extractive Industry Projects*, dated December 2020.

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2 At the date of preparation of this report, the EPA web guide is not available as a version controlled formal document. This report is based on the EPA webpage version of this publication, last updated on 2 May 2025.

3 At the date of preparation of this report, this publication is not available as a version controlled formal document. This report is based on the Resources Victoria webpage version of this publication, last updated on 16 April 2024.

4 See EPA commerce, industry and trade noise guidelines through this weblink

5 See EPA noise advice for business through this weblink

6 See EPA unreasonable noise guidelines through this weblink

3.2 Vibration

The EP Act defines noise as both sound and vibration. The provisions of the EP Act with respect to the GED and unreasonable noise therefore apply to both sound and vibration.

While EPA Publication 1834.2 provides general guidance on both noise and vibration, there are no legislated or guideline quantitative criteria for the control of construction vibration levels in Victoria.

In lieu of Victorian quantitative vibration criteria, reference is made to the Transport for NSW publication *Construction Noise and Vibration Guideline (Roads)* published December 2024 (NSW CNVG) for guidance.

The NSW CNVG sets out indicative minimum working distances from sensitive receivers for typical items of vibration intensive plant. The indicative minimum working distances are quoted for effects relating to cosmetic damage and human comfort.

The indicative minimum working distances defined in the NSW CNVG for human comfort are noted to be greater than for the avoidance of cosmetic damage. This reflects the thresholds for human exposure to vibration being lower than accepted thresholds for minor cosmetic damage to lightweight structures.

The indicative minimum working distances detailed in the NSW CNVG are the primary reference for assessing construction vibration related risks at the planning stage. The relevant criteria that would subsequently apply to any potential compliance monitoring are discussed in Appendix C and comprise:

- BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings* (BS 6472-1) for assessing the risks of disturbance of human comfort
- DIN 4150-3:2016-12 *Vibrations in buildings – Part 3: Effects on structures* (DIN 4150-3) for assessing the risk of vibration induced damage of building structures.

4.0 ASSESSMENT METHOD

The scoping requirements' evaluation objective in relation to noise is to manage the potential adverse effects of noise and vibration at noise sensitive receivers in the vicinity of the project.

The assessment method is therefore broadly structured around:

- identifying noise sensitive receivers and ERS natural areas in the vicinity of the project
- reviewing existing noise conditions in the project area and assessing background noise levels at key noise sensitive receivers and ERS natural areas around the project
- predicting noise levels associated with the project, accounting for inherent and proposed risk controls as appropriate
- an assessment of compliance with mandatory noise limits, where applicable
- identification of additional noise mitigation measures where appropriate
- assessing the inherent and residual noise and vibration risks associated with the project.

The methods of assessment are specific to each aspect of the project and are proportionate to the level of risk. In particular, these methods differ on account of varying:

- procedural requirements of Victorian legislation and guidelines for different sources
- levels of information typically available at the planning stage of a project.

Details of the assessment methods for each aspect of the project are discussed subsequently as part of the assessment sections of this report.

The following sections provide a discussion of the methods for establishing existing conditions, predicting noise levels and assessing risk.

4.1 Existing conditions

Background noise level information is used for a range of assessment purposes which include:

- setting construction noise limits where construction activity may need to occur outside of normal working hours, including unavoidable works
- setting operational noise limits for wind turbines and related infrastructure (e.g. terminal station, BESS) of a renewable energy project.
- considering the existing noise environment in ERS natural areas.

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 related infrastructure.

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 in accordance with NZS 6808 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 farm noise predictions to identify all noise sensitive receiver locations where predicted noise levels are higher than 35 dB L_{A90}
- identification of selected noise sensitive receivers where background noise monitoring should be undertaken prior to development of the wind farm, if required.

If monitoring is warranted, the surveys involve measurements of background noise levels at receiver locations 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 of the relationship between the background noise levels and the site wind speeds at the proposed hub height of the turbines. This trend defines the value of the background noise for the different wind speeds in which the 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.

4.2 Noise prediction methods

4.2.1 Construction noise

Predicted noise levels have been calculated in general accordance with the method detailed in AS 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* (AS 2436). This method enables the calculation of sound propagation over hard or soft ground, but does not provide the ability to calculate predicted noise levels for mixed ground cover with varied soil conditions. The standard also notes that caution must be applied when considering predicted noise levels at distances beyond 100 m. For these reasons, predicted noise levels have been determined as the arithmetic average of the hard and soft ground prediction methods. This approach is broadly consistent with the equivalent prediction procedure in BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise* (BS 5228-1) (document referenced in AS 2436) and represents a cautious account of ground conditions (i.e. results in slightly higher predicted noise levels than a strict application of the standard).

Key elements of the noise prediction method are provided in Table 46 of Appendix E.

4.2.2 Operational noise

Operational noise levels from the project (wind turbines, on-site terminal station, BESS, on-site quarry and concrete batching plants) are predicted using:

- noise emission data for the relevant equipment (e.g. wind turbines, transformers, inverters, excavating equipment)
- 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 9613-2:1996 (see further discussion in Appendix E2). 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 noise levels from both wind turbines and other operational noise sources. For example, for both types of sources, equivalent ground and atmospheric conditions are used for the calculations. However, when applied to wind turbine noise, additional and specific input choices apply, based on 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).

Key elements of the noise prediction method together with discussion of the method and the calculation choices are provided in Table 45 of Appendix E.

4.3 Cumulative noise

The noise limits established by Victorian noise legislation and guidelines apply to the total noise levels of all assessable sources and premises. For example, operational wind turbine noise limits apply to the combined wind turbine noise of the project and any neighbouring wind farm developments. Similarly, the noise limits for the on-site quarry, batching plants, terminal station, and BESS apply to the combined noise of commercial and industrial trade premises in the area.

The assessment in this study therefore addresses:

- elements of the project which could operate at the same time
- whether existing or approved developments in the area around the project could contribute to total wind turbine or industry noise levels at noise sensitive receivers.

4.4 Risk assessment

A risk-based assessment is used to evaluate noise and vibration impacts associated with construction and operation of the project. Given that noise and vibration is an inevitable consequence of the construction and operation of a major infrastructure project, it is the risk of harm to human health or the environment as a result of noise, as defined by the EP Act, which is assessed in this study. Risks are assessed by accounting for their consequence (accounting for noise level, character and duration) and likelihood. The objective of the risk assessment is to determine the appropriate risk controls.

There are multiple factors which influence both the consequence and likelihood of noise and vibration related risks. These include:

- the type of noise or vibration source being assessed and its characteristics (e.g. a continuous or varying noise source and its frequency characteristics)
- the nature of the noise or vibration source (e.g. an activity that can be readily modified or relocated versus an essential activity with limited opportunity to modify, relocate or reschedule)
- the environment in which the noise or vibration is produced (e.g. the context and the background level of noise or vibration)
- the time, duration and regularity of the noise or vibration
- environmental factors which may change the background noise environment and/or the noise level of the source in question (e.g. wind conditions)
- the type and number of sensitive locations potentially affected by the noise or vibration
- the type of assessment being used to evaluate the risks (e.g. prediction or measurement-based assessments), and the level of information available for the assessment
- the assessment framework for each noise and vibration source, and whether acceptable levels of noise and vibration are clearly defined (e.g. legislation which defines prescriptive compliance requirements in quantitative terms or management-based guidance)
- the options available to mitigate or manage the noise or vibration source.

EPA Publication 1695.1 *Assessing and controlling risk: A guide for business* has been adopted to conduct an assessment of risk consequence and likelihood for the project. EPA Publication 1695.1 provides an example framework as depicted in Figure 1 and Figure 2.

Figure 1: Example risk matrix reproduced from EPA Publication 1695.1

Consequence		Rare	Unlikely	Possible	Likely	Certain
Permanent or long-term serious environmental harm / life threatening or long-term harm to health and wellbeing.	Severe	Medium	High	High	Extreme	Extreme
Serious environment harm / high-level harm to health and wellbeing.	Major	Medium	Medium	High	High	Extreme
Medium level of harm to health and wellbeing or the environment over an extended period of time.	Moderate	Low	Medium	Medium	High	High
Low environmental impact / low potential for health and wellbeing impacts.	Minor	Low	Low	Medium	Medium	High
No or minimal environmental impact, or no health and wellbeing impacts.	Low	Low	Low	Low	Medium	Medium
	Likelihood	Could happen but probably never will	Not likely to happen in normal circumst-ances	May happen at some time	Expected to happen at some time	Expected to happen regularly under normal circumst-ances

Figure 2: Description of risk ratings reproduced from EPA Publication 1695.1

Risk level	Description
Extreme	Totally unacceptable level of risk. Stop work and/or take action immediately.
High	Unacceptable level of risk. Controls must be put in place to reduce to lower levels.
Medium	Can be acceptable if controls are in place. Attempt to reduce to *low*.
Low	Acceptable level or risk. Attempt to eliminate risk but higher risk levels take priority.

Quantitative assessments of noise and vibration, such as measurement and prediction-based studies, inform the assessment of both consequence and likelihood. For example, where there are clearly defined noise limits, low and minor consequence ratings are generally assigned to a compliant noise level. A moderate or higher consequence is generally only applicable to a non-compliant noise level, although a moderate rating may be applicable if there are multiple contributing factors which individually increase the consequence.

Defining quantitative thresholds to further separate consequence levels according to the wide range of factors outlined earlier is complex and subject to considerable uncertainty. Given these uncertainties, defining quantitative boundaries between each consequence level would involve the assignment of arbitrary thresholds which could be misleading and imply a greater level of assessment accuracy than is afforded by the current state of knowledge. To enable consequence levels to be practically assigned, it is therefore necessary for an element of the consequence ratings to be informed by qualitative assessment, accounting for the range of relevant factors.

A similar level of qualitative assessment is also required to determine the likelihood of the risk, accounting for the range of relevant factors.

5.0 STUDY AREA

The study area for the noise and vibration assessment extends to 5 km from the proposed locations of the wind turbines and related temporary and project infrastructure. This is a nominal distance selected to address the minimum 3 km distance referenced in the scoping requirements, and enable a complete account of construction, operational and potential cumulative noise considerations associated with the project.

The study area is predominantly rural and includes the townships of Caramut to the north-west, Hexham to the north-east and Ellerslie to the south-east. To assess the potential noise of off-site traffic movements during construction, the assessment also extends to the township of Mortlake to the east of the project. The land in the study area is mainly designated as Farming Zone (see zoning map in Appendix I).

The types of locations within the study area where noise and vibration is 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 location where an assessment of noise is required, other than natural areas (see subsequent discussion in Section 5.2). 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 and related infrastructure. The assessment also considers potential noise levels at receivers located along local traffic routes which may be used by construction traffic associated with the project.

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.*

Based on the above, and accounting for the requirements of the EP Regulations, wind turbine noise limits only apply to receivers located outside the project boundary. This includes stakeholder receivers that are subject to existing or proposed noise agreements, depending on the date and content of the agreement.).

A total of 188 receivers were identified by the proponent within 5 km of the proposed wind turbines and related temporary and project infrastructure, comprising:

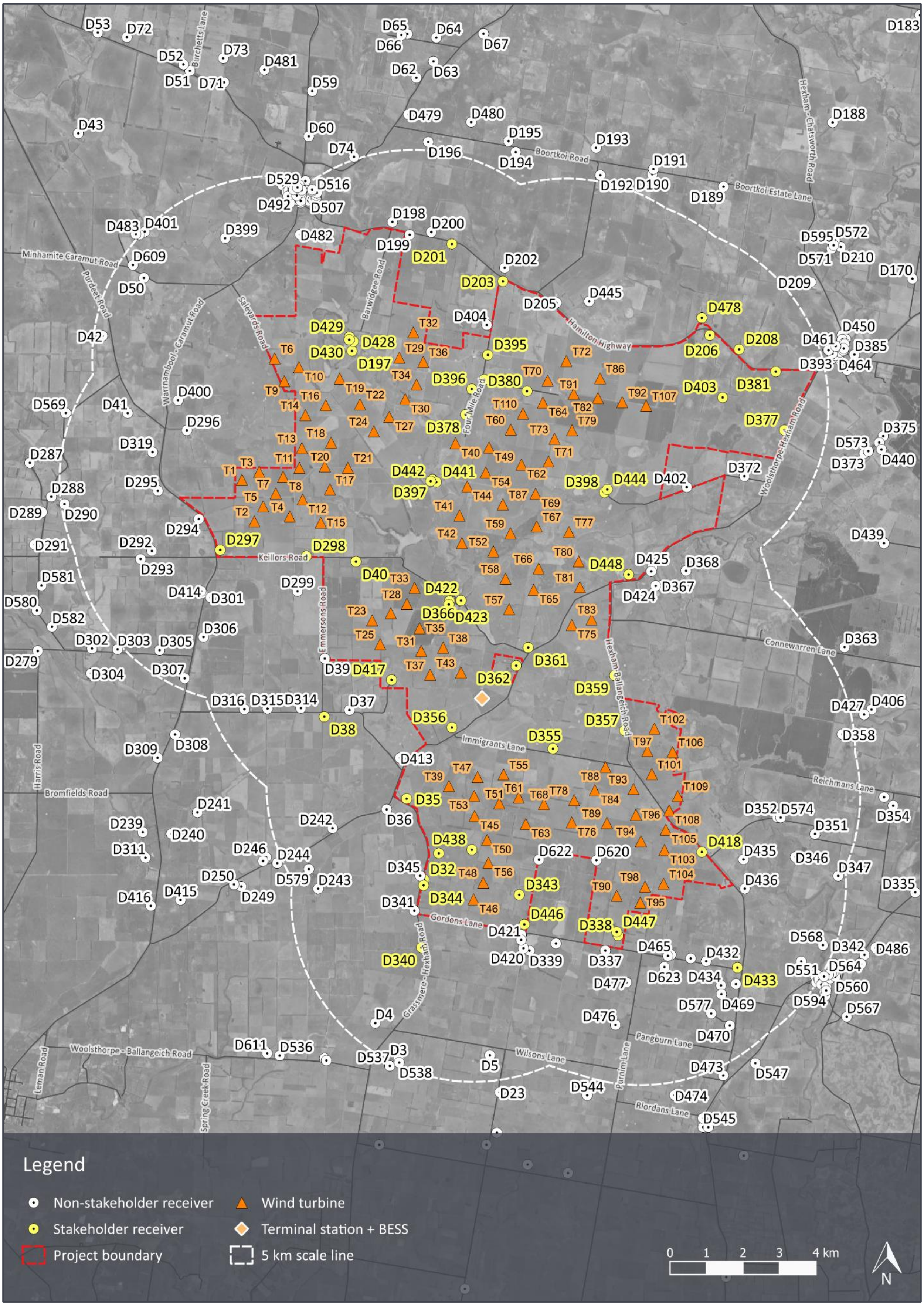
- 139 non-stakeholder receivers on properties that are not associated with the project
- 49 residential dwellings on properties that are associated with the wind farm (referred to as *stakeholder receivers* herein) including:
  - 42 receivers within the project boundary
  - 7 receivers outside the project boundary where a noise agreement is proposed between the landowner and the proponent.

In contrast to the assessment of wind turbine noise in accordance with NZS 6808, the assessments of construction noise and vibration levels operational noise levels do not differentiate between stakeholder and non-stakeholder receivers.

The coordinates of all assessed receivers within 5 km of the proposed turbines and related temporary and project infrastructure are provided in Appendix F.

A site layout plan illustrating the turbine layout, on-site terminal station, BESS and receivers is provided in Figure 3.

Figure 3: Site map of proposed wind turbines, on-site terminal station, BESS 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.*

Considering the above and information available in Parks and Conservation Reserves state mapping (PARKRES), the proponent identified the following natural areas within 15 km of the project: [7]

- Hexham School Historic Reserve, approximately 4.4 km to the northeast of the project
- Mortlake Common Flora Reserve, approximately 10.2 km to the east of the project
- Cobra Killuc Wildlife Reserve, approximately 10.6 km to the east of the project
- Hopkins River, Framlingham Streamside Reserve, approximately 12 km to the south of the project.

Although not listed in PARKRES, Lake Connewarren, located approximately 4.7 km to the east of the project, is included in this assessment for completeness.

The natural areas around the project are presented in Figure 4 in the following section, along with other projects in and around the study area.

5.3 Other projects

The approved and operating projects, identified within 15 km of the project, that may be relevant for assessing cumulative impacts, are the: [8]

- operational Mortlake Power Station is also located approximately 4 km to the east
- operational Hawkesdale Wind Farm, located approximately 14.1 km to the southwest
- operational Salt Creek Wind Farm, located approximately 14.7 km to the northeast
- approved Mortlake Energy Hub, adjacent to the east of the Mortlake Power Station, comprising a 360 MW solar energy facility and a 300 MW BESS[9]
- approved Mortlake Power Station BESS, on the eastern side of the Mortlake Power Station site, with a capacity of 300 MW/650 MWh.[10]

Other projects in the vicinity of the project that are noted for reference are the:

- proposed Mt Fyans Wind Farm, located approximately 10.5 km to the east
- operational Mortlake South Wind Farm, located just beyond 15 km to the southeast
- approved Woolsthorpe Wind Farm, located just beyond 15 km to the southwest

These other projects are presented in Figure 4 in the context of the project and natural areas detailed in the preceding section.

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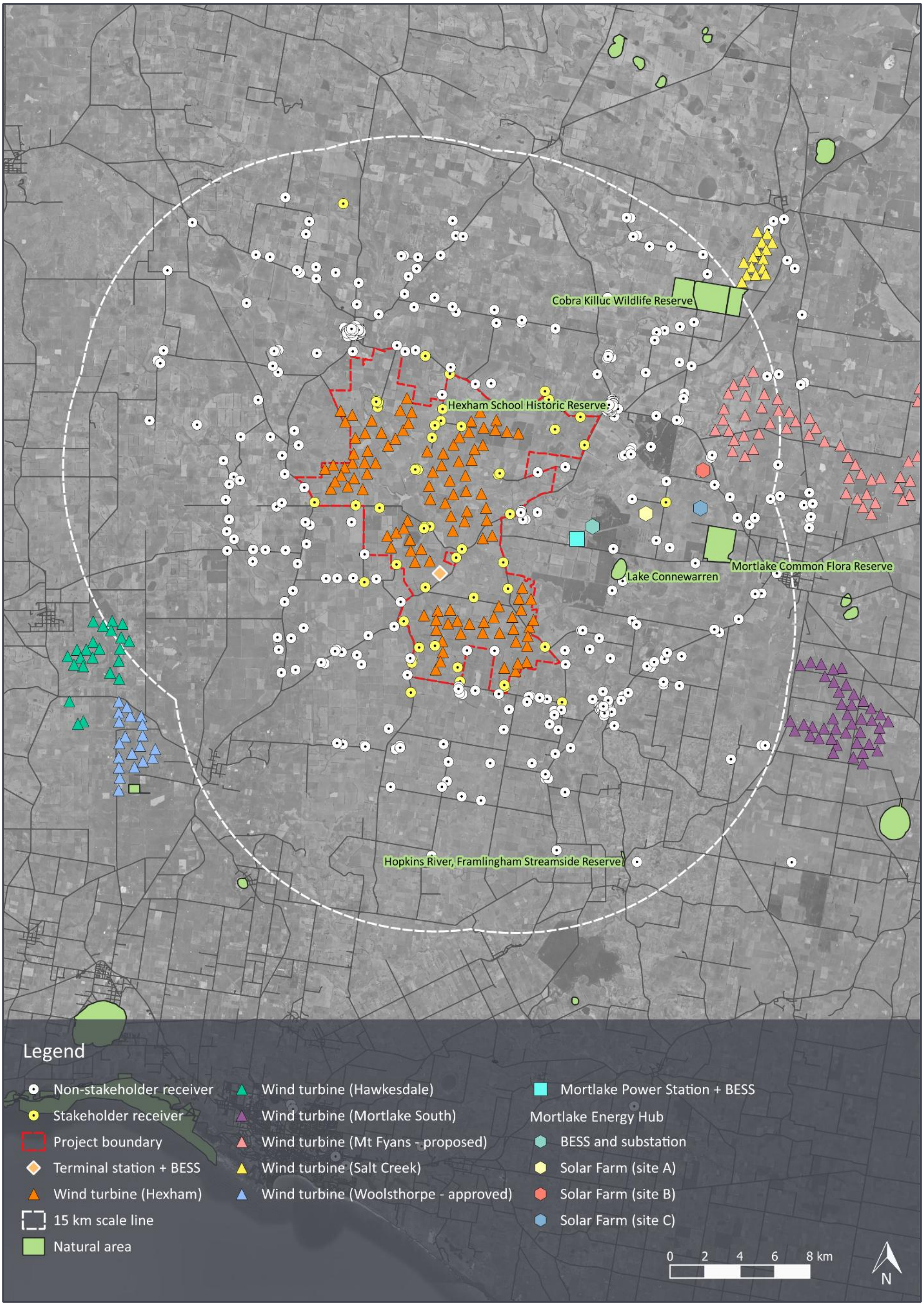
[7] Data Vic webpage

[8] Based on aerial imagery and the Department of Transport and Planning *Renewable Energy Projects Victoria* webpage

[9] Based on publicly available noise assessment report (weblink)

[10] Origin Energy website weblink

Figure 4: Project area, surrounding identified natural areas and other projects



6.0 EXISTING NOISE ENVIRONMENT

The scoping requirements requires the following:

> *Characterise the ambient noise environment in adjacent established residential, farming zone, commercial and open space areas and at other sensitive land use locations.*

As there are no sensitive commercial premises identified within the study area, characterising the existing noise environment at commercial areas is not relevant to this assessment.

This section presents:

- the results of background noise monitoring conducted in accordance with NZS 6808 at receivers in the vicinity of the project
- a discussion of the ambient sound environment at natural areas in the vicinity of the project.

6.1 Receivers

Background noise monitoring was conducted at a selection of receivers in the vicinity of the project. The results inform a range of aspects of the assessment, but particularly the wind turbine noise component of the assessment.

NZS 6808 provides detailed guidance for conducting background noise monitoring, including identification of the locations where monitoring is warranted, based on the predicted noise levels associated with the wind farm. The noise modelling results that are subsequently presented in Section 9.4 demonstrate that predicted noise levels are between 35 and 40 dB L_{A90} for 2 non-stakeholder receivers (D620 and D622). In accordance with NZS 6808, background noise monitoring should therefore be undertaken at the identified receivers.

It is noted that consent to undertake background noise monitoring was not granted at receiver D620. Considering the location of this receiver, suitable alternative receivers were not available.

For community engagement purposes, the proponent also requested that additional, voluntary, noise monitoring be undertaken at 6 other non-stakeholder receivers where predicted noise levels are below 35 dB L_{A90} and one stakeholder receiver (D362). However, consent to undertake background noise monitoring was not granted at one of these additional non-stakeholder receivers. The additional monitoring locations were identified at distributed locations around the wind farm to represent noise levels in different directions from the project.

Based on the above, background noise monitoring was carried out from 5 June to 20 July 2023 at 7 receivers, as presented in Figure 5 together with the 35 dB L_{A90} noise contour. Analysis and results of the survey are detailed in the Background Noise Report.[11]

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[11] MDA Report Rp 003 R01 20190086 *Hexham Wind Farm – Background noise monitoring*, dated 8 October 2025

Figure 5: Background noise monitoring locations

Consistent with common practice for wind farm noise assessments in Victoria, the background noise levels have been separately analysed for the all-time (day and night combined) and night period. The tabulated data presented in Table 2 and Table 3 summarise the background noise levels determined in accordance with NZS 6808 for the all-time and night-time periods, respectively.

The data in the following tables is provided for the valid range of 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 location in the appendices of the Background Noise Report.

Table 2: Background noise levels at all monitoring locations, dB L_{A90} – all-time period

Receiver	Hub height wind speed, m/s [a]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D39	- [b]	28.4	28.4	28.9	29.7	30.9	32.3	34.0	35.9	37.9	40.0	42.2	44.4
D205	- [b]	- [b]	33.3	33.4	33.8	34.5	35.4	36.5	37.7	39.1	40.5	42.0	43.6
D294	27.9	28.2	28.8	29.6	30.7	32.0	33.5	35.1	36.8	38.5	40.3	42.0	43.7
D362 (S)	- [b]	29.5	29.7	30.2	31.1	32.1	33.5	35.0	36.6	38.4	40.3	42.3	44.3
D367	- [b]	29.6	29.8	30.2	30.8	31.6	32.6	33.8	35.2	36.6	38.2	39.8	41.5
D413	- [b]	28.0	28.1	28.4	29.1	30.1	31.3	32.8	34.4	36.1	37.9	39.8	41.7
D622	27.5	27.8	28.1	28.6	29.2	29.9	30.6	31.5	32.5	33.6	34.8	36.0	37.4

(S) Stakeholder receiver

a DRY02 met mast – 149 m above ground level at 642090 E, 5779958 N (MGA2020 zone 54)

b Regression lines indicate an increase of background noise levels as hub height wind speed decreases. As this feature is deemed to be an artifact of the regression analysis process due to the large scatter of points at low hub height wind speeds, the regression lines have been truncated at their lowest values.

Table 3: Background noise levels at all monitoring locations, dB L_{A90} – Night-time period

Receiver	Hub height wind speed, m/s [a]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D39	- [b]	- [b]	22.8	22.8	23.6	24.9	26.8	29.0	31.5	34.3	37.2	40.0	42.8
D205	- [b]	- [b]	26.9	26.9	27.4	28.3	29.6	31.2	33.0	35.1	37.2	39.4	41.6
D294	21.9	21.9	22.4	23.4	24.8	26.5	28.5	30.6	32.9	35.3	37.7	40.1	42.3
D362 (S)	- [b]	- [b]	23.9	24.2	25.0	26.4	28.1	30.2	32.5	35.0	37.6	40.3	42.9
D367	- [b]	- [b]	- [b]	24.5	24.7	25.4	26.6	28.1	29.9	32.0	34.3	36.7	39.2
D413	- [b]	- [b]	- [b]	23.4	23.6	24.5	25.9	27.8	30.0	32.4	35.0	37.7	40.4
D622	- [b]	- [b]	24.1	24.2	24.6	25.3	26.2	27.4	28.9	30.5	32.2	34.1	36.0

(S) Stakeholder receiver

a DRY02 met mast – 149 m above ground level at 642090 E, 5779958 N (MGA2020 zone 54)

b Regression lines indicate an increase of background noise levels as hub height wind speed decreases. As this feature is deemed to be an artifact of the regression analysis process due to the large scatter of points at low hub height wind speeds, the regression lines have been truncated at their lowest values.

The values presented in the above tables would need to be updated if the final hub height is different from 149 m.

6.2 Natural areas

The natural areas identified in Section 5.2 encompass a broad range of ambient sound environments. The map in Figure 4 of Section 5.2 provides an overview to illustrate the project site and the natural areas identified in the vicinity of the project.

The sound environment within the natural areas in the vicinity of the project would be characterised by a varying mix of natural sounds and intermittent anthropogenic noise sources. For example:

- at the Hexham School Historic Reserve, to the northeast of the project, the sound environment would include intermittent road traffic movements on the Hamilton Highway and Woolsthorpe-Hexham Road, anthropogenic activities within the Hexham township and agricultural activity such as ongoing forestry operations.
- at the Mortlake Common Flora Reserve, to the east of the project, the sound environment would include intermittent road traffic movements on the Hamilton Highway, anthropogenic activities within the Hexham township and nearby agricultural activity such as ongoing forestry operations.
- at the Cobra Killuc Wildlife Reserve, to the northeast of the project, the sound environment would include intermittent road traffic movements on the Mortlake-Ararat Road, the adjacent Salt Creek Wind Farm and nearby agricultural activity.
- at the Hopkins River, Framlingham Streamside Reserve, to the south of the project, the sound environment would include intermittent road traffic movements on the Ellerslie-Panmure Road and Mortlake-Framlingham Road and nearby agricultural activity.
- at Lake Connewarren, to the east of the project, the sound environment would include intermittent distant road traffic movements on the Hopkins Highway and Woolsthorpe-Hexham Road, Mortlake Power Station and agricultural activity such as ongoing forestry operations.

As a result of these factors, and the extent of the natural areas, background noise levels are likely to vary significantly. At locations in the vicinity of townships, the background noise levels would be elevated by the effect of road traffic noise and anthropogenic noise. At other locations where wind disturbance of vegetation is a key influence, the background noise would vary significantly according to factors such as ground elevation (in turn affecting exposure to the wind) and the type and density of vegetation in the surrounding area.

Background noise monitoring in the areas around the project were primarily used to quantify noise levels at locations where the data is used to establish quantitative noise criteria. However, the results of the noise monitoring presented in presented in Section 6.0 generally demonstrate low background noise levels across the wind speed range. For example, even at the wind speeds comparable to the speed when the wind turbines would be approaching their maximum noise emissions, background noise levels are generally comparable to or lower than 35 dB L_{A90}.

7.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT – CONSTRUCTION ACTIVITY

This section presents an assessment of noise and vibration from the majority of the proposed construction activities. The exceptions are the proposed on-site quarry and concrete batching plants which are assessed separately in Section 8.0.

A site layout plan illustrating the location of the proposed construction activities and receivers is provided in Figure 6.

7.1 Assessment requirements

The requirements of the EP Act are applicable to noise and vibration associated with construction activities. The following obligations therefore apply under the EP Act:

- Construction activities must not cause unreasonable noise according to the listed factors set out in the EP Act.
- The risk of harm from construction noise and vibration must be minimised so far as reasonably practicable, in accordance with the GED under the EP Act.

EPA Publication 1834.2 provides guidance relevant to meeting the obligations of the EP Act. However, unlike the operational aspects of the project, there are no defined noise levels at which construction noise is prescribed to be unreasonable, and the EP Regulations do not set mandatory assessment requirements. Specifically, there are no prescriptive regulatory requirements concerning the level of noise and vibration generated by construction activities.

In the absence of direct regulation relating to construction noise levels, the ERS objectives and indicators are relevant and provide a reference for gauging the potential risk of construction related noise and vibration.

Specific details of the assessment guidelines applicable to noise and vibration associated with construction activities are detailed in Sections C7 to C9 of Appendix C.

7.2 Construction hours

The majority of the construction works associated with the project are proposed to be restricted to normal working hours as defined by EPA Publication 1834.2:

- Monday to Friday: 0700 to 1800 hrs
- Saturday: 0700 to 1300 hrs

In accordance with EPA Publication 1834.2, construction activities that are justified as low-noise impact, managed impact or unavoidable works may occur outside normal working hours.

Unavoidable works outside of normal hours are expected to comprise the delivery of oversized turbine components (turbine blades) at times selected to minimise traffic disturbance on surrounding roads, foundation concrete pours during hot days, and may potentially include turbine installation activities that are sensitive to weather conditions (e.g. installation of rotors). No other unavoidable works outside of normal hours are anticipated at this stage in the project.

Any proposed low-noise impact, managed impact or unavoidable works that may occur outside normal working hours would need to be documented in a construction noise and vibration management plan (CNVMP), along with a protocol for the justification, approval and management of the works.

In the event of any other low-noise impact, managed impact or unavoidable works being identified during the detailed construction planning for the project or during construction, these would need to be assessed in accordance with the protocol detailed in the CNVMP.

Figure 6: Site map of proposed construction activities and receivers

7.3 Construction noise sources

A variety of construction equipment would be used for the project.

Sound power levels for the proposed construction equipment have been determined based on noise level data from previous projects of a similar nature together with data sources including AS 2436 and BS 5228.

Table 4 summarises the noise emissions used to represent key items of plant associated with construction.

Table 4: Construction noise sources sound power data, dB L_{WA}

Noise source	Sound power level
Bulldozer	108
Concrete pump	108
Concrete truck	108
Crane (1,200 t)	115
Crane (200 t)	105
Crane (500 t)	110
Delivery truck	107
Dump truck	117
Excavator	107
Generator	99
Grader	110
Horizontal directional drill	110
Vibratory roller	108

Overall aggregated total sound power levels for key construction tasks have been determined on the basis of an indicative schedule of equipment associated with each task. The actual equipment choices and equipment numbers for each task are not presently defined in detail. The schedule of equipment listed here therefore does not represent a final or definitive list of plant and has been adopted in this assessment solely for the purpose of a risk assessment of construction noise levels.

The overall total aggregated sound power levels for each of the key construction tasks are detailed in Table 5, and assume that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period.

Table 5: Overall sound power levels of key construction tasks, dB L_{WA}

Construction task	Plant/Equipment	Approximate overall sound power level
Access road and tracks construction	1 x Bulldozer, 7 x Delivery truck, 2 x Dump truck, 2 x Excavator, 1 x Grader	120
BESS Terminal station	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (500 t), 1 x Delivery truck, 1 x Excavator, 1 x Generator, 1 x Vibratory roller	115
Cable trench digging	1 x Bulldozer, 1 x Dump truck, 1 x Excavator	120
Horizontal directional drilling	1 x Delivery truck, 1 x Generator, 1 x Horizontal drilling	110
Permanent met mast	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (500 t), 1 x Excavator	115
Powerline pole	1 x Bulldozer, 1 x Concrete truck, 1 x Crane (200 t), 1 x Excavator	115
Powerline stringing	2 x Crane (200 t), 1 x Delivery truck, 1 x Excavator, 1 x Generator	115
Site compound Site O&M and carpark Staging areas Temporary construction site office Wind turbine hardstands	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery truck, 1 x Excavator, 1 x Generator, 1 x Vibratory roller	115
Turbine assembly	1 x Crane (1,200 t), 2 x Crane (200 t), 2 x Crane (500 t), 1 x Generator	120
Turbine foundations	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery truck, 2 x Excavator, 1 x Generator	115

Horizontal directional drilling may be required for cable crossings at creeks, roads and wetlands, but the location of these activities is not yet confirmed.

Construction activities would also include operation of one on-site quarry and up to 7 concrete batching plants.

Blasting is proposed for the quarry aggregate extraction processing and may also be required as part of construction of wind turbine foundations. A blasting assessment is not included in this assessment as it has been addressed in a separate technical study which is included and considered in the draft quarry work plan.

An extraction period of approximately 2 years is expected for the on-site quarry for construction activities to provide material for road sub-base and base/pavement.

The concrete batching plants may also be required to operate throughout the estimated 2-year construction period. As the project is proposed to be constructed in one stage, it is assumed that all 7 proposed concrete batching plants may be operating simultaneously.

As a result of the projected duration of operation of the on-site quarry and batching plants, these activities have been assessed against the noise limits determined in accordance with the Noise Protocol (refer to Section 8.0).

7.4 Predicted construction noise levels – on-site activities

7.4.1 Receivers

Noise levels associated with each of the main construction tasks have been predicted at the nearest receivers to provide an indication of the upper range of noise levels, as detailed in Section 4.2.1.

Given that the precise equipment selections and methods of working would be determined during the development of a construction plan, and that the noise associated with construction plant and activity varies significantly, the predicted noise levels are provided in the following sections as an indicative range of levels which may occur in practice.

The predicted noise levels for each of the main construction tasks are presented in Table 6 and Table 7 for non-stakeholder receivers and stakeholder receivers, respectively.

Table 6: Indicative range of construction noise predictions – Non-stakeholder receivers

Construction task	Nearest receiver	Distance to nearest receiver, m	Predicted level range, dB L_{Aeq}
Access road and tracks construction	D482	322	55-60
BESS Terminal station	D413	2,584	30-35
Cable trench digging	D620	788	45-50
Permanent met mast	D205	909	40-45
Powerline pole	D299	728	45-50
Powerline stringing	D299	727	40-45
Site compound Site O&M and carpark Staging areas Temporary construction site office Wind turbine hardstands	D482	379	50-55
Turbine assembly	D622	1,041	45-50
Turbine foundations	D622	1,041	40-45

Table 7: Indicative range of construction noise predictions, dB L_{Aeq} – Stakeholder receivers

Construction task	Nearest receiver	Distance to nearest receiver, m	Predicted level range, dB L_{Aeq}
Access road and tracks construction	D418 (S)	142	65-70
BESS Terminal station	D356 (S)	937	40-45
Cable trench digging	D380 (S)	379	55-60
Permanent met mast	D418 (S)	667	45-50
Powerline pole	D355 (S)	401	50-55
Powerline stringing	D355 (S)	400	45-50
Site compound Site O&M and carpark Staging areas Temporary construction site office Wind turbine hardstands	D418 (S)	233	55-60
Turbine assembly	D438 (S)	494	50-55
Turbine foundations	D438 (S)	494	45-50

The predicted noise levels presented above are typical of the range expected for the construction of a wind farm. The highest predicted noise levels are noted to occur during the construction of access roads near a non-stakeholder receiver, followed by cable trench digging. The increased noise levels from these activities occur as a result of the work occurring at reduced separating distances when these activities are closest to receivers. However, the works associated with these construction activities progress relatively quickly and therefore these levels would only be expected to be reached for a short period of time (typically significantly less than three to four weeks for the construction of access roads and less than one week for cable trench digging).

EPA Publication 1834.2 construction noise guidance does not apply receiver noise limits during normal working hours. However, the magnitude of the predicted noise levels is sufficient to warrant the works being restricted to normal working hours. Further, the predicted levels, combined with the scale of the project, are sufficient to warrant the implementation of EPA Publication 1834.2 requirements with respect to both noise emissions and managerial controls.

Further, the predicted noise levels are above the ERS day period objective of 40 dB $L_{Aeq,16hr}$ which is relevant to the areas around the project (see Table 38 of Appendix C3). While the ERS objective is not a design requirement or assessment criterion, and is a very stringent reference for considering temporary noise sources, it provides a further indication of the potential risk of construction noise. This comparison supports the need for all reasonably practicable measures to be implemented to minimise the risk of harm from noise, in accordance with the GED under the EP Act.

In terms of potential out of hours work, and consistent with EPA Publication 1834.2, this would need to be limited to low-impact noise works, managed impact works and unavoidable works.

Prior to construction of the project, all reasonably practicable measures that would be implemented to minimise the risk of harm from construction noise and vibration should be documented in the CNVMP. Given that brief periods of high levels are predicted from some activities, the plan should include provisions to notify receivers of the timing of the nearest construction activities.

7.4.2 Natural areas

Construction activities represent a temporary source of undesirable noise in sections of the natural areas around the project.

The overall construction period for the project is approximately 2 years, from enabling works through to commissioning. Within this period, the location of the works would be constantly varying as the work front for each construction stage progress through the project area. As a result, at a given location within the neighbouring natural areas, construction noise would only be experienced for a portion of the overall construction period. As the construction activities move further away from a given location within the natural area, the intermittent noise of construction would progressively reduce and the noise would be akin to that of distant/intermittent agricultural activity in the surrounding area.

In terms of the extent of areas affected, the likelihood of very low background noise levels at distant and sheltered parts of the natural areas means there is the potential for construction activities to be audible over distances of up to 3 to 5 km from the work sites.

As detailed in Section 5.2, the nearest natural areas, being Hexham School Historic Reserve and Lake Connewarren, are both approximately 4.5 km from the project. All other identified natural areas are located more than 10 km away from the project.

The actual distance at which construction activities could be heard in practice would depend on a range of factors, particularly atmospheric conditions and background sound levels. This is particularly relevant for natural areas near major roads and townships where background noise levels would be elevated and construction activity would only likely be audible when it is occurring at the nearest sections of the project.

Construction noise levels are estimated up to 30-35 dB L_{Aeq} at both the Hexham School Historic Reserve and Lake Connewarren as a result of access track construction and cable trench digging (activities which only occur briefly near a sensitive location as construction progresses). For most construction activities, the predicted construction noise levels at identified natural areas are less than 35 dB L_{Aeq}.

It is important to note that these represent worst case predicted noise levels for the nearest work site to each location, all equipment associated with the activity operating continuously, and for conditions which favour sound propagation. Actual noise levels from a given work site would be lower in practice, and would be significantly lower as the construction work front moves to other sections of the project.

The predicted noise levels are therefore low for temporary sources of noise and would be comparable to the range of noise levels that would occur when occasional farming activities are occurring in surrounding areas. However, while the predicted noise levels are low, the noise of construction activity is distinct from that of the natural sound environment, in terms of both the frequency and temporal characteristics of the noise. Construction activity and equipment that are characterised by tonal or impulsive sources would be most prominent and are likely to represent the greatest source of impact on natural soundscapes. Construction activity would therefore impact the value of the soundscape in these natural areas when the works are occurring.

Based on the above, while construction noise impacts to the environmental value would be temporary, the effects of construction noise on *human tranquillity and enjoyment outdoors* should be accounted for in the preparation and implementation of the CNVMP for the project. The key measures for addressing the noise of construction are as follows:

- Selection of low noise emission plant for construction activity throughout the project (i.e. wider adoption of the noise mitigation and management measures which would typically be implemented when working near residential locations)
- Selection of construction equipment to minimise any distinctive undesirable characteristics which could be more intrusive over wider areas, such as tonal reversing signals and low frequency noise emissions
- Maintenance of site equipment and infrastructure to minimise noise emissions, particularly with respect to site access tracks where surface deterioration can lead to excess impact noise from the carriages of heavy vehicles
- Planning for the most efficient way to complete the works and minimise the duration of the noise
- Restriction of construction activities to normal working hours wherever practical do so.

Adoption of these measures would enable the extent of natural areas affected by construction activity, and the duration the areas are affected for, to be practicably minimised.

7.5 Predicted construction noise levels – off-site traffic

Construction of the project would generate traffic on the surrounding road network comprising:

- car movements associated with construction personnel
- heavy vehicle movements associated with the transportation of construction plant, construction materials and components of the proposed turbines and related infrastructure.

A significant component of the potential traffic movements relates to the sourcing of aggregate for construction. The project includes a proposed on-site quarry which would enable aggregate to be sourced from within the site boundary, thereby reducing traffic on the surrounding road network. While this is the preferred option for the project, the on-site quarry is subject to a separate approvals process. The Traffic Assessment for the project has therefore considered the potential impact of 2 options:[12]

- Scenario 1: 100% of all aggregate for the construction of internal tracks and hardstand areas sourced from the on-site quarry (on-site material sourcing)
- Scenario 2: all construction material sourced off-site (off-site material sourcing)

The Traffic Assessment notes that, subject to resolving the establishment of an on-site quarry, unsealed internal access roads, hardstand areas and the upgrade/upkeep of local external roads used for project construction traffic would be constructed from material sourced from the on-site quarry.

Prior to the establishment of the on-site quarry, or in the event that on-site materials sourcing is not possible, material for road and hardstand construction would be sourced externally from one or more quarries in the vicinity of the project.

For consistency with the Traffic Assessment, the potential noise from off-site traffic associated with the 2 scenarios has been considered.

[12] Ratio Consultants Pty Ltd, *Transport Impact Assessment Report – Hexham Wind Farm Project (19790T-F03)* dated 13 August 2025 (Traffic Assessment)

Two key traffic routes have been considered for the purposes of the noise assessment:

- Hamilton Highway within the township of Mortlake (Dunlop Street): this section of highway is one of the key transport routes to the project and would potentially support the highest number of heavy vehicle movements for off-site material sourcing (scenario 2). The route is also adjoined by receivers including dwellings and a school (St Colman's School).
- Connewarren Lane between Mortlake and the project site: a local road which would support the highest number of heavy vehicle movements for both on-site and off-site material sourcing. There are also non-stakeholder receivers in proximity to this route.

Other highways and local roads in the area around the project would also be used for construction. However, the project traffic movements on these routes would be lower and the receivers along these routes are generally positioned at comparable or further setbacks. The 2 key routes considered in this assessment therefore provide a worst-case representation of off-site traffic noise.

To assess off-site traffic, reference has been made to vehicle movement data for existing conditions and the 2 scenarios considered in the traffic assessment. The data was generally sourced from the Traffic Assessment, with the exception of existing vehicle movement data through Mortlake which was sourced from the DTP online traffic volume database. The relevant traffic data is summarised in Table 8. The vehicle movement data for the project relates to the peak period of construction.

Table 8: Average daily vehicle movements

Route	Existing conditions		Peak construction traffic: on-site sourcing		Peak construction traffic: off-site sourcing	
	Total	Heavy vehicles (%)	Total [a]	Heavy vehicles (%)	Total [a]	Heavy vehicles (%)
Hamilton Highway (Dunlop St)	3,387 [b]	654 (19%) [b]	396 [c]	281 (71%) [c]	780 [c]	665 (85%) [c]
Connewarren Lane	380	19-57 (5-15%) [d]	337	252 (75%)	682	597 (88%)

a Excluding oversized deliveries (movement numbers are small and would be scheduled separately for safety and to minimise disruption on the network)

b Data sourced from DTP traffic volume database, corresponding to the 2020 estimate of the annual average daily traffic

c Estimate based on the sum of the traffic assessment data for Connewarren Lane and the Hamilton Highway east of gate 11 site access. This will slightly overestimate the movement numbers for the off-site sourcing scenario because it includes the potential heavy vehicle movements associated with aggregate sourcing from the Gillear Quarry, to the south of the project, which would not enter the township of Mortlake.

d Heavy vehicle percentage not provided in DTP traffic volume database or Traffic Assessment – indicative range of 5-15% assumed for assessment purposes.

From the traffic data presented in Table 8, traffic noise levels have been predicted using the Calculation of Road Traffic Noise (CoRTN) prediction method. This method is widely used in Australia for the prediction of traffic noise. However, the method is primarily intended for predicting traffic noise levels from high volume road and is not designed for modelling roads with low vehicle numbers. The results using CoRTN are therefore indicative only and enable comparisons to be made between baseline traffic conditions and the 2 scenarios.

The following assumptions have been adopted as inputs for the CoRTN predictions:

- The daily traffic volumes associated with existing conditions and construction of the project have been normalised to hourly values for assessment purposes. The hourly traffic volumes have been approximated based on the data shown in Table 8 and assuming an even distribution of both existing traffic (over a 24-hour period) and peak construction traffic (over a 10-hour working day).
- The hourly upper noise levels ($L_{A10,1h}$) are calculated using CoRTN and then converted to hourly average noise levels ($L_{Aeq,1h}$) for comparison with guidance from the ERS. The conversion is based on subtraction of 3 dB from the from the hourly upper noise levels (the typical difference between the upper and average noise level of road traffic).

  The reference levels from the ERS are strictly based on average noise levels over a 16-hour period (0700 – 2300 hrs). However, as the hourly movement numbers referenced in the assessment are an average across the total periods (24 hours for existing traffic and 10 hours for peak construction traffic), the indicative values are suitable for direct comparison with the ERS reference levels.[13]

  Note also that equivalent noise levels (L_{Aeq}) are used as a metric for comparing baseline, scenarios and ERS reference levels. This provides a suitable basis for identifying the risk of construction noise impacts. However, noise levels in practice would be experienced as intermittent noise increases from individual movements.
- Traffic speeds have been set to 60 km/h for Hamilton Highway/Dunlop St and 100 km/h for Connewarren Lane.
- Ground cover between the road and the receivers is assumed to be mixed within the township of Mortlake and grass or cultivated fields between Connewarren Lane and receivers.
- Representative calculation distances have been selected for the noise assessment based on typical receiver setback distances along the relevant road sections – 25 m for Hamilton Highway/Dunlop St and 100 m for Connewarren Lane.
- The predicted noise levels are determined for free-field conditions, consistent with the guidance in the ERS.

[13] This provides a conservative assessment as the 16-hour noise level of construction traffic will be slightly lower than the value calculated using hourly values calculated from a 10-hour working day.

The predicted noise levels for each route and scenario are presented in Table 9.

Table 9: Predicted off-site traffic noise levels during the peak period of construction, dB $L_{Aeq,1h}$

Route	Existing	Proposed [a]	Change
On-site material sourcing			
Hamilton Highway/Dunlop St	58	60	+2
Connewarren Lane	39-40 [b]	48	+8
Off-site material sourcing			
Hamilton Highway/Dunlop St	58	62	+4
Connewarren Lane	39-40 [b]	52	+12

a Combined existing and construction traffic volumes

b Range based on assumed HV percentages for Connewarren Lane

In broad terms, the results indicate that construction traffic is likely to result in clearly discernible increases in total road traffic noise levels for both the on-site and off-site material sourcing scenarios. The increases would be most pronounced for the off-site sourcing, consistent with the higher number of truck movements associated with this scenario. The following specific points are noted in relation to each scenario:

- On-site material sourcing: in terms of average noise levels, the predicted 2 dB increase at receivers adjacent to the Hamilton Highway in the township of Mortlake equates to a just perceptible increase in noise levels. This would typically be considered a minor increase. However, as the increase primarily relates to the influence of additional heavy vehicle movements, the change is likely to be observed as more frequent instances of increased noise levels during a truck pass-by. At receivers adjacent to the Connewarren Lane route, the average noise level increase would represent a clearly noticeable change – primarily as a result of the low number of existing movements on this route.
- Off-site material sourcing: in terms of average noise levels, the 4 dB and 12 dB predicted increases adjacent to the Hamilton Highway in Mortlake and Connewarren Lane respectively both represent noticeable increases.. As the increases primarily relate to heavy vehicle movements, the increases at both locations would be more readily perceived as a clearly noticeable increase in the regularity of increased noise levels during truck pass-by events.

To provide further context to the noise levels, the objectives defined in the ERS are relevant to construction traffic noise. While the ERS objectives do not represent limits or design targets, they serve as a reporting benchmark, and noise levels above the objective are an indicator of risk.

The ERS objectives for receivers along the traffic routes (land category IV under the ERS) are 40 dB $L_{Aeq,16h}$ and 35 dB $L_{Aeq,8h}$ for the day and night respectively. The modelling indicates predicted total noise levels above the objectives along both traffic routes, particularly for off-site material sourcing and the receivers adjacent the Hamilton Highway in Mortlake. The predicted existing noise levels are also noted to be above the objectives at receivers adjacent to the Hamilton Highway and comparable to the objectives at receivers adjacent Connewarren Lane. This is solely a point of context and does not infer the predicted noise level increases are acceptable or otherwise.

There are no mandatory noise limits or guidelines in Victoria which are directly applicable to the noise of off-site construction traffic. However, the predicted noise level increases, and the comparisons with the ERS objectives, demonstrate a clear risk of amenity impacts as a result of construction traffic.

In accordance with the GED, the risk of harm would need to be minimised so far as reasonably practicable. In this respect, the modelling results provide support for the preferred option of an on-site quarry to minimise the number of off-site vehicle movements associated with material sourcing. Further, the assessment of construction traffic has been based on heavy vehicle movements occurring over a 10-hour period, consistent with the normal working hours of on-site activities. Averaging the movements over a 10-hour period also results in a higher number of hourly movements for conservative noise modelling purposes. However, the normal working hours defined in EPA Publication 1834.2 directly relate to on-site activities. Without specific controls in place, heavy vehicle movements associated with material sourcing could occur outside of these hours, and potentially during the night period prior to 0700 hrs. This introduces additional risks with respect to the potential for sleep disturbance from traffic noise. In recognition of this, heavy vehicle movements associated with material sourcing from local quarries should not occur on the surrounding road network before 0700 hrs. Specifically, heavy vehicle movements associated with material sourcing from local quarries should not occur on the local road network or within local townships around the project before 0700 hrs.

Consistent with the recommendations for on-site construction activities, reasonably practicable measures that would be implemented to minimise the risk of harm from construction traffic noise should be documented in the CNVMP. The plan should address the measures noted above and other measures for:

- the education of heavy vehicle drivers about their obligations under the GED
- informing local communities and other relevant stakeholders (e.g. local council) about the peak periods of construction traffic and the measures that will be implemented to minimise the noise so far as reasonably practicable.

7.6 Construction vibration

The nearest receiver to construction activities is a stakeholder receiver (D418) located approximately 140 m from the proposed access tracks. The nearest non-stakeholder receiver (D482) is located approximately 320 m from the proposed access tracks.

This distance is greater than minimum working distances for cosmetic damage (25 m) and human comfort (100 m) as detailed in Table 41 of Section C8. As such, construction activities are beyond the safe working distances for both cosmetic damage and human response.

Vibration is therefore considered a low risk for the project and, as such, vibration monitoring is not expected to be required.

7.7 Mitigation measures and risk assessment

Based on the findings in the previous sections, the recommended mitigation measure for addressing construction noise and vibration is to establish a requirement for a CNVMP to be prepared prior to commencement of construction (mitigation measure reference number EMM-NV01). The purpose of the CNVMP is to document all controls that would be used to minimise construction noise and vibration risks as far as reasonably practicable, based on updated information about the planned construction works and equipment selections. This includes risk related to on-site construction activities and off-site construction traffic on the surrounding road network. The risk controls must be proportionate to the risk of harm from noise. The full requirements of the CNVMP are documented in Section 11.0 within a consolidated list of mitigation measures for the project.

Accounting for the assessment findings and the proposed mitigation measures, an assessment of construction noise and vibration risk associated with on-site activities is presented in Table 10. An assessment of the construction noise risk associated with offsite construction traffic is subsequently presented in Table 11. The risk assessment for off-site construction traffic is applicable to both the on-site and off-site material sourcing options considered.

Table 10: Construction noise and vibration – on-site activities - risk assessment

Item	Rating		Comments
	Inherent	Residual	
Consequence	Minor	Minor	Construction works are proposed to be limited to normal working hours for the majority of activities. Construction noise levels are also predicted to be low at most receivers for most of the construction period. The highest predicted noise levels relate to activities that progress quickly and would therefore occur relatively briefly at a given receiver.
Likelihood	Possible	Unlikely	The predicted construction noise levels are based on conservative assumptions. Noise levels in practice are expected to be lower than predicted for most of the time. The development and implementation of a CNVMP would minimise the likelihood of construction noise and vibration risks.
Overall rating	Medium	Low	The applicable EPA Publication 1695.1 guidance for the residual risk rating is: *Acceptable level of risk. Attempt to eliminate risk but higher risk levels take priority.*

Table 11: Construction noise and vibration – off-site traffic - risk assessment

Item	Rating		Comments
	Inherent	Residual	
Consequence	Moderate	Minor	Off-site construction traffic is predicted to result in clearly noticeable increases in traffic noise levels on the surrounding road network. Without controls, the inherent consequence includes an increased risk of sleep disturbance as result of the potential for heavy movements during the night (prior to 0700 hrs). With the recommended mitigation measures, particularly the restriction of heavy vehicles associated with material sourcing to avoid movements in the local townships or on the local road network before 0700 hrs, the residual effects of construction traffic noise would be minor.
Likelihood	Likely	Likely	The predicted off-site traffic noise levels are based on conservative assumptions. Noise levels in practice are expected to be lower than predicted for most of the time. However, the clear increases in heavy movement numbers on the surrounding road network, particularly for the off-site material sourcing scenario, indicates that amenity impacts as a result of traffic noise level increases are likely during the construction period.
Overall rating	High	Medium	The applicable EPA Publication 1695.1 guidance for the residual risk rating is: *Can be acceptable if controls are in place. Attempt to reduce to low.*

8.0 CONSTRUCTION NOISE ASSESSMENT – QUARRY AND BATCHING PLANT OPERATIONS

A site layout plan illustrating the proposed on-site quarry, concrete batching plants and receivers is provided in Figure 6.

8.1 Operating hours

Consistent with the construction hours presented in Section 7.2, on-site quarry and concrete batching plants are proposed to operate during normal working hours as defined by EPA Publication 1834.2:

- Monday to Friday: 0700 to 1800 hrs
- Saturday: 0700 to 1300 hrs

8.2 Assessment criteria

The proposed on-site quarry and concrete batching plants would operate during various periods of the construction stage of the project. While these activities are temporary operations associated with construction, they may be required to operate over a period of approximately 2 years, given the size of the project. As a result of the projected duration of operation, and as required by the scoping requirements, the on-site quarry and concrete batching plants have been assessed against Victorian noise requirements for commercial, industrial and trade premises (industry premises). It is however noted that these noise limits do not differentiate between temporary and permanent operations.

Based on the above, the following obligations apply under the EP Act and EP Regulations:

- Operation of the on-site quarry and batching plants 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 on-site quarry and batching plants 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. The rural areas procedures of the Noise Protocol apply to the project.

In accordance with the Noise Protocol, the on-site quarry is considered as an earth resources premises with specific procedures for determining noise limits. The procedures account for the land zoning where the noise receivers are located and, where applicable, the background noise in the area.

Noise limits associated with the operation of the concrete batching plants are 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, including background noise.

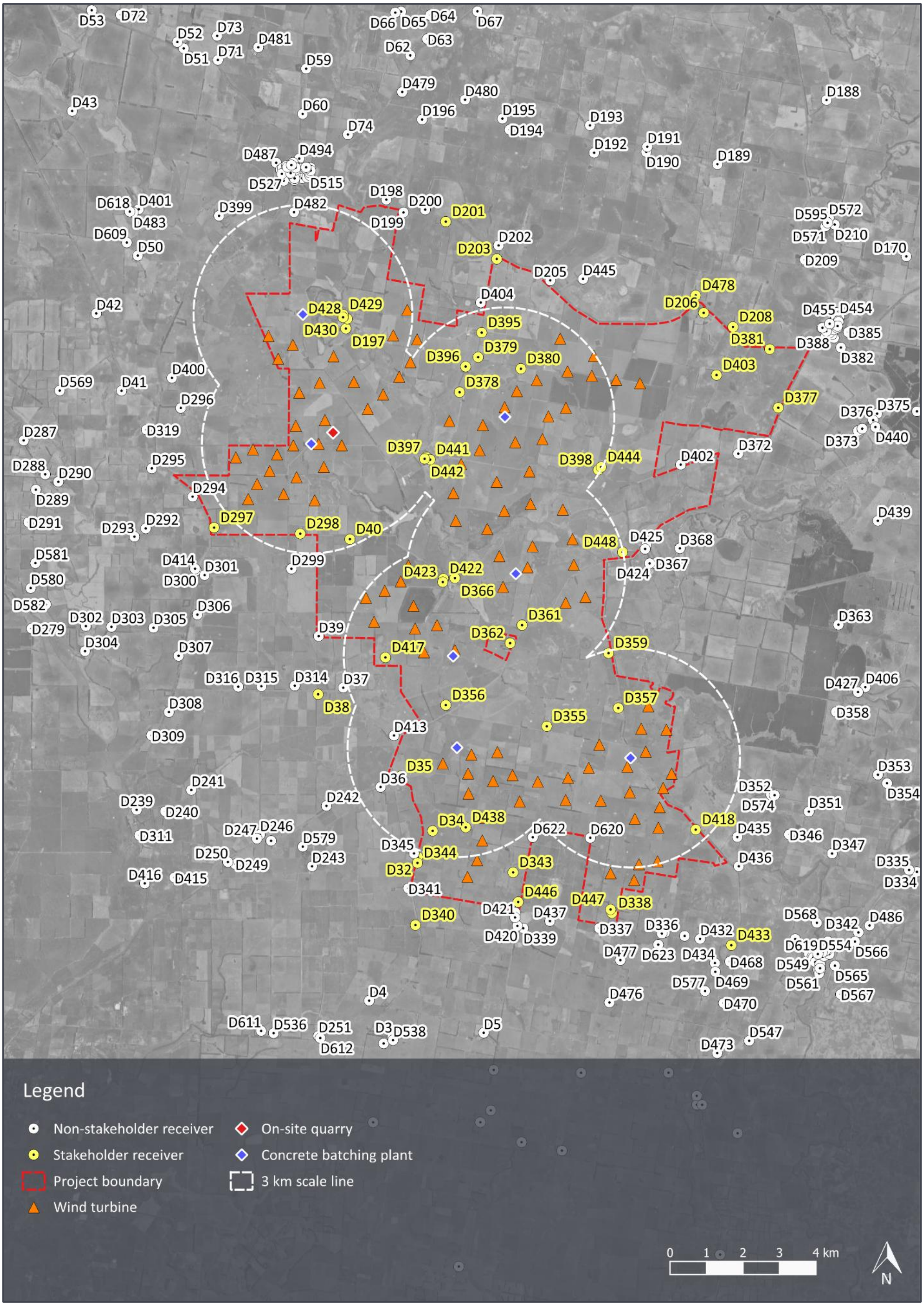
Adjustments for 'background relevant areas' are not warranted in this instance, as the background noise levels during the relevant assessment conditions for the on-site quarry and concrete batching plants (i.e. low wind speeds) are relatively low. Considering that the land zoning is continuous between the proposed on-site quarry and concrete batching plants and the nearest receivers, a distance adjustment is not applicable.

As shown on the land zoning maps presented in Appendix I, both receivers and noise sources (on-site quarry and concrete batching plants) are located within land designated as Farming Zone (FZ). Accordingly, the applicable noise limits are detailed in Table 12.

Table 12: Applicable Noise Protocol noise limits, dB ENL

Period	Day of week	Start time	End time	Noise limit
Day	Monday – Saturday	0700 hrs	1800 hrs	46
Evening	Monday – Saturday	1800 hrs	2200 hrs	41
	Sunday, Public holidays	0700 hrs	2200 hrs	
Night	Monday – Sunday	2200 hrs	0700 hrs	36

Figure 7: Site map of proposed on-site quarry, concrete batching plants and receivers



8.3 Noise emissions

The design of the on-site quarry and concrete batching plants, the schedule of equipment to be used, and the intensity of operations, would be developed in greater detail during subsequent stages of the project.

Preliminary information has therefore been modelled to develop estimated noise level predictions based on the example schedule of plant and noise emissions described in the previous section and excluding any source screening. In the absence of a detailed quarry profile design, a simplified terrain profile has been used for the modelling. This approach is conservative as the inclusion of quarry profiles would add screening effect resulting in lower predicted noise levels at receivers. Given these inputs, the noise predictions presented in the subsequent section are indicative only, and would be subject to refinement when further information becomes available.

A variety of plant would be used at the proposed on-site quarry and concrete batching plants. Sound power levels for the types of equipment expected have been determined primarily based on noise level data from previous projects of a similar nature, together with noise data sourced from AS 2436.

Table 13 summarises the noise emissions used to represent key items of plant associated with the proposed on-site quarry and concrete batching plants. The noise emissions are presented in the form of sound power levels, which are a measure of the sound energy produced by each item of equipment.

Table 13: Noise sources sound power data, dB L_{WA}

Noise source	Sound power level (per equipment item)
On-site quarry	
2 x Concrete trucks	108
3 x Dump trucks	117
1 x Excavator (100 to 200 kW)	107
1 x Excavator fitted with pneumatic breaker	118
2 x Front end loaders	113
1 x Generator	99
2 x Rock crushers	120
On-site concrete batching plants	
1 x Batching plant	110
6 x Concrete trucks	108
1 x Concrete pump	108

8.4 Predicted noise levels

The predicted noise levels have been calculated using the method detailed in Section 4.2.2 and are presently based on all plant continuously operating simultaneously within any given 30-minute assessment period. In practice, variations in the duration and intensity of operation of each item of plant are likely to result in lower noise levels. These variations in operating characteristics would need to be accounted for in the detailed design assessment report.

An adjustment of +2 dB has then been applied to the predicted noise levels to account for the potential characteristics of noise from mobile plants (i.e. tonal reversing alarms, impulsive rock breaking). Adjustments for other potential noise characteristics such as impulsiveness or intermittency may also occur but are unlikely to occur simultaneously or apply cumulatively. The relevance and magnitude of the actual adjustment in practice is dependent on several variables. This is discussed in the subsequent sections.

The predicted noise levels primarily relate to total A-weighted noise levels with adjustments for assessable characteristics under the Noise Protocol.

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 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 8.6 and in further detail in Section 11.0.

8.4.1 On-site quarry

Predicted noise levels from the proposed on-site quarry at all 6 receivers located within 3 km (all stakeholder receivers within the project boundary) are detailed in Table 14.

Table 14: Estimated noise levels from on-site quarry

Receiver	Separating distance, m	Estimated noise level, dB ENL
D40 (S)	2,957	41
D197 (S)	2,873	36
D298 (S)	2,914	41
D397 (S)	2,646	42
D441 (S)	2,763	37
D442 (S)	2,609	42

The results presented in Table 14 indicate estimated levels are lower than the noise limit of 46 dB ENL applicable to the day period by at least 4 dB.

The predicted noise level from the on-site quarry at the nearest non-stakeholder receiver (D299, located approximately 3.9 km away) is 37 dB ENL, 9 dB below the noise limit applicable to the day period.

The above indicates that noise from the proposed on-site quarry is not likely to be a design constraint for the project provided that the operations are limited to the day period only.

Further, it is recommended that a quarry noise management plan is prepared as part of the quarry work plan, and that this plan includes details of all reasonably practicable mitigation measures to be implemented to fulfil the GED under the EP Act and achieve the noise limits determined in accordance with the Noise Protocol.

8.4.2 Concrete batching plants

Predicted noise levels from the proposed concrete batching plants at the 34 receivers within 3 km are detailed in Table 15.

Table 15: Estimated noise levels from concrete batching plants

Receiver	Minimum separating distance, m	Estimated noise level, dB ENL
Non-stakeholder receivers		
D36	2,357	28
D413	1,758	37
D482	2,813	30
D620	2,451	29
Stakeholder receiver outside the project boundary		
D362 (S)	1,600	24
Stakeholder receivers within the project boundary		
D34 (S)	2,377	16
D35 (S)	1,734	19
D40 (S)	2,818	42
D197 (S)	1,239	32
D298 (S)	2,481	28
D355 (S)	2,455	18
D356 (S)	1,204	19
D357 (S)	1,409	14
D359 (S)	2,936	12
D361 (S)	2,070	25
D366 (S)	2,137	19
D378 (S)	1,415	28
D379 (S)	1,794	25
D380 (S)	1,392	27
D395 (S)	2,398	32
D396 (S)	1,751	22
D397 (S)	2,418	31
D398 (S)	2,944	25
D417 (S)	1,858	26

Receiver	Minimum separating distance, m	Estimated noise level, dB ENL
D418 (S)	2,654	13
D422 (S)	2,138	19
D423 (S)	2,049	19
D428 (S)	1,221	43
D429 (S)	1,107	40
D430 (S)	1,104	43
D438 (S)	2,198	16
D441 (S)	2,359	41
D442 (S)	2,484	31
D444 (S)	2,974	25

(S) Stakeholder receiver

The estimated noise levels presented in Table 15 are below the noise limit of 46 dB ENL, applicable during the day period, at all receivers, by at least 3 dB. Following preliminary noise modelling, concrete batching plants were relocated to reduce noise levels at receivers.

The above indicates that noise from the proposed concrete batching plants is not likely to be a design constraint for the project provided that the operations are limited to the day period only.

Further, it is recommended that construction noise and vibration management procedures be developed and documented in the CNVMP. The procedures should include details of all reasonably practicable mitigation measures to be implemented to fulfil the GED under the EP Act and achieve the noise limits determined in accordance with the Noise Protocol.

8.4.3 Cumulative assessment

In accordance with the Noise Protocol, the noise limits detailed in Section 8.2 apply to the noise level generated by all activities under consideration (i.e. on-site quarry and concrete batching plants).

As a conservative assessment, it is assumed that the on-site quarry and all 7 concrete batching plants would be operating simultaneously and continuously over the period nominated in Section 8.1.

Cumulative noise levels are presented in Table 16 for receivers detailed in the preceding sections to account for any potential period of overlapping operation.

Table 16: Cumulative estimated effective noise levels from on-site quarry and concrete batching plants, dB

Receiver	Nearest noise source	On-site quarry	Concrete batching plants	Cumulative, dB ENL [a]
Non-stakeholder receivers				
D36	Batching plant	22	26	29
D413	Batching plant	24	35	37
D482	Batching plant	26	28	32
D620	Batching plant	13	27	30
Stakeholder receiver outside the project boundary				
D362 (S)	Batching plant	26	38	40
Stakeholder receivers within the project boundary				
D34 (S)	Batching plant	16	30	32
D35 (S)	Batching plant	22	35	37
D40 (S)	Batching plant	39	26	41
D197 (S)	Batching plant	34	39	42
D298 (S)	Batching plant	39	30	41
D355 (S)	Batching plant	22	32	34
D356 (S)	Batching plant	20	41	43
D357 (S)	Batching plant	16	38	40
D359 (S)	Batching plant	22	27	30
D361 (S)	Batching plant	26	39	41
D366 (S)	Batching plant	31	36	39
D378 (S)	Batching plant	36	38	42
D379 (S)	Batching plant	28	34	37
D380 (S)	Batching plant	30	38	40
D395 (S)	Batching plant	27	30	34
D396 (S)	Batching plant	34	35	39
D397 (S)	Batching plant	40	29	42
D398 (S)	Batching plant	26	29	32

Receiver	Nearest noise source	On-site quarry	Concrete batching plants	Cumulative, dB ENL [a]
D417 (S)	Batching plant	28	29	34
D418 (S)	Batching plant	11	28	30
D422 (S)	Batching plant	31	30	35
D423 (S)	Batching plant	29	30	34
D428 (S)	Batching plant	36	40	43
D429 (S)	Batching plant	35	41	44
D430 (S)	Batching plant	36	41	44
D438 (S)	Batching plant	15	31	33
D441 (S)	Batching plant	35	29	38
D442 (S)	Batching plant	40	29	43
D444 (S)	Batching plant	26	28	32

(S) Stakeholder receiver

a Estimated effective noise levels include a +2 dB adjustment for the potential presence of tonality

The estimated cumulative levels presented in Table 16, assuming simultaneous operation of the on-site quarry and all 7 proposed concrete batching plants, are below the applicable noise limit of 46 dB ENL at all receivers, by at least 2 dB.

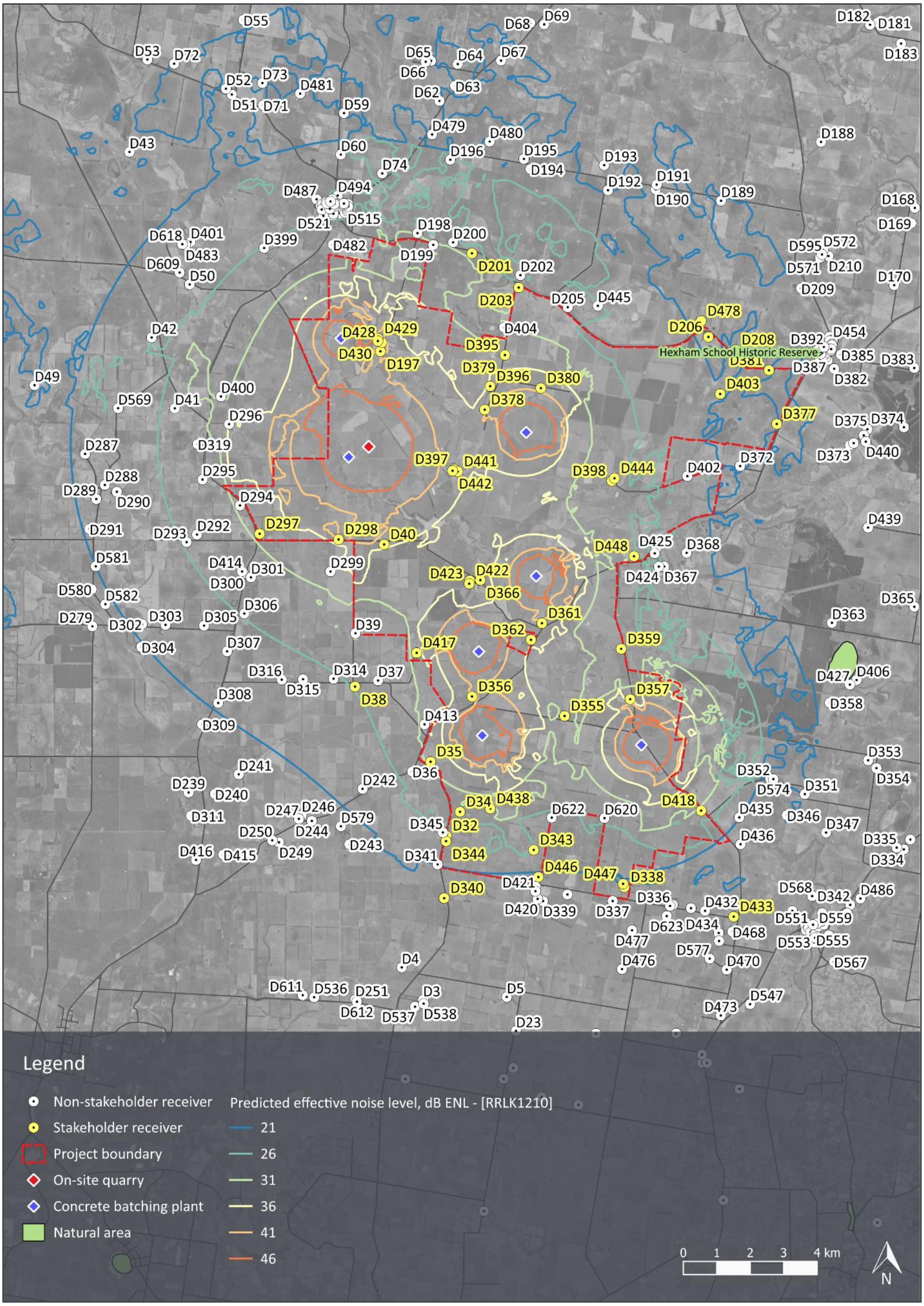
Noise contour maps showing cumulative estimated noise levels from the proposed on-site quarry and concrete batching plants is presented in Figure 8.

The assessment presented above and illustrated in Figure 8, is primarily based on the cumulative noise of the on-site quarry and batching plants. However, consideration has also been given to the potential cumulative noise of the on-site quarry and batching plants in combination with other existing and approved industry sites in the surrounding area. Specifically, the:

- operational Mortlake Power Station is also located approximately 4 km to the east of the project
- approved Mortlake Energy Hub, adjacent to the Mortlake Power Station, comprising a 360 MW solar energy facility and a 300 MW BESS.

In this respect, the nearest receivers to the project are sufficiently far from the Mortlake Power Station and Mortlake Energy Hub such that the noise of these sites is not expected to approach the noise limits, particularly on account of the proximity of other receivers nearer Mortlake Power Station and Mortlake Energy Hub which would dictate their noise control requirements. Further, at the receivers to the east of the project that are nearest to the Mortlake Power Station and Mortlake Energy Hub, the combined predicted noise level of the project's on-site quarry and batching plants is less than 30 dB ENL and would not materially affect compliance margins for these receivers (noting that the on-site quarry and batching plants are restricted to daytime operation).

Figure 8: Cumulative estimated operational noise levels from the on-site quarry and concrete batching plants



8.5 Natural areas

Operation of the on-site quarry and concrete batching plants is a relevant consideration for natural areas during the construction period. These elements of the project would operate for a greater portion of the construction period than other types of construction activity.

As with other types of construction activity, the extent of areas in which the noise would be audible would be highly variable. However, natural areas where predicted noise level are lower than 20 dB L_{Aeq} are not likely to experience audible noise from these sites even when daytime background noise levels are low and conditions favour the propagation of sound from the on-site quarry and concrete batching plants.

The predicted cumulative noise levels are presented in Figure 8 and provide an indication of the extent of the areas in which noise from the on-site quarry and concrete batching plants may be audible at natural areas.

The results indicate that the predicted cumulative noise level from operation of the on-site quarry and concrete batching plants is below 20 dB L_{Aeq} at the nearest natural areas (Hexham School Historic Reserve and Lake Connewarren). As such, operation of the on-site quarry and concrete batching plants is expected to not be audible during the day period at the identified natural areas in the vicinity of the project.

Consistent with the requirements of the GED and the recommended noise management measures for general construction activity (see Section 7.7), the extent and nature of the effect can be reduced by:

- selecting low noise emission equipment
- minimising distinctive undesirable characteristics which could be more intrusive over wider areas, such as tonal reversing signals and low frequency noise emissions
- maintaining site equipment and infrastructure to minimise noise emissions, particularly with respect to access and site roads where surface deterioration can lead to excess impact noise from the carriages of heavy vehicles.

8.6 Mitigation measures and risk assessment

Based on the findings in the previous sections, the recommended mitigation measures for addressing environmental noise from the on-site quarry and concrete batching plants are:

- EMM-NV02: Quarry work plan

  The purpose of this mitigation measure is to establish a requirement for the quarry work plan to document control measures which minimise the risk of harm from operational noise, prevent noise that is prescribed to be unreasonable under the EP Act and account for potential risks related to low frequency noise.

- EMM-NV03: Concrete batching plants

  The purpose of this mitigation measure is to establish design and operational requirements for all temporary concrete batching plants in accordance with Victorian regulatory requirements. Specifically, the plans must be designed and operated to minimise the risk of harm from operational noise, prevent noise that is prescribed to be unreasonable under the EP Act and account for potential risks related to low frequency noise.

Accounting for the assessment findings and the proposed mitigation measures, an assessment of risk associated with noise from the on-site quarry and concrete batching plants is presented in Table 17 and Table 18, respectively.

Table 17: On-site quarry noise – risk assessment

Item	Rating		Comments
	Inherent	Residual	
Consequence	Minor	Minor	The quarry's hours of operation are proposed to be restricted to normal working hours of construction activities, and the predicted noise levels are below the noise limits at all receivers. The quarry would also only operate during the construction phase of the project. The above are the decisive factors in determining the risk consequence. However, obligations with respect to the GED and unreasonable noise provisions of the EP Act remain applicable, particularly with respect to the control of any audible characteristics such as tonality and low frequency noise.
Likelihood	Possible	Unlikely	The predicted quarry noise levels are based on conservative assumptions. Noise levels in practice are expected to be lower than predicted. The objective of implementing noise controls within the quarry work plan will be to minimise the likelihood of construction noise risks.
Overall rating	Medium	Low	The applicable EPA Publication 1695.1 guidance for the residual risk rating is: *Acceptable level of risk. Attempt to eliminate risk but higher risk levels take priority.*

Table 18: Batching plants noise – risk assessment

	Rating		Comments
Item	Inherent	Residual	
Consequence	Minor	Minor	The operating hours of the batching plants are proposed to be restricted to normal working hours of construction activities, and the predicted noise levels are below the noise limits at all receivers. The batching plants would also only operate during the construction phase of the project. The above are the decisive factors in determining the risk consequence. However, obligations with respect to the GED and unreasonable noise provisions of the EP Act remain applicable, particularly with respect to the control of any audible characteristics such as tonality and low frequency noise.
Likelihood	Possible	Unlikely	The predicted batching plant noise levels are based on conservative assumptions. Noise levels in practice are expected to be lower than predicted. The objective of implementing noise controls within the CNVMP will be to minimise the likelihood of construction noise risks.
Overall rating	Medium	Low	The applicable EPA Publication 1695.1 guidance for the residual risk rating is: *Acceptable level of risk. Attempt to eliminate risk but higher risk levels take priority.*

9.0 OPERATIONAL NOISE ASSESSMENT – WIND TURBINES

This section presents an assessment of operational noise associated with the proposed wind turbines.

9.1 Assessment criteria

NZS 6808 provides methods for the prediction, measurement, and assessment of sound from wind turbines.

The 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 applicable base limit applied in Victoria is dependent on factors relating to land zoning, background noise levels and whether the receiver is involved with the project. These factors are discussed in the following subsections.

9.1.1 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. As detailed in Section C5.4 of Appendix C, this is based on a two-step approach comprising:

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

Based on the predicted noise level contours presented subsequently in Section 9.4, and the zoning map for the area presented in Appendix I, receivers within the predicted 35 dB L_{A90} contour are located within areas identified as Farming Zone (FZ).

Consistent with the guidance from EPA web guide, 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.

All of the land within the predicted 35 dB L_{A90} contour is designated as Farming Zone. Further, the nearest Township Zones to the project are well outside the predicted 35 dB L_{A90} noise contour:

- Caramut township, approximately 4.0 km to the northwest
- Hexham township, approximately 4.2 km to the northeast
- Ellerslie township approximately 4.7 km to the southeast.

The other types of zones where the Technical Guideline indicates that the high amenity area noise limit applies are not present in the area around the wind farm.

Based on the above, the high amenity noise limit is not justified for the project.

9.1.2 Stakeholder receivers

The definition of noise sensitive locations in NZS 6808 specifically excludes dwellings located within a wind farm project boundary. Further, Section C5.2 of Appendix C provides details of the statutory context of NZS 6808 and indicates the method is not intended to be applied to noise sensitive locations outside the project boundary where a noise agreement exists or is proposed between the occupants and the proponent of the development.

However, consistent with the Victorian Wind Energy Guidelines, regulation 131BA of the EP Regulations specifies a noise limit for stakeholder receivers 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 advised that noise agreements are currently proposed between the landowners and the proponent at 7 receivers outside the project boundary and within 5 km of a wind turbine, as presented in Appendix F. These receivers are assessed against the noise limits which would apply when an agreement is established after 1 November 2021.

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 stakeholder receivers within the project boundary.

9.1.3 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 19.

Table 19: Applicable noise limits, dB L_{A90}

Receiver status	Noise limit
Non-stakeholder	40 dB or background L_{A90} + 5 dB, whichever is the greater
Stakeholder outside the project boundary, where a noise agreement is proposed	45 dB or background L_{A90} + 5 dB, whichever is the greater
Stakeholder within the project boundary	Not applicable Reference level of 45 dB or background L_{A90} + 5 dB, whichever is the greater

Applicable noise limits based on the background noise levels presented in Table 2 and Table 3 of Section 6.0 are summarised in Table 20 and Table 21.

Table 20: Operational wind turbine noise limits at background monitoring locations, dB L_{A90} – all-time period

Receiver	Hub height wind speed, m/s [a]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D39	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.9	42.9	45.0	47.2	49.4
D205	40.0	40.0	40.0	40.0	40.0	40.0	40.4	41.5	42.7	44.1	45.5	47.0	48.6
D294	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.1	41.8	43.5	45.3	47.0	48.7
D362 (S)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.3	47.3	49.3
D367	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.2	41.6	43.2	44.8	46.5
D413	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.1	42.9	44.8	46.7
D622	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.0	42.4

(S) Stakeholder receiver

a DRY02 met mast – 149 m above ground level at 642090 E, 5779958 N (MGA2020 zone 54)

Table 21: Operational wind turbine noise limits at background monitoring locations, dB L_{A90} – night-time period

Receiver	Hub height wind speed, m/s [a]												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D39	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.2	45.0	47.8
D205	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.1	42.2	44.4	46.6
D294	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.3	42.7	45.1	47.3
D362 (S)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.3	47.9
D367	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.7	44.2
D413	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.7	45.4
D622	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.0

(S) Stakeholder receiver

a DRY02 met mast – 149 m above ground level at 642090 E, 5779958 N (MGA2020 zone 54)

9.2 Candidate wind turbine model

The final turbine model for the site would be selected after a tender process to procure the supply of turbines. The final selection would be based on a range of design requirements including achieving compliance with the EP Regulations noise limits at surrounding receivers (refer to Appendix D for an overview of the various stages in the noise assessment of a wind farm).

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

For this assessment, the proponent has nominated the Vestas V162-6.8MW as the candidate wind turbine model. This model is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the wind turbines being regulated by control systems which vary the pitch of the wind turbine blades (the angular orientation of the blade relative to its axis).

This assessment has been based on the wind turbines operating in 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 model are provided in detailed in Table 22.

Table 22: Selected candidate wind turbine model

Item	Detail
Make	Vestas
Model	V162
Rotor diameter	162 m
Operating mode	PO6800 [a]
Rated power	6.8 MW
Hub height	149 m
Blade serrations	Yes
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	13 m/s
Cut-out wind speed (hub height)	25 m/s

a 'PO6800' is a manufacturer designation which indicates an unconstrained, Power Optimised mode of operation to achieve a rated power of 6.8 MW (i.e. without noise curtailment)

The rated power of the candidate wind turbine is consistent with the proposal for the project to utilise turbines with a capacity between 6 and 8 MW. The noise emission characteristics of a wind turbine are ultimately dependent on a range of factors such as the blade design, the rotor size, and the speed of rotation. As such, while size and power rating of contemporary wind turbines have increased, the noise emissions 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 blades, and enhanced blade design features such as serrations for noise control). The candidate wind turbine model is therefore considered appropriate to represent the class of wind turbine being considered for the project.

The modelled hub heights detailed above are suitable for noise assessment purposes. It is our understanding that the final hub height of the selected wind turbine model may differ slightly. However, the magnitude of the potential changes is expected to be minor and inconsequential with respect to predicted noise levels at receivers. Irrespective, revised noise modelling would be conducted for the final wind turbine layout, model selection and hub height to verify compliance. The results of the revised noise modelling would be documented in the noise management plan required under regulation 131E of the EP Regulations.

9.3 Wind turbine noise emissions

9.3.1 Sound power level data

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

Sound power level data for the candidate wind turbine model, including sound frequency characteristics, has been sourced from the Vestas Power Solutions document 0111-1246_03 *Third octave noise emission EnVentus™ V162-6.8MW 50/60 Hz* dated 13 January 2023.

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

The overall A-weighted sound power levels (including the +1.0 dB addition) as a function of hub height wind speed are presented in Table 23 with the octave band values presented in Table 24. These represent the total noise emissions of the wind turbine for each sound mode, including the secondary contribution of ancillary plant associated with each wind turbine (e.g. cooling fans).

Table 23: Sound power levels (including the +1.0 dB addition) versus hub height wind speed, dB L_{WA}

	Hub height wind speed, m/s											
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**≥15**
L_{WA}	95.0	95.0	96.0	99.3	102.5	104.3	104.3	104.4	104.8	105.1	105.3	105.5

Table 24: Octave band sound power levels, dB L_{WA}

	Octave band centre frequency, Hz									
	31.5	**63**	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**	**Total**
L_{WA}	76.0	88.5	96.4	99.7	100.2	98.7	94.2	86.7	76.0	105.5

Note: Based on one-third octave band levels at 15 m/s

These sound power levels are also illustrated in Appendix K.

The values presented above are indicative of the noise emissions which can achieved by a range of comparable multi-megawatt wind turbine options on the market.

Some of the larger turbines presently on the market indicate the potential for higher noise emissions. However, the options for larger turbines are currently limited and the available data is insufficient to reach conclusions about representative emissions. In this respect, industry research into the noise emission characteristics of a range of wind turbine models has shown that there isn't a clear relationship between sound power levels and a wind turbine's size or power output.[14] In practice, the sound power levels of a wind turbine are influenced by 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 have remained generally 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).

Based on the above, the noise emissions presented in Table 23 and Table 24 are suitable for a planning stage assessment of the wind farm. However, if the project is ultimately approved, the noise modelling would need to be updated to:

- reflect the sound power levels of the final layout, hub height and wind turbine model selected for the project
- assess compliance with the noise limits specified in the conditions of approval
- determine the mitigation strategies which would apply with the selected wind turbine, if required.

9.3.2 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 nominated candidate wind turbine model. However, the occurrence of tonality in the noise of contemporary multi-megawatt wind turbine designs is unusual. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical.

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

Given the above, adjustments for special audible characteristics have not been applied to the predicted noise levels presented in this assessment. 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 (see mitigation measures documented subsequently in Section 11.0). Specifically, where manufacturer sound power level test data is available for the proposed final turbine selection, the tonality data for the turbine would be reviewed and assessed as part of the pre-construction wind turbine noise assessment for the project. Tonality would also be subject to further review and evaluation as part of the sound power level testing proposed during the early stages of construction. A complete assessment of all special audible characteristics, including amplitude modulation, impulsiveness and tonality would then be conducted as part of the post-constructing noise monitoring required under the EP Regulations.

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[14] 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

9.4 Predicted noise levels

This section presents the predicted wind turbine noise levels associated with the project at surrounding receivers and natural areas.

9.4.1 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 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 project have been predicted using the sound power level data detailed in Section 9.3.1 for the nominated candidate turbine model and are summarised in Table 25 for the wind speeds which result in the highest predicted noise levels.

The locations of the predicted 30, 35, 40 and 45 dB L_{A90} noise contours are illustrated in Figure 9, corresponding to the hub height wind speed which results in the highest predicted noise levels.

Predicted noise levels for each integer wind speed are tabulated in Table 49 of Appendix J for all considered receivers, including receivers where the highest predicted noise level is below 30 dB L_{A90}.

Table 25: Highest predicted wind turbine noise levels at receivers with predicted levels 30 dB L_{A90} or above

Receiver	Highest predicted noise level, dB L_{A90}
Non-stakeholder receivers	
D36	32.9
D37	33.1
D39	34.3
D202	30.6
D205	33.4
D294	34.8
D295	31.0
D296	32.7
D299	34.8
D300	30.9
D301	31.1
D314	30.6
D319	30.4
D336	32.9
D337	33.7
D339	32.1
D341	32.4

Receiver	Highest predicted noise level, dB L_{A90}
D345	34.3
D352	30.4
D367	32.9
D368	31.2
D400	31.1
D402	31.4
D404	34.5
D413	34.4
D414	30.9
D419	33.6
D420	32.4
D421	33.2
D424	33.4
D425	33.5
D426	33.6
D431	31.5
D432	30.4
D435	32.7
D436	31.7
D437	32.6
D445	32.9
D465	32.9
D477	30.8
D574	30.2
D620	39.6
D622	38.9
D623	31.8
Stakeholder receivers outside the project boundary	
D38 (S)	31.4
D340 (S)	30.5
D362 (S)	36.6

Receiver	Highest predicted noise level, dB L_{A90}
Stakeholder receivers within the project boundary	
D32 (S)	34.6
D34 (S)	37.1
D35 (S)	35.3
D40 (S)	37.3
D197 (S)	39.0
D203 (S)	31.5
D297 (S)	35.3
D298 (S)	38.3
D338 (S)	36.6
D343 (S)	37.6
D344 (S)	34.4
D355 (S)	37.9
D356 (S)	36.9
D357 (S)	40.0
D359 (S)	35.3
D361 (S)	37.6
D366 (S)	39.5
D378 (S)	40.0
D379 (S)	37.8
D380 (S)	43.4
D395 (S)	36.3
D396 (S)	38.2
D397 (S)	39.5
D398 (S)	36.8
D403 (S)	30.1
D417 (S)	38.6
D418 (S)	38.2
D422 (S)	40.0
D423 (S)	40.1
D428 (S)	37.8
D429 (S)	37.3
D430 (S)	37.6
D438 (S)	43.1

Receiver	Highest predicted noise level, dB L_{A90}
D441 (S)	39.9
D442 (S)	39.3
D444 (S)	36.6
D446 (S)	34.5
D447 (S)	37.1
D448 (S)	36.0

(S) Stakeholder receiver

The results presented in Table 25 demonstrate that wind turbine noise levels associated with the project are predicted to comply with the noise limits for all receivers.

Specifically, the predicted wind turbine noise levels are:

- below the applicable base noise limit of 40 dB L_{A90} by at least 0.4 dB at all non-stakeholder receivers
- below the applicable base noise limit of 45 dB L_{A90}, by at least 8.4 dB at all stakeholder receivers outside the project boundary where a noise agreement is proposed.

  Also, considering the predicted noise levels are at least 3.4 dB below the base noise limit of 40 dB L_{A90} applicable to non-stakeholders, a noise agreement is not required to achieve compliance with the EP Regulations.
- below the reference base noise level of 45 dB L_{A90} by at least 1.6 dB at all stakeholder receivers within the project boundary.

Supplementary noise modelling is presented in Appendix K to provide an indication of how wind turbine noise levels would vary with wind direction. This directional analysis has been carried out to provide context to the predicted noise levels presented in this section, which are solely based on worst-case wind direction.

9.4.2 Natural areas

With respect to operational noise of the project in natural areas, the primary consideration is noise from wind turbines which would most likely be audible on some occasions at locations where wind turbine noise levels are above 30 dB L_{A90}.

The nearest identified natural area to the project is Lake Connewarren and the highest predicted noise level at this location is 26 dB L_{A90}. Wind turbine noise at this level may be audible at times, but this would depend on wind conditions and the specific characteristics of the background environment. On the limited occasions when wind turbine noise may be audible, it is likely to be difficult to distinguish from other ambient noise sources, particularly in the presence of any wind disturbance of vegetation in the area.

The distribution of wind turbine noise levels in the identified natural areas is presented in Figure 10.

9.4.3 Cumulative assessment

Due to the significant separating distance to the nearest approved and/or operating wind farm detailed in Section 5.3, cumulative assessment of noise levels from the project and other surrounding wind farm(s) is not warranted.

9.5 Mitigation measures and risk assessment

Based on the findings in the previous sections, the recommended mitigation measures for addressing operational wind turbine noise are:

- EMM-NV04: Pre-construction noise assessment of wind turbines

  The purpose of this mitigation measure is to establish a requirement for a pre-construction assessment of operational noise associated with the project's wind turbines, based on the final wind turbine layout and model selection. Results of the pre-construction assessment would be documented in the NMP prepared under EMM-NV06.

- EMM-NV05: Schedule of sound power level testing

  The purpose of this mitigation measure is to establish a requirement to conduct early testing of a representative selection of wind turbines to verify that the noise emissions (sound power levels) of the installed wind turbines are consistent with the pre-construction noise assessment prepared under EMM-NV04.

- EMM-NV06: Noise management plan

  Establishes a requirement to prepare the noise management plan (NMP) for operational wind turbine noise, as required under the EP Regulations, prior to commencement of operation of the facility.

Accounting for the assessment findings and the proposed mitigation measures, an assessment of risk associated with operational wind turbine noise is presented in Table 26.

Table 26: Wind turbine noise – risk assessment

Item	Rating		Comments
	Inherent	Residual	
Consequence	Minor	Minor	The predicted noise levels are below the applicable noise limits for non-stakeholder and stakeholder locations.
Likelihood	Possible	Unlikely	The predicted noise levels are approaching the noise limits at 2 non-stakeholder receivers, but are below the applicable noise limits by clear margins at all other receivers. There are however extensive controls in place (proposed and regulatory) so that the project would be designed and operated within the applicable noise limits.
Overall rating	Medium	Low	The applicable EPA Publication 1695.1 guidance for the residual risk rating is: *Acceptable level of risk. Attempt to eliminate risk but higher risk levels take priority.*

Figure 9: Highest predicted noise level contours, dB L_{A90}

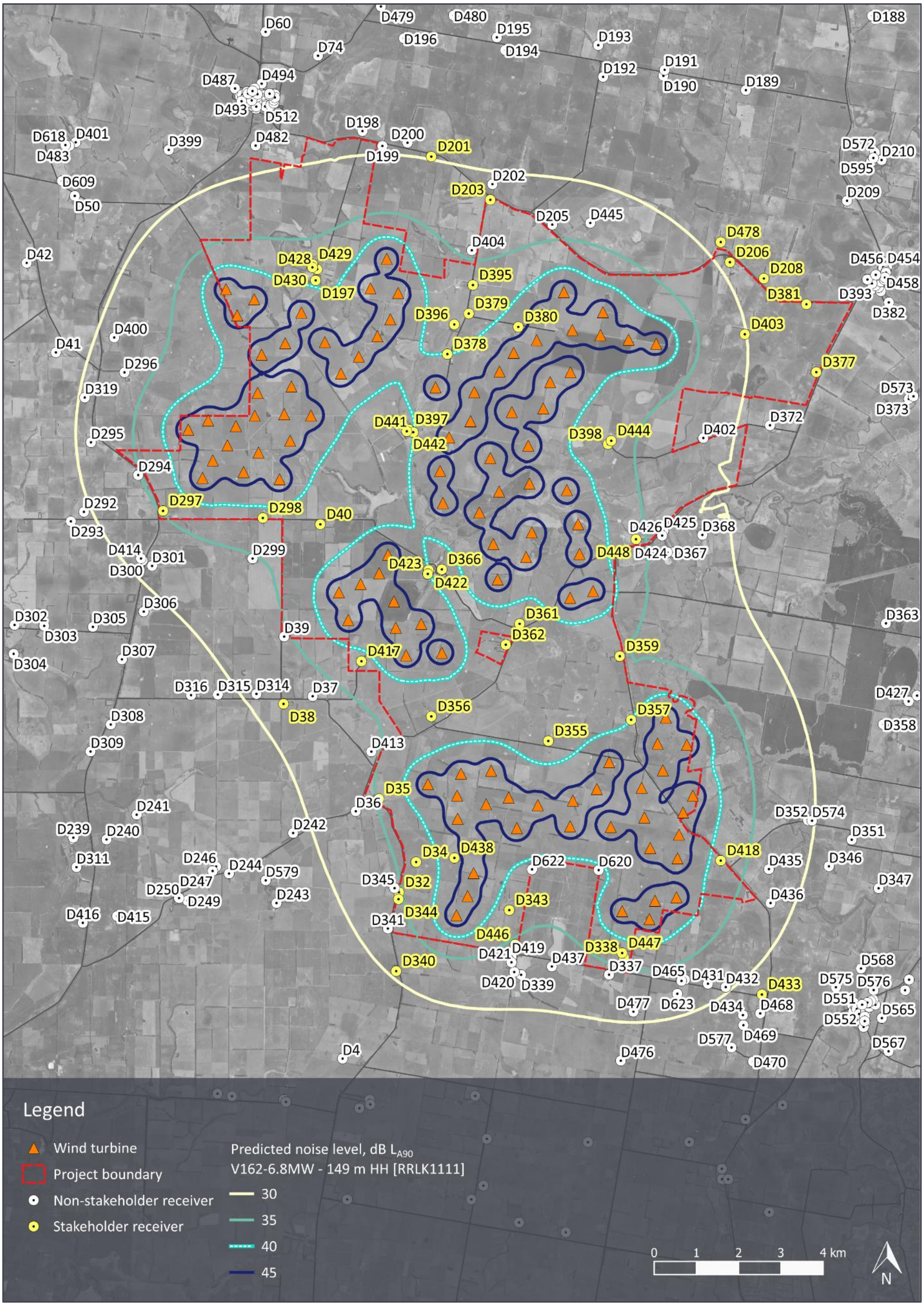


Figure 10: Predicted operational wind turbine noise levels and identified natural areas

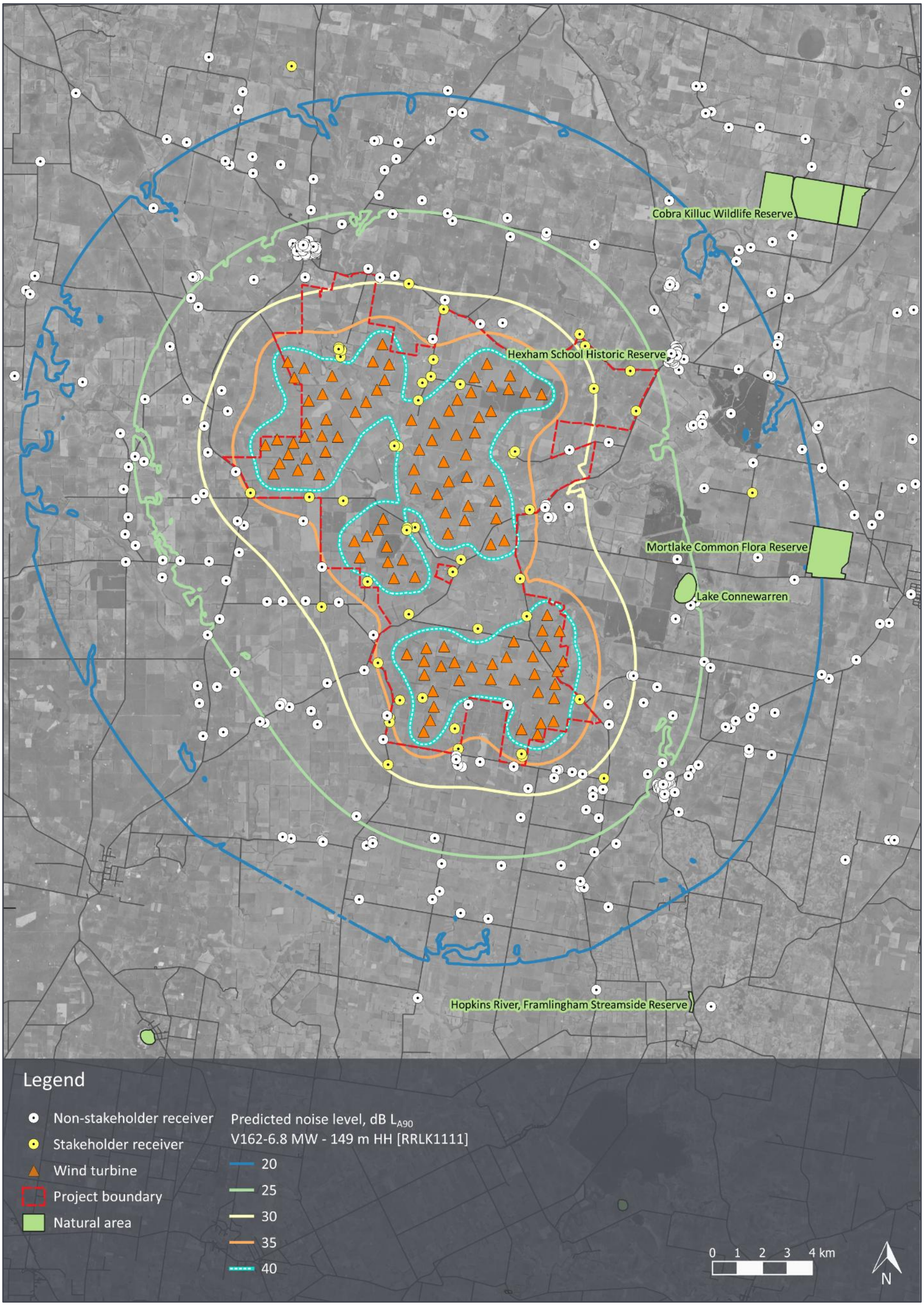
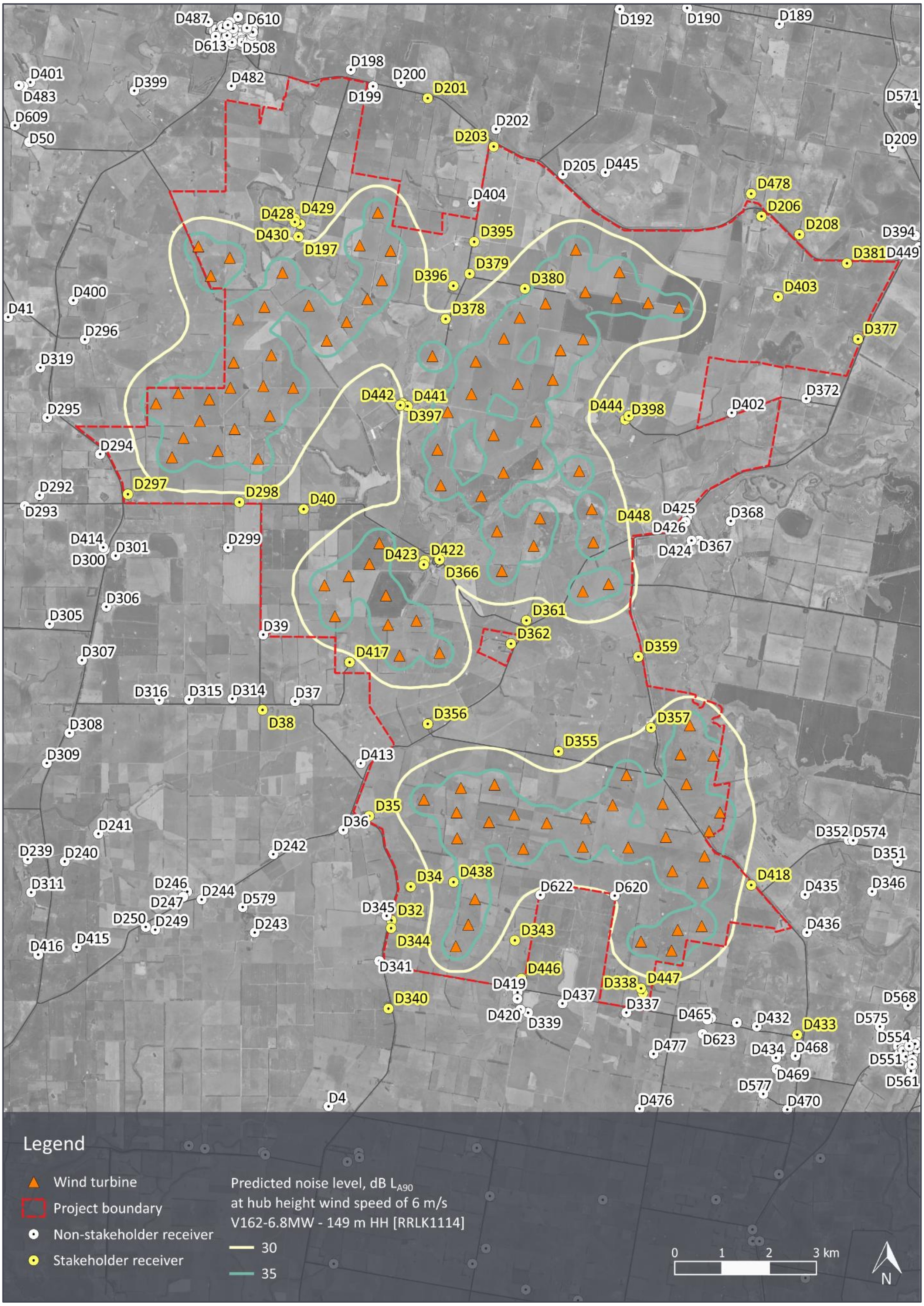


Figure 11: Predicted noise level contours at hub height wind speed of 6 m/s, dB L_{A90}



10.0 OPERATIONAL NOISE ASSESSMENT – TERMINAL STATION AND BESS

This section presents an assessment of operational noise from the on-site terminal station and BESS associated with the wind farm. The terminal station and the BESS are co-located within the project boundary.

A site layout plan illustrating the on-site terminal station and BESS and receivers is provided in Figure 3 of Section 5.1.

10.1 Assessment criteria

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

- Operation of the terminal station 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 terminal station 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 on-site terminal station and BESS (i.e. low wind speeds) are relatively 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 on-site terminal station and BESS are located on land designated as Farming Zone (FZ) (see land zoning map in Appendix I), the noise limits applicable at the nearest receivers are summarised in Table 27.

Table 27: Noise Protocol time periods and noise limits, dB ENL

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

As the on-site terminal station and BESS are proposed to operate 24 hours a day and 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.

10.2 Noise emissions

10.2.1 Terminal station

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

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 3 transformers, each with a rating of 280 MVA, would be representative.

10.2.2 BESS

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 has been developed by the proponent. Based on information provided by the Proponent, it is understood that this concept layout corresponds with a capacity of 200 MW / 800 MWh.

The concept comprises a layout of separate inverters, medium voltage (MV) transformers and battery modules. The concept layout, indicating the number and position of each equipment item alongside the terminal station HV transformers, is shown in Figure 12.

A summary of the relevant information is shown in Table 28.

Table 28: BESS equipment details

Equipment item	Quantity
Battery	256
Inverter	64
MV transformer (4.2 MVA)	64

10.2.3 Sound power level data

Sound power levels for individual equipment items, as used in the noise model, are detailed in Table 29. Data is provided as un-weighted (linear) octave band spectra and A-weighted overall sound power level.

Manufacturer sound power level data for battery and inverter units has been taken from MDA's noise database. Noise associated with transformers has been derived considering appropriate technical standards. Further detail is provided in Table 30.

Table 29: 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	L_{WA}
Transformer station								
HV transformer (280 MVA)	95	97	92	92	86	81	76	92
BESS								
Battery	93	90	79	75	76	70	65	81
Inverter	62	67	74	71	70	78	87	88
MV transformer (4.2 MVA)	77	79	74	74	68	63	58	75

Figure 12: Terminal station/BESS concept noise source layout

Table 30: Sound power level data description

Item	Description
Terminal station	
HV transformer (280 MVA)	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, MDA understands that 3 HV transformers are proposed for the project, each expected to be rated at 280 MVA. In the absence of measured sound power level data for a specific transformer model, reduced maximum sound power levels have been estimated, based on the nominated power rating, using the method described in Annex ZA of AS 60076-10:2023. Octave band spectral data 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 sound power level.
BESS	
Battery	Manufacturer third octave band sound power levels measured in accordance with ISO 3744:2010 associated with a containerised battery system have been sourced from MDA library data. [15] The noise data aligns with 100% operation of the subject battery, i.e. worst-case sound power level. Noise data associated with the selected battery unit is towards the lower 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 have been sourced from MDA library data. The noise data aligns with 100% operation of the subject inverter, i.e. worst-case sound power level and is inclusive of an OEM noise attenuation kit. Noise data associated with the selected inverter is at the lower end of the range of sound power levels exhibited on the market.
MV transformer (4.2 MVA)	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, MDA understands that the MV transformers proposed for the project are expected to be rated at approximately 4.2 MVA. In the absence of measured sound power level data for a specific transformer model, reference has been made to the standard maximum method for estimating overall transformer sound power levels for a given power rating described in AS 60076-10:2023. [16] Octave band spectral data 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 sound power level. [17]

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.

[15] 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*

[16] AS 60076-10:2023 *Power transformers – Part 10: Determination of sound levels (IEC 60076-10:2016 (ED. 2.0) MOD)*

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

10.3 Predicted noise levels

The predicted noise levels in this section primarily relate to total A-weighted noise levels with adjustments for assessable characteristics under the Noise Protocol.

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 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 10.4 and in further detail in Section 11.0.

10.3.1 Receivers

Predicted effective noise levels at all receivers within 3 km of the proposed on-site terminal station and BESS are detailed in Table 31.

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

Table 31: Predicted effective noise levels from terminal station and BESS at receivers within 3 km

Receiver	Nearest item	Distance to nearest item, m	Terminal station, dB L_{Aeq}	BESS, dB L_{Aeq}	Terminal station + BESS, dB ENL [a]
Non-stakeholder receivers					
D413	BESS	2,632	12	21	24
Stakeholder receiver outside the project boundary					
D362	BESS	1,091	21	31	33
Stakeholder receivers within the project boundary					
D355	Terminal station	2,151	15	22	25
D356	Terminal station	994	23	31	34
D361	BESS	1,668	11	21	23
D366	BESS	2,579	<10	16	18
D417	BESS	2,288	<10	17	19
D422	BESS	2,658	<10	16	18
D423	BESS	2,577	<10	16	19

a Includes +2 dB adjustment for tonality

The effective noise levels in Table 31 are predicted below the applicable night-time noise limit set out in Table 27 of Section 10.1 by at least 9 dB at all receivers with the exception of 2 stakeholder receivers. At these receivers, effective noise levels are predicted at or within 1 dB of the night-time noise limit.

The following contextual notes are provided:

- The predicted effective noise levels conservatively assume concurrent worst-case operation of the BESS and transformer station (i.e. 100% fan duty). In practice this is unlikely to occur particularly during the night period.
- Effective noise levels associated with reduced duties would result in lower noise levels than that shown in Table 31.
- A +2 dB adjustment for tonality has been assumed at all receivers in order to provide a conservative assessment. For many receivers the predicted effective noise levels are very low and would be comparable to or less than background noise levels in many instances. The adjustment for tonality may therefore not be applicable if the tonal character of the on-site terminal station 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 prominent at the receiver), additional noise control treatment measures would be required to minimise the risk of harm from noise and achieve compliance with the noise limits at all receivers.

These results indicate that the proposed on-site terminal station and BESS associated with the project are capable of being designed and operated such that the applicable noise limits are achieved.

Sound power levels associated with the inverters and battery units currently incorporated into the preliminary project design can range significantly depending on the demand on the unit. Sound power levels are directly related to the fan speed of the cooling systems. The fan speed, in turn, is directly linked to a number of factors including charge/discharge rate and ambient temperature. The units are designed such that worst-case operation, i.e. 100% fan speed, is likely to occur during elevated ambient temperatures and full rate charge/discharge conditions.

At this stage, prior to finalisation of the project design and equipment selections, it is not practical or feasible to definitively determine the range of operational conditions likely to occur at the project. On this basis, and to provide a conservative assessment, the noise model has been developed with reference to the maximum sound power levels associated with the selected inverters and battery units - as outlined in Table 30 - as theoretically occurring during the night period. Based on this, the noise model represents the expected upper limit of noise levels that would result from the project based on the current site design and equipment selections. On this basis, the indicated marginal compliance of the upper limit noise model is not expected be a constraining factor for the project.

Based on typical night-time ambient temperatures, it is known that 100% fan duty operation is highly unlikely to occur, and that noise levels at night will be lower than the worst-case predictions for a majority, if not all night-time periods.

Notwithstanding the above, the predicted noise levels should be reviewed at the time when the project design, equipment numbers and selections are finalised, accounting for manufacturer noise emission data and reducing the preliminary conservative assumptions adopted in this assessment (e.g. related to noise modelling based on 100% fan speed which would not occur at night in practice). This may include consideration of representative operational duties in respective time periods (in lieu of the conservative 100% operational duty adopted herein) and discrete assessment of tonality on a receiver by receiver basis. Given the conservative assumptions, and indicated marginal compliance, it is expected the project would afford flexibility with respect to layout design and equipment procurement during detailed design and tender.

Further, the low predicted noise levels indicate noise from the on-site terminal station and BESS is unlikely to represent a risk of harm to the environment as a result of noise. The general environmental duty under the EP Act is therefore expected to be addressed through selection of equipment with low noise emissions, and the inclusion of OEM noise attenuation kits where practical. As an example, transformer should be selected with noise emissions equivalent to, or lower than, the AS 60076-10 empirical values referenced in of Section 10.2.3. Given that actual noise emission values for contemporary transformer designs are usually lower than the empirical values of the standard, this is considered a reasonably practicable noise mitigation measure for the purposes of the EP Act.

10.3.2 Natural areas

Noise associated with the operation of the terminal station 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 level 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 proposed terminal station and BESS locations.

Predicted cumulative noise contours are presented in Figure 13 and provide an indication of the extent of the areas in which noise from the terminal station and BESS may be audible at natural areas.

It is noted that the nearest natural area considered within this assessment is located approximately 10 km away from the proposed terminal station and BESS location. Notwithstanding this, the predicted noise contours shown in Figure 13 indicate that the cumulative terminal station and BESS noise level is predicted to be significantly below 10 dB ENL at the nearest natural area (Lake Connewarren). As such, operation of the terminal station and BESS is expected to not be audible during all assessment periods at the identified natural areas in the vicinity of the project.

10.3.3 Cumulative assessment

Consideration has also been given to the potential cumulative noise of the terminal station and BESS in combination with the other existing and approved industrial premises in the surrounding area identified in Section 5.3. Specifically, the:

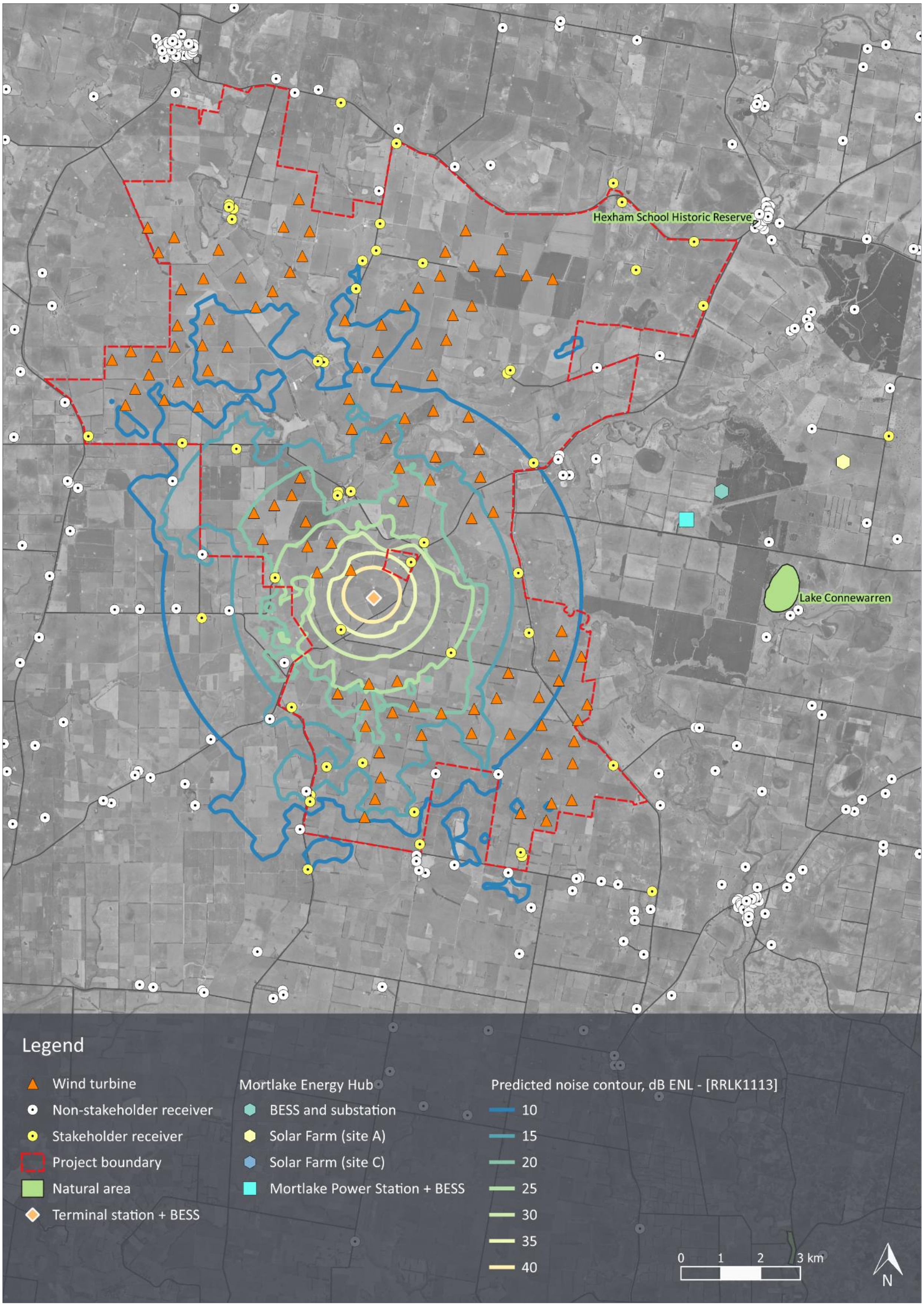
- operational Mortlake Power Station is also located approximately 4 km to the east of the project
- approved Mortlake Energy Hub, adjacent to the Mortlake Power Station
- approved Mortlake Power Station BESS, on the eastern side of the Mortlake Power Station site.

It is noted that the minimum distance between the noise generating infrastructure associated with the terminal station and BESS and the other projects identified above is approximately 8 km.

This means that the nearest receivers to the terminal station and BESS are sufficiently far from the other projects such that the noise from these sites is not expected to approach the noise limits, particularly due to the proximity of other receivers nearer to them which would dictate their noise control requirements.

Further, as shown in Figure 13, at the receivers to the east of the project that are nearest to the other projects, the combined predicted noise levels of the on-site terminal station and BESS is less than 10 dB ENL and therefore would not materially affect the compliance margins for these receivers.

Figure 13: Predicted BESS/terminal station effective noise level contours, dB ENL



10.4 Mitigation measures and risk assessment

Based on the findings in the previous sections, the recommended mitigation measure for addressing construction noise and vibration is to establish a requirement for a pre-construction noise assessment of the on-site terminal station and BESS (MM–NV07). The purpose of this requirement is to verify the controls that would be used to minimise operational noise risks as far as reasonably practicable, and verify compliance with the applicable noise limits, based on the actual equipment selections and final plant arrangement. The full requirements of the pre-construction noise assessment of this plant are documented in Section 11.0 within a consolidated list of mitigation measures for the project.

Accounting for the assessment findings and the proposed mitigation measures, an assessment of risk associated with cumulative operational noise from the terminal station and BESS is presented in Table 32.

Table 32: Cumulative operational noise from the terminal station and BESS – risk assessment

Item	Rating		Comments
	Inherent	Residual	
Consequence	Minor	Minor	The predicted noise levels are below the applicable noise limits at all non-stakeholder receivers. Further, the predicted noise levels are also low and are likely to be comparable to or lower than the background noise level at most receivers. In particular, at non-stakeholder receivers, the predicted noise levels are likely to be well below the background noise level. The predicted noise levels are also generally well within the applicable noise limits at stakeholder receivers. The only exception is 2 of the nearest stakeholder receivers where the predicted noise levels are at or within 1 dB of the night period noise limit. The above are the decisive factors in determining the risk consequence. However, obligations with respect to the GED and unreasonable noise provisions of the EP Act remain applicable, particularly with respect to the control of any audible characteristics such as tonality and low frequency noise.
Likelihood	Unlikely	Unlikely	There is a clear margin between the predicted noise levels and the noise limits at all non-stakeholder receivers. While predicted noise levels are close to the night period noise limits at the 2 nearest stakeholder receivers, this is conservatively based on 100% fan speeds at night which is unlikely to occur in practice. The mitigation measures also include additional controls so that the compliant outcomes are maintained through the design and operational stages of the project.
Overall rating	Low	Low	The applicable EPA Publication 1695.1 guidance for the residual risk rating is: *Acceptable level of risk. Attempt to eliminate risk but higher risk levels take priority.*

11.0 MITIGATION MEASURES

Based on the assessment findings presented in this preceding sections, the recommended mitigation measures for the control of noise and vibration associated with construction and operation of the project are detailed in Table 33. The mitigation measures establish requirements at each stage of the project from design through to ongoing operation and decommissioning.

The objective of the mitigation measures is to minimise the risk of harm from noise and vibration associated with construction and operation of the project, so far as reasonably practicable, in accordance with the GED under the EP Act. The risks to be minimised, under the EP Act, include adverse effects on both human health and amenity.

Table 33: Recommended noise and vibration mitigation measures

EMM ID	Mitigation measure
EMM-NV01	Construction noise and vibration management plan 1. Prior to the commencement of development, a construction noise and vibration management plan (CNVMP) will be prepared as a sub-plan to the construction environmental management plan (EMM01) to address the effects of construction noise related to on-site activities and off-site traffic movements, and construction vibration associated with any activities expected to occur at less than 100 m from a receiver. 2. The CNVMP will include the following: a. A clear description of the proposed construction program including the expected timing and duration of key elements of the works. b. Details of all reasonably practicable measures proposed to fulfil the general environmental duty under the *Environment Protection Act 2017* (EP Act), accounting for guidance under EPA Publication 1834.2 *Civil construction, building and demolition guide.* The measures will include (but not be limited to): i. restriction of construction activities to normal working hours wherever practical ii. selection of major construction plant to achieve low noise emissions and minimise any distinctive undesirable characteristics iii. maintenance of site equipment and infrastructure to minimise noise emissions iv. planning for the most efficient way to complete the works and minimise duration of the noise v. processes and governance for addressing the general environmental duty (GED), with particular reference to any out of hours work. c. A schedule of noise emission data for the major plant items to be used for construction of the project, including the source reference for this data. d. Definition and justification for all anticipated unavoidable works, low-noise works and managed-impact works which may occur outside of normal working hours, such as out of hours deliveries or wind turbine installation activities that are subject to weather constraints. e. Details relating to proposed routing and timing of construction traffic, including protocols to minimise noise along local roads and within Mortlake to the extent reasonably practicable. This will establish a restriction to avoid heavy vehicle movements related to construction aggregate sourcing from local quarries (if required) prior to 0700 hrs on the local road network around the project or within local townships. f. Management measures relating to off-site vehicle movements including education of drivers about the general environmental duty under the EP Act and considerate driving practices. g. Details of the measures to be implemented to address noise characteristics such as tonality, impulsive noise and low frequency noise, including consideration of residential receivers and noise levels in natural areas. h. The proposed scheduling of any out of hours works, and provide evidence to support that low-noise or managed-impact works meet the criteria defined in EPA Publication 1834.2. i. Identification of specific activities which warrant notification of neighbouring residents in advance of the work occurring, including unavoidable works outside of normal working hours, peak periods of off-site construction traffic, and activities with potential to cause perceptible vibration. j. Details of the complaints management procedure as part of the complaints and grievance mechanism (EMM-SE02). k. Requirements for periodic reviews and updates, as necessary, including those informed by complaints and any remedial actions taken in response to the Complaints and Grievance Mechanism (SE02). 3. The CNVMP will be prepared in consultation with relevant stakeholders, including the EPA.

EMM ID	Mitigation measure
EMM-NV02	Quarry work plan 1. Prior to the commencement of development, a quarry noise management plan will be prepared in consultation with relevant authorities and endorsed as part of the quarry work plan (EMM07). 2. The quarry noise management plan will document measures to: a. minimise the risk of harm from operational noise so far as reasonably practicable, in accordance with the general environmental duty under the *Environment Protection Act 2017* (EP Act). b. prevent prescribed unreasonable noise by complying with noise limits determined in accordance with EPA publication 1826.5 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol). c. prevent unreasonable noise according to the factors defined in part (a) of the definition of unreasonable noise in section 3(1) of the EP Act, accounting for the low frequency guidance of EPA Publication 1996 *Noise guidelines: assessing low frequency noise* (as amended or replaced from time to time).
EMM-NV03	Concrete batching plants – noise management 1. All temporary concrete batching plants will be designed and operated in accordance with the general management measures in EPA Publication 1806 *Reducing risk in the premixed concrete industry*. 2. The design and operation of the batching plants will implement measures to: a. minimise the risk of harm from operational noise so far as reasonably practicable, in accordance with the general environmental duty under the Environment Protection *Act 2017* (EP Act). b. prevent prescribed unreasonable noise by complying with noise limits determined in accordance with EPA publication 1826.5 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol). c. prevent unreasonable noise according to the factors defined in part (a) of the definition of unreasonable noise in section 3(1) of the EP Act, accounting for the low frequency guidance of EPA Publication 1996 *Noise guidelines: assessing low frequency noise* (as amended or replaced from time to time).
EMM-NV04	Pre-construction noise assessment - wind turbines 1. Prior to the installation of wind turbines, a pre-construction noise assessment will be completed. This assessment will be undertaken to assess the final project layout and equipment selection to ensure that the noise criteria are achieved at all assessable receivers for all wind speeds. 2. The pre-construction noise assessment will: a. be based on the final wind turbine layout, representative noise emission data for the final selected wind turbine model and the location of all receivers surrounding the wind farm (existing or approved noise sensitive receivers at the date of the time of project approval). b. identify all stakeholder receivers where noise agreements have been established. c. be prepared in accordance with the assessment and documentation requirements of NZS 6808:2010 *Acoustics – Wind farm noise*. d. be verified by an EPA appointed independent environmental auditor in accordance with regulation 52.32-4 of the Moyne Planning Scheme. e. be documented in the operational noise management plan prepared under EMM-NV06.

EMM ID	Mitigation measure
EMM-NV05	Wind turbine sound power level testing 1. Prior to commencement of wind turbine operations, a schedule of sound power level testing and reporting will be prepared. This will be undertaken to verify that the noise emissions of a representative selection of installed wind turbines are consistent with the noise emissions presented in the pre-construction noise assessment prepared under EMM-NV04. 2. An EPA appointed independent environmental auditor (IEA) will be engaged to prepare a report verifying the schedule of sound power level testing. 3. The schedule of sound power level testing and the IEA's verification report will be provided to EPA upon request. Sound power level testing and reporting will subsequently be undertaken in accordance with the schedule.
EMM-NV06	Operational noise management plan 1. Prior to commencement of wind turbine operations, an operational noise management plan (NMP) will be prepared for operational wind turbine noise in accordance with the requirements of regulation 131E of the *Environment Protection Regulations 2021* (EP Regulations), as a sub-plan to the operations environmental management plan (EMM09). 2. In accordance with the EP Regulations, the Operational Noise Management Plan will include requirements for an annual statement detailing the actions undertaken to ensure compliance, and noise monitoring to be undertaken every five years (or as otherwise specified in the EP Regulations) to verify compliance with the applicable noise limits). 3. In addition to the requirements of the EP Regulations, the NMP will: a. document the pre-construction noise assessment conducted under EMM-NV04 b. account for the guidance of EPA webpage *Wind Energy Facility Turbine Noise Regulation Guidelines* and EPA-DTP Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline* c. stipulate that the post-construction noise monitoring report and the accompanying auditor's verification report will, where practicable, be submitted to the EPA within 10 days of the auditor's verification report being completed d. include requirements for periodic reviews and updates, as necessary, including those informed by complaints and any remedial actions taken in response to the Complaints and Grievance Mechanism (SE02). 4. An EPA appointed independent environmental auditor (IEA) will be engaged to prepare a report verifying the NMP. 5. Both the NMP and the IEA's verification report will be provided to EPA upon request.
EMM-NV07	Pre-construction noise assessment - on-site terminal station and battery energy storage system 1. Prior to commencement of construction, a pre-development noise assessment is to be submitted to the Responsible Authority demonstrating that the design and operation of the on-site terminal station and battery energy storage system (BESS) include measures to: a. minimise the risk of harm from operational noise so far as reasonably practicable, in accordance with the general environmental duty under the *Environment Protection Act 2017* (EP Act). b. prevent prescribed unreasonable noise by complying with noise limits determined in accordance with EPA publication 1826.5 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* (Noise Protocol). c. prevent unreasonable noise according to the factors defined in part (a) of the definition of unreasonable noise in section 3(1) of the EP Act, accounting for the low frequency guidance of EPA Publication 1996 *Noise guidelines: assessing low frequency noise* (as amended or replaced from time to time).

EMM ID	Mitigation measure
EMM-NV08	1. A decommissioning noise and vibration management plan will be prepared and submitted to the Responsible Authority for endorsement. This will be a sub-plan to the decommissioning management plan (EMM10) and will: a. provide a detailed assessment of decommissioning noise and vibration from project activities b. outline proposed measures to minimise potential impacts.

12.0 SUMMARY

An assessment has been undertaken of the potential noise and vibration impacts associated with construction, operation and decommissioning of the Hexham Wind Farm within the study area.

The assessment addresses the environmental noise and vibration assessment requirements of the *Scoping Requirements Hexham Wind Farm Environment Effects Statement* published by the Minister for Transport and Planning in September 2024. It is based on evaluation of potential noise and vibration impacts in accordance with applicable Victorian assessment criteria.

The EES evaluation objective for the Hexham Wind Farm with respect to noise and vibration is to manage potential adverse effects for noise sensitive locations, having regard to both construction and operation of the wind farm.

In particular, the results of the modelling demonstrate that the proposed wind turbines are predicted to achieve compliance with the applicable noise limits determined in accordance with NZS 6808 for all receivers based on a candidate wind turbine model.

The assessment has also considered operational noise associated with the proposed on-site terminal station and BESS, in accordance with EP Act and EP Regulations. The assessment demonstrates that the operational noise levels from the on-site terminal station and BESS are predicted below the noise limits determined in accordance with the Noise Protocol.

Noise and vibration during the construction and decommissioning of the project has been assessed and can be satisfactorily addressed with good practice measures, accounting for the guidance of EPA Publication 1834.2 and subject to dedicated controls to address the noise of off-site construction traffic. In this respect, the preferred option for the project includes the development of an on-site quarry to limit off-site vehicle movements associated with material sourcing. Restriction of the times when these movements can occur on the surrounding road network have also been recommended.

The assessment has also considered the proposed on-site quarry and concrete batching plants, in accordance with the Noise Protocol. The results demonstrate that the predicted noise levels associated with operation of the on-site quarry and concrete batching plants during the construction period are below the noise limits determined in accordance with the Noise Protocol.

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

Implementation of the recommended mitigation measures will minimise the noise and vibration impact of the Hexham Wind Farm to nearby noise sensitive locations.

The findings of the noise assessment therefore demonstrate that the project can comply with the requirements of the applicable Victorian legislation and guidelines. As such, the project is expected to achieve the EES evaluation objective.

APPENDIX A GLOSSARY OF TERMINOLOGY

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.

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 1826.5 *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}
Frequency spectrum	The collection of frequencies that a sound is composed of, and the sound power level or sound pressure levels across these frequencies. Under the Environment Protection Regulations 2021 (Vic), frequency spectrum is a prescribed factor for noise emitted from commercial industrial and trade premises. This means that the frequency spectrum of noise associated with this type premises is a relevant factor to consider when assessing if the noise is unreasonable under the Environment Protection Ac (2017).	-
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.	-
Peak particle velocity	The measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment.	PPV
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

Term	Definition	Abbreviation
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).	-
Vibration	When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into the vertical direction (up and down vibration), the horizontal transverse direction (side to side) and the horizontal longitudinal direction (front to back).	-
Vibration Dose Value	Based on British Standard BS 6472:1992 *Guide to Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)* and provides guidelines for the evaluation of whole-body exposure to intermittent vibration. VDV can be used to take into account the weighted measured RMS vibration from many vibration sources including rail vehicles, construction equipment such as jackhammers and industry. VDV takes into account the duration of each event and the number of events per day, either at present or in the foreseeable future and calculates a single value index.	VDV

APPENDIX B DESCRIBING SOUND

Sound is an important feature of the environment in which we live; it provides information about our surroundings and influences our overall perception of amenity and environmental quality.

While sound is a familiar concept, its description can be complex. This appendix provides general information about the definition of sound and the ways that different sound characteristics are described.

B1 Definition of sound

Sound is a term used to describe very small and rapid changes in the pressure of the atmosphere. Importantly, for pressure fluctuations to be considered sound, the rise and fall in pressure needs to be repeated at rates ranging from tens to thousands of times per second.

These small and repetitive fluctuations in pressure can be caused by many things such as a vibrating surface in contact with the air (e.g. the cone of a speaker) or turbulent air movement patterns. The common feature is a surface or region of disturbance that displaces the adjacent air, causing a very small and localised compression of the air, followed by a small expansion of the air.

These repeated compressions and expansions then spread into the surrounding air as waves of pressure changes. Upon reaching the ear of an observer, these waves of changing pressure cause structures within the ear to vibrate; these vibrations then generate signals which are able to be perceived as sounds.

The waves of pressure changes usually occur as complex patterns, comprising varied rates and magnitudes of pressure changes. The pattern of these changes will determine how a sound spreads through the air and how the sound is ultimately perceived when it reaches the ear of an observer.

B2 Physical description of sound

There are many situations where it can be useful to objectively describe sound, such as the writing or recording of music, hearing testing, measuring the sound environment in an area or evaluating new man-made sources of sound.

Sound is usually composed of complex and varied patterns of pressure changes. As a result, a number of attributes are used to describe sound. Two of the most fundamental sound attributes are:

- sound pressure
- sound frequency

Each of these attributes is explained in the following sections, followed by a discussion about how each of these attributes varies.

B2.1 Sound pressure

The compression and expansion of the air that is associated with the passage of a sound wave results in changes in atmospheric pressure. The pressure changes associated with sound represent very small and repetitive variations that occur amidst much greater pressures associated with the atmosphere.

The magnitude of these pressure changes influences how quiet or loud a sound will be; the smaller the pressure change, the quieter the sound, and vice versa. The perception of loudness is complex though, and different sounds can seem quieter or louder for reasons other than differences in pressure changes.

To provide some context, Table 34 lists example values of pressure associated with the atmosphere and different sounds. The key point from these example values is that even an extremely loud sound equates to a change in pressure that is thousands of times smaller than the typical pressure of the atmosphere.

Table 34: Atmospheric pressure versus sound pressure – example values of pressure

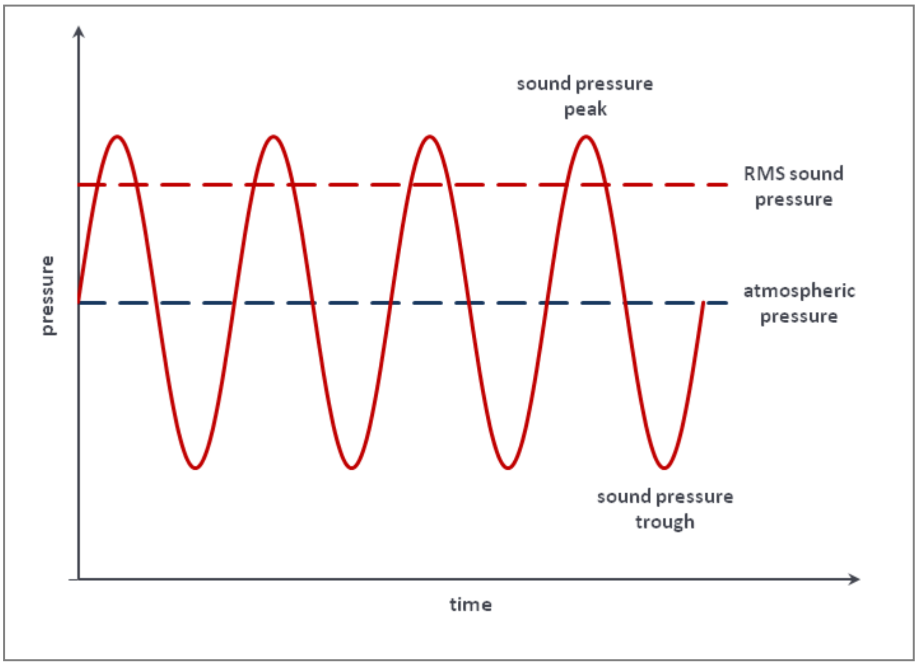
Example	Pascals, Pa	Bars	Pounds per Square Inch (PSI)
Atmospheric pressure	100,000	1	14.5
Pressure change due to weather front	10,000	0.1	1.5
Pressure change associated with sound at the threshold of pain	20	0.0002	0.003
Pressure change associated with sound at the threshold of hearing	0.00002	0.0000000002	0.000000003

The pressure values in Table 34 also show that the range of pressure changes associated with quiet and loud sounds span over a very large range, albeit still very small changes compared to atmospheric pressure. To make the description of pressure changes more practical, sound pressure is expressed in decibels or dB.

To illustrate the pressure variation associated with sound, Figure 14 shows the repetitive rise and fall in pressure of a very simple and steady sound. This figure illustrates the peaks and troughs of pressure changes relative to the underlying pressure of the atmosphere in the absence of sound. The magnitude of the change in pressure caused by the sound is then described as the sound pressure level. Since the magnitude of the change is constantly varying, the sound pressure may be defined in terms of:

- Peak sound pressure levels: the maximum change in pressure relative to atmospheric pressure i.e. the amplitude as defined by the maximum depth or height of the peaks and troughs respectively; or
- Root Mean Square (RMS) sound pressure levels: the average of the amplitude of pressure changes, accounting for positive changes above atmospheric pressure, and negative pressure changes below atmospheric pressure.

Figure 14: Pressure changes relative to atmospheric pressure associated with sound



B2.2 Frequency

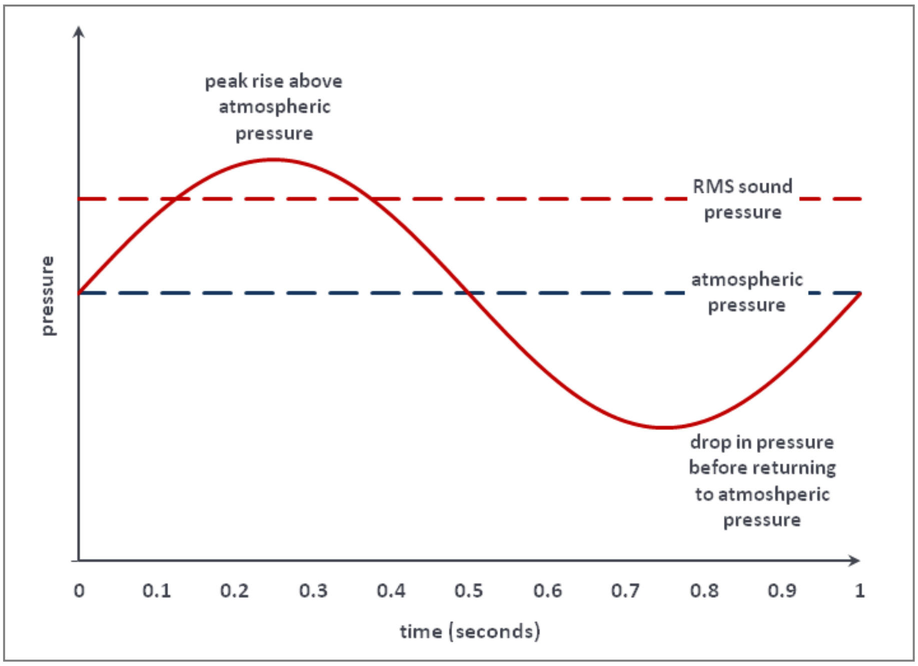
Frequency is a term used to describe the number of times a sound causes the pressure to rise and fall in a given period of time. The rate of change in pressure is an important feature that determines whether it is able to be perceived as a sound by the human ear.

Repetitive changes in pressure can occur as a result of a range of factors with widely varying rates of fluctuation. However, only a portion of these fluctuations are able to be perceived as sound. In many cases, the rate of fluctuation will either be too slow or too fast for the human ear to detect the pressure change as a sound. For example, local fluctuations in atmospheric pressure can be created by someone waving their hands back and forth through the air; the reason this cannot be perceived as a sound is the rate of fluctuation is too slow.

At the rates of fluctuation that can be detected as sound, the rate will influence the character of the sound that is perceived. For example, slow rates of pressure change correspond to rumbling sounds, while fast rates correspond to whistling sounds.

The rate of fluctuation is numerically described in terms of the number of pressure fluctuations that occur in a single second. Specifically, it is the number of cycles per second of the pressure rising above, falling below, and then returning to atmospheric pressure. The number of these cycles per second is expressed in Hertz (Hz). This concept of cycles per second is illustrated in Figure 15 which illustrates a 1 Hz pressure fluctuation. The figure provides a simple illustration of a single cycle of pressure rise and fall occurring in a period of a single second.

Figure 15: Illustration of a pressure fluctuation with a frequency of 1Hz

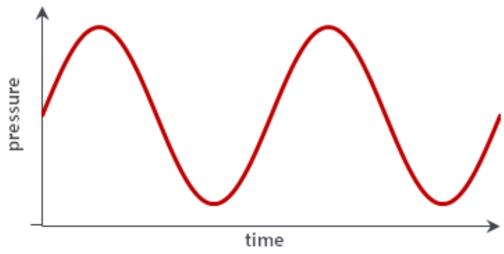


The rate that sound pressure rises and falls will vary depending on the source of the sound. For example, the surface of a tuning fork vibrates at a specific rate, in turn causing the pressure of the adjacent air to fluctuate at the same rate. Recalling the idea of pressure fluctuations from someone waving their hands, the pressure would fluctuate at the same rate as the hands move back and forth; a few times a second translating to a very low frequency below our hearing range (termed an infrasonic frequency). Examples of low and high frequency sound are easily recognisable, such as the low frequency sound of thunder, and the high frequency sound of crashing cymbals. To demonstrate the differences in the patterns of different frequencies of sound, Figure 16 illustrates the relative rates of pressure change for low, mid and high frequency sounds. Note that in each case the amplitude of the pressure changes remains the same; the only change is the number of fluctuations in pressure that occur over time.

Figure 16: Examples of the rate of change in pressure fluctuations for low, mid and high frequencies

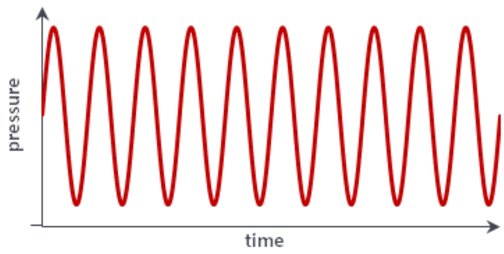
Low frequency sounds:

20 to 200 Hz



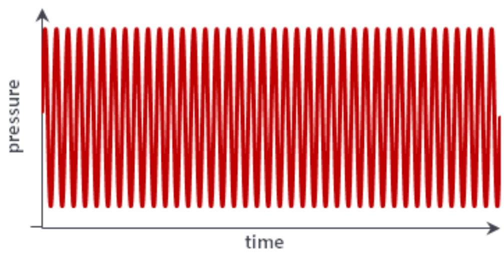
Mid-frequency sounds:

200 to 800 Hz



High frequency sounds:

greater than 800 Hz



B2.3 Sound pressure and frequency variations

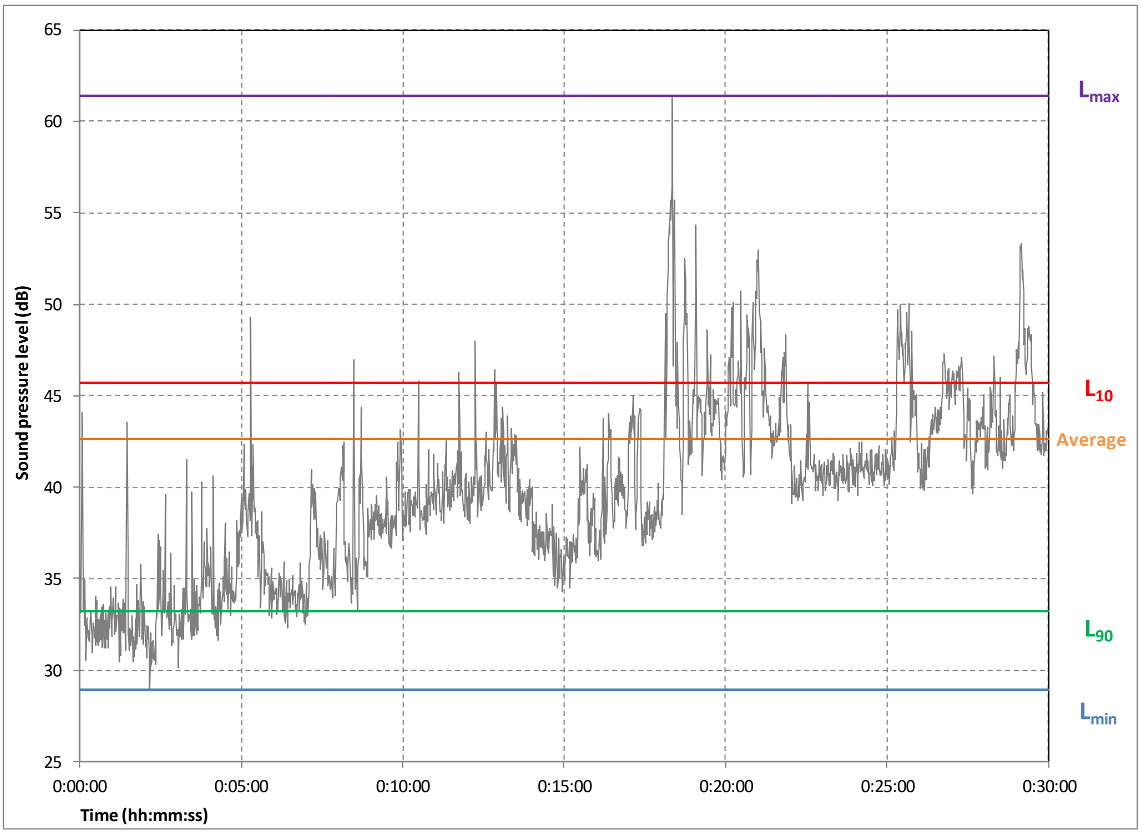
The preceding sections describe important aspects of the nature of sound, the changes in pressure and the changes in the rate of pressure fluctuations.

The simplest type of sound comprises a single constant sound pressure level and a single constant frequency. However, most sounds are made up of many frequencies, and may include low, mid and high frequencies. Sounds that are made up of a relatively even mix of frequencies across a broad range of frequencies are referred to as being 'broad band'. Common examples of broad band sounds include flowing water, the rustling of leaves, ventilation fans and traffic noise.

Further, sound quite often changes from moment to moment, in terms of both pressure levels and frequencies. The time varying characteristics of sound are important to how we perceive sound. For example, rapid changes in sound level produced by voices provide the component of sound that we interpret as intelligible speech. Variations in sound pressure levels and frequencies are also features which can draw our attention to a new source of sound in the environment.

To demonstrate this, Figure 17 illustrates an example time-trace of total sound pressure levels which varies with time. This variation presents challenges when attempting to describe sound pressure levels. As a result, multiple metrics are generally needed to describe sound pressure, such as the average, minimum or maximum noise levels. Other ways of describing sound include statistics for describing how often a defined sound pressure level is exceeded; for example, typical upper sound levels are often described as an L_{10} which refers to the sound pressure exceeded for 10% of the time, or typical lower levels or lulls which are often described as an L_{90} which refers to the sound exceeded for 90% of the time.

Figure 17: Example of noise metrics that may be used to measure a time-varying sound level



This example illustrates variations in terms of just total sound pressure levels, but the variations can also relate to the frequency of the sound, and frequently the number of sources affecting the sound.

These types of variations are an inherent feature of most sound fields and are an important point of context in any attempt to describe sound.

B3 Hearing and perception of sound

This section provides a discussion of:

- The use of the decibel to practically describe sound levels in a way that corresponds to the pressure levels the human ear is able to detect as sounds
- The relationship between sound frequency and human hearing.

The section concludes with a discussion of some of the complicating non-acoustic factors that influence our perception of sound.

B3.1 Sound pressure and the Decibel

Previous sections discussed the wide range of small pressure fluctuations that the ear is able to detect as sound. Owing to the wide range of these fluctuations, the way we hear sound is more practically described using the decibel (dB). The decibel system serves two key purposes:

- Compressing the numerical range of the quietest and loudest sounds commonly experienced.

  As an indication of this benefit, the pressure of the loudest sound that might be encountered is around a million times greater than the quietest sound that can be detected. In contrast, the decibel system reduces this to a range of approximately 0-120 dB.

- Consistently representing sound pressure level changes in a way that correlate more closely with how we perceive sound pressure level changes.

  For example, a 10 dB change from 20-30 dB will generally be subjectively perceived as a similar to a 10 dB change from 40-50 dB. However, expressed in units of pressure as Pascals, the 40-50 dB change is ten times greater than the 20-30 dB change. For this reason, sound pressure changes cannot be meaningfully communicated in terms of units of pressure such as Pascals.

Sound pressure levels in most environments are highly variable, so it can be misleading to describe what different ranges of sound pressure levels correspond to. However, as a broad indication, Table 35 provides some example ranges of sound pressure levels, expressed in both dB and units of pressure.

Table 35: Example sound pressure levels that might be experienced in different environments

Environment	Example Sound Pressure Level	
Outside in an urban area with traffic noise	50-70 dB	0.006-0.06 Pa
Outside in a rural area with distant sounds or moderate wind rustling leaves	30-50 dB	0.0006-0.006 Pa
Outside in a quiet rural environment in calm conditions	20-30 dB	0.0002-0.0006 Pa
Inside a quiet bedroom at night	<20 dB	0.0002 Pa

The impression of how much louder or quieter a sound is will be influenced by the magnitude of the change in sound pressure. Other important factors will also influence this, such as the frequency of the sound which is discussed in the following section. However, to provide a broad indication, Table 36 provides some examples of how different changes in sound pressure levels can be perceived.

Table 36: Perceived changes in sound pressure levels

Sound pressure level change	Indicative change in perceived sound
1 dB	Unlikely to be noticeable
2-3 dB	Likely to be just noticeable
4-5 dB	Clearly noticeable change
10 dB	Distinct change - often subjectively described as halving or doubling the loudness

The example sound pressure level changes in Table 36 are based on side-by-side comparison of a steady sample of sound heard at different levels. In practice, changes in sound pressure levels may be more difficult to perceive for a range of reasons, including the presence of other sources of sound, or gradual changes which occur over a longer period of time.

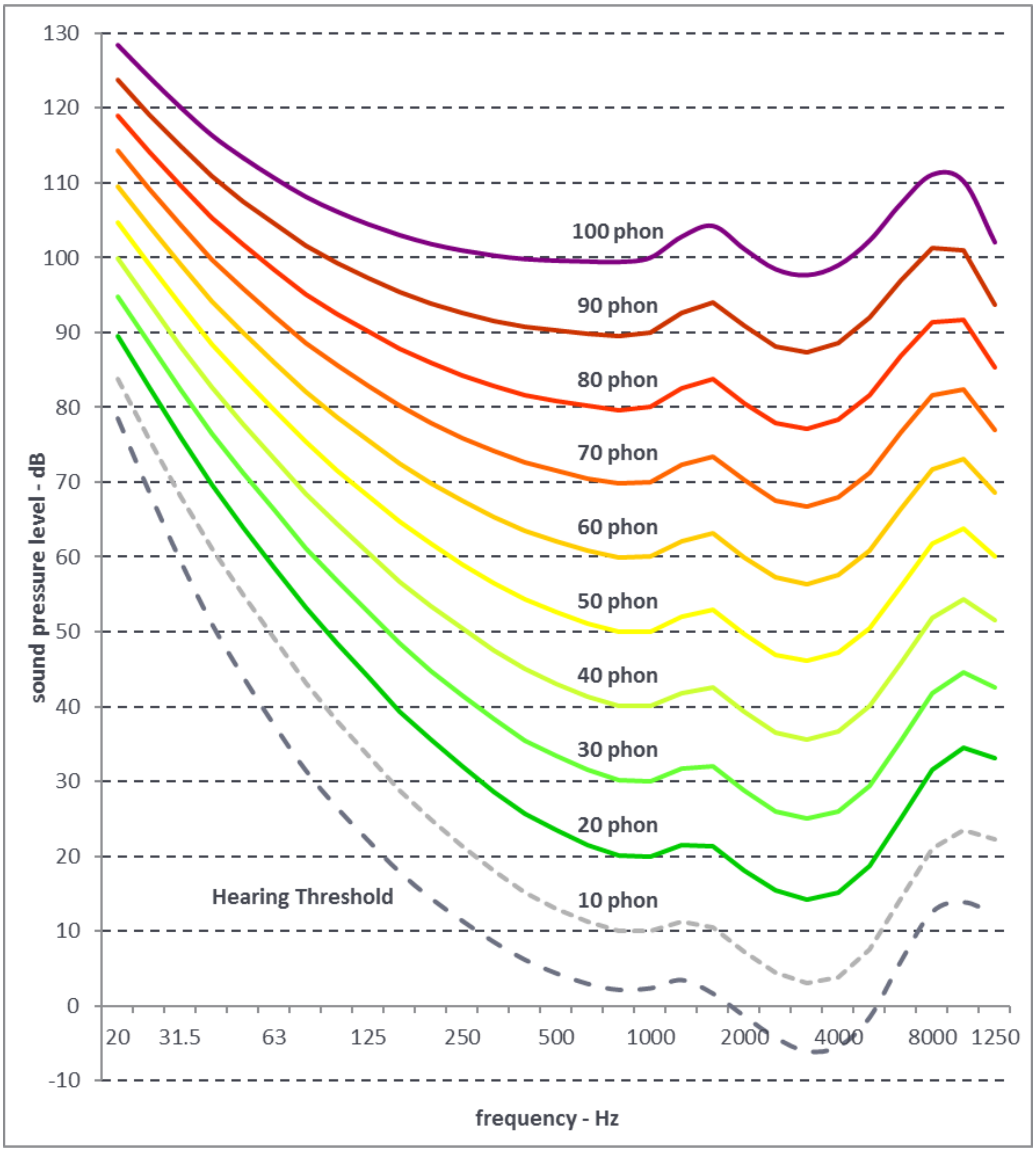
B3.2 Sound frequency and loudness

Although sound pressure level and the sensation of loudness are related, the sound pressure level is not a direct measure of how loud a sound appears to humans. Human perception of sound varies and depends on a number of physical attributes, including frequency, level and duration.

An example of the relationship between the sensation of loudness and frequency is demonstrated in Figure 18. The chart presents equal loudness curves for sounds of different frequencies expressed in ‘phons’. Each point on the phon curves represents a sound of equal loudness. For example, the 40 phon curve shows that a sound level of 100 dB at 20 Hz (a very low frequency sound) would be of equal loudness to a level of 40 dB at 1,000 Hz (a whistling sound) or approximately 50 dB at just under 8,000 Hz (a very high pitch sound). The information presented is based on an international standard[18] that defines equal loudness levels for sounds comprising individual frequencies. In practice, sound is usually composed of a large number of different frequencies, so this type of data can only be used as an indication of how different frequencies of sound may be perceived. An individual’s perceptions of sound can also vary significantly. For example, the lower dashed line in Figure 18 shows the threshold of hearing, which represents the sounds an average listener could correctly identify at least 50% of the time. However, these thresholds represent the average of the population. In practice, an individual’s hearing threshold can vary significantly from these values, particularly at the low frequencies.

[18] ISO 226:2003 *Acoustics - Normal equal-loudness-level contours*

Figure 18: Equal loudness contours for pure tone sounds



The noise curves in Figure 18 demonstrate that human hearing is most sensitive at frequencies from 500 to 4,000 Hz, which usefully corresponds to the main frequencies of human speech. The contours also demonstrate that sounds at low frequencies must be at much higher sound pressure levels to be judged equally loud as sounds at mid to high frequencies.

To account for the sensitivity of the ear to different frequencies, a set of adjustments were developed to enable sound levels to be measured in a way that more closely aligns with human hearing. Sound levels adjusted in this way are referred to as A-weighted sound levels.

B3.3 Interpretation of sound and noise

Human interpretation of sound is influenced by many factors other than its physical characteristics, such as how often the sound occurs, the time of day it occurs and a person's attitude towards the source of the sound.

For example, the sound of music can cause very different reactions, from relaxation and pleasure through to annoyance and stress, depending on individual preferences, the type of music and the circumstances in which the music is heard. This example illustrates how sound can sometimes be considered noise; a term broadly used to describe unwanted sounds or sounds that have the potential to cause negative reactions.

The effects of excess environmental sound are varied and complicated, and may be perceived in various ways including sensations of loudness, interference with speech communication, interference with working concentration or studying, disruption of resting/leisure periods, and disturbance of sleep. These effects can give rise to behavioural changes such as avoiding the use of exposed external spaces, keeping windows closed, or timing restful activities to avoid the most intense periods of disruption. Prolonged annoyance or interference with normal patterns can lead to possible effects on mental and physical health. In this respect, the World Health Organization (preamble to the *Constitution of the World Health Organization*, 1946) defines health in the following broad terms:

> *A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*

The World Health Organization *Guidelines for Community Noise* (Berglund, Lindvall, & Schwela, 1999) documents a relationship between the definition of health and the effects of community noise exposure by noting that:

> *This broad definition of health embraces the concept of well-being, and thereby, renders noise impacts such as population annoyance, interference with communication, and impaired task performance as 'health' issues.*

The reaction that a community can have to sound is highly subjective and depends on a range of factors including:

- The hearing threshold of individuals across the audible frequency range

  These thresholds vary widely across the population, particularly at the lower and upper ends of the audible frequency range. For example, at low frequencies the distribution of hearing thresholds varies above and below the mean threshold by more than 10 dB.

- The attitudes and sensitivities of individuals to sound, and their expectations of what is considered an acceptable level of sound or intrusion

  This in turn depends on a range of factors such as general health and the perceived importance of sound amongst other factors relevant to overall amenity perception.

- The absolute sound pressure level of the sound in question

  The threshold for the onset of community annoyance varies according to the type of sound; above such thresholds, the percentage of the population annoyed generally increases with increasing sound pressure level.

- The sound pressure level of the noise relative to background noise conditions in the area, and the extent to which general background noise may offer beneficial masking effects

- The characteristics of the sound in question such as whether the sound is constant, continually varies, or contains distinctive audible features such as tones, low frequency components or impulsive sound which may draw attention to the noise

- The site location and the compatibility of the source in question with other surrounding land uses. For example, whether the source is in an industrial or residential area

- The attitudes of the community to the source of the sound

  This may be influenced by factors such as the extent to which those responsible for the sound are perceived to be adopting reasonable and practicable measures to reduce their emissions, whether the activity is of local or national significance and whether the noise producer actively consults and/or liaises with the community.

- The times when the sound is present, the duration of exposure to increased sound levels, and the extent of respite periods when the sound is reduced or absent (for example, whether or not the sound ceases at weekends).

The combined influence of the above considerations means that physical sound levels are only one factor influencing community reaction to sound. Importantly, this means that individual reactions and attitudes to the same type and level of sound will vary within a community.

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 1826.5 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues* dated September 2025.

The relevant publication for the assessment of construction noise in Victoria is the EPA Publication 1834.2 *Civil construction, building and demolition guide*, dated 12 September 2025 (EPA Publication 1834.2).

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 measures to demonstrate compliance post-construction.

Specifically, the EP Regulations outline the following:

- Noise agreements

  An owner or operator of a wind energy facility may enter into a written agreement with a 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[19]*; 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

---

19 *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 37.

Table 37: 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 38.

Table 38: 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) [a]
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)

a 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 39.

Table 39: Indicators and objectives for the ambient sound environment

Land use category	Indicators	Objectives (free-field conditions)
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[20].*
>
> *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.*

Based on the above, receivers within the project boundary and/or with a noise agreement are referred to herein as *stakeholder 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*
- *Corrective institution*
- *Dependent person's unit*
- *Dwelling*
- *Group accommodation*
- *Host farm*
- *Residential aged care facility*
- *Residential building*
- *Residential village*
- *Retirement village*

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

[20] *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.*

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

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

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

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 webpage *Wind Energy Facility Turbine Noise Regulation Guidelines* EPA-DTP Publication 3011 *Wind Energy Facility Turbine Noise – Technical Guideline* dated 20 December 2024.[21]

[21] At the date of preparation of this report, the EPA webpage is not available as a version controlled formal document. This report is based on the EPA webpage version of this publication, last updated on 2 May 2025.

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 1826.5 (Noise Protocol)

EPA Publication 1826.5 *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 terminal station 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 stakeholder and non-stakeholder 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.

C7 EPA Publication 1834.2

Guidelines for noise and vibration from construction and demolition works are detailed in EPA Publication 1834.2 *Civil construction, building and demolition guide*, dated 12 September 2025.

EPA Publication 1834.2 reflects the general environmental duty introduced by the EP Act, and reiterates the requirement to eliminate or reduce noise and vibration risks associated with construction activity as far as reasonably practicable.

Section 4.1.1 of EPA Publication 1834.2 states the following:

> *Noise from civil construction, building and demolition activities can adversely affect the health and wellbeing of people and animals (considered to be sensitive receivers) when not managed appropriately.*

As well as causing annoyance, environmental noise and vibration is now recognised as a public health issue that can have serious or long-term health impacts which may include:

- inability to sleep or reduced quality of sleep
- impaired communication
- reduced cognitive performance (e.g. reduced attention span, memory and concentration in people working and children studying)
- exacerbation of mental health problems (e.g. stress, anxiety and depression)
- changes to the natural behaviour of animals, which affects their ability to survive and reproduce (e.g. reduced ability to hear alarm calls warning of predators)
- discomfort caused by vibration.

In extreme cases, vibration may also result in damage to buildings and infrastructure.

EPA Publication 1834.2 indicates that noise and vibration should be minimised at all times, and that limiting the times when noisy equipment is used is an effective way of reducing noise and vibration impacts. The guidance also notes that the primary way of minimising the likelihood of noise and vibration causing harm is to limit the frequency of occurrence and its duration. This applies especially when noise and vibration are likely to have a greater impact.

EPA Publication 1834.2 sets out definitions for normal working hours to inform project planning. The guidance states that projects should aim to constrain works to normal working hours.

However, where necessary, EPA publication 1834.2 states that works or activities outside normal working hours may occur for:

- low-noise impact works which are inherently quiet or unobtrusive and do not have intrusive characteristics
- managed-impact works which are controlled through actions specified in a noise and vibration management plan and do not have intrusive characteristics
- unavoidable works that cannot practicably be restricted to normal working hours, due to safety or practical constraints.

EPA Publication 1834.2 states that approval from the relevant authority may be required for justified works outside or normal hours.

Where there is justified out of hours work, which includes low-noise impacts works and managed-impact works, EPA Publication 1834.2 states that the activities are required to follow an outside of normal working hours schedule which specifies noise level restrictions.

For the evening period, these restrictions are defined in terms of an objective criterion related to background noise levels. For the night period, the noise restriction is defined in terms of an inaudibility requirement.

The level of construction noise that corresponds to inaudibility will depend on a range of variables such as the level and character of construction noise, the level and character of the background sound and the hearing threshold of the individual observing the noise. EPA Publication 1834.2 states that inaudibility *is not* meant to be a measurable criterion in dB, it states the following:

> *to predict construction noise, a reference level set at background level +0 dB could be used as a suitable reference level for inaudible. Where this approach is used apply adjustments to consider the potential character of the noise'.*

This approach should therefore only be used to inform the risk assessment regarding the scheduling of works and not for compliance purposes.

The normal working hours and the restrictions that apply to justified construction activity during the evening and night are summarised in Table 40.

Table 40: EPA Publication 1834.2 – construction noise guidance summary

Period	Day of the week	Time Period	Construction activity for up to 18 months	Construction activity after 18 months
Normal working hours	Monday – Friday	0700-1800 hrs	Receiver limits do not apply – noise requirements are defined in terms of emission and managerial controls	
	Saturday	0700-1300 hrs		
Weekend/evening work hours	Monday – Friday	1800-2200 hrs	Noise to be less than 10 dB above background (L_{A90}), outside residential dwelling	Noise to be less than 5 dB above background (L_{A90}), outside residential dwelling
	Saturday	1300-2200 hrs		
	Sundays and Public Holidays	0700-2200 hrs		
Night period	Monday – Sunday	2200-0700 hrs	Noise from construction activities must be inaudible inside a habitable room with windows open	

For measurement-based assessments, EPA Publication 1834.2 specifies that construction noise should be assessed as an L_{Aeq} and compared to the background noise at the time of impact. Both construction and background noise should be measured for a period that is representative at the time of impact (a minimum of 5 minutes). If the construction noise contains tonal or impulsive characteristics, an adjustment of 2 to 5 dB applies for each characteristic according to their prominence.

Noise control measures for construction activities outlined in EPA Publication 1834.2 include the following:

- Scheduling works
  - Undertaking work during normal working hours
  - Avoiding work when there are special events
  - Scheduling noisy works together to reduce the overall duration of exposure
  - Scheduling noisy activities for less sensitive times, for example, delay a rock-breaking task to later in the morning or afternoon
  - Avoiding work that coincides with sensitive ecological processes, if required

    This would normally be subject to the advice and recommendations of a project ecologist as to whether or not the impact of the proposed activity is sufficient to warrant rescheduling.
  - Optimising the number of vehicle trips to and from site
  - Promoting good driver behaviour, to prevent sudden acceleration and unjustified use of compression engine brakes
  - Consulting and informing potentially noise-affected residences regarding designated access routes to your site. Ensure drivers are aware and use nominated vehicle routes
  - Schedule deliveries to nominated hours only
- Community information and consultation
  - In the early stages of planning, identify and assess those potentially impacted by noise, then document and maintain the information for the duration of the project
  - Engage community to keep them informed, for example community meetings with community and workers
  - Notify community before and during construction, communicating information such as start and finish times, the type of noise and measures to reduce noise impacts and contact details for information and complaints
  - Install and maintain a site information board at the front of the site with contact details of operations, after hours emergency contact details and regular information updates visible from the outside boundary
  - Maintain a process for managing complaints

- Controlling noise at the source
  - Undertake preparatory work offsite where possible
  - Connect to the electricity grid as soon as possible to avoid reliance on diesel generators
  - Plan vehicle movement to avoid manoeuvres and idling at locations close to noise-sensitive areas
  - Use quieter equipment or methods (including installation of mufflers, avoiding metal-to-metal contact, utilising electric or hydraulic substitutes for diesel-powered activities, turning off equipment when not in use)
  - Use low-noise emitting generators
  - Use non-tonal alarms
  - Maintain equipment (e.g. by inspecting regularly to maintain good working order, checking seals on equipment and doors to make sure they seal properly and maintaining air lines on pneumatic equipment to make sure they don't leak)
  - Limit noise caused by people on site (e.g. avoiding yelling and shouting, minimising the use and volume of radios, stereos or public address systems)
- Noise reduction between source and receiver
  - Plan to increase separating distances between source and receiver where possible
  - Maximise shielding by taking into account topography of the site, existing structures and material stockpiles, construction of barriers or bunds and avoiding placing noise sources close to reflecting surfaces
- Reducing noise impacts offsite
  - Increasing sound insulation at receivers by retrofitting acoustic glazing
  - Provide respite offers that reflect the level of impact.

C8 Construction noise and vibration guidelines

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 the NSW Roads and Maritime Service's publication *Construction Noise and Vibration Guideline* dated August 2016 (NSW RMS Construction Noise & Vibration Guideline).

Section 7.1 of the NSW RMS Construction Noise & Vibration Guideline sets out minimum working distances from sensitive receivers for typical items of vibration intensive plant. The minimum distances are quoted for effects relating to cosmetic damage and human comfort, based on guidance contained in BS 7385-2:1993[22] and the NSW Department of Environment and Conservation publication *Assessing Vibration: A Technical Guideline* dated February 2006 (NSW DEC Vibration Guideline), respectively.

[22] BS 7385-2:1993 *Evaluation and measurement for vibration in buildings - Guide to damage levels from groundborne vibration*

The minimum working distances are reproduced below in Table 41.

Table 41: Recommended minimum working distances for vibration intensive plant from sensitive receivers (reproduced from Table 2 of Section 7.1 of the NSW RMS Construction Noise & Vibration Guidelines)

Plant item	Rating / Description	Minimum working distance	
		Cosmetic damage	Human response
Vibratory roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small hydraulic hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

The NSW RMS Construction Noise & Vibration Guideline notes that the minimum working distances are indicative and will vary depending on the particular item of plant and local geotechnical conditions. The guideline also notes the values are defined in relation to cosmetic damage of typical buildings under typical geotechnical conditions, and recommends vibration monitoring to confirm the minimum working distances at specific sites.

In relation to human comfort, the NSW RMS Construction Noise & Vibration Guideline notes that the minimum working distances relate to continuous vibration. The guideline further notes that for most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed.

The data in Table 41 indicates that the minimum working distances for human comfort are significantly greater for than for the avoidance of cosmetic damage. This is based on the thresholds for human exposure to vibration being generally well below accepted thresholds for minor cosmetic damage to lightweight structures.

The NSW DEC Vibration Guideline presents preferred and maximum vibration criteria for use in assessing human response to vibration.

The acceptable values of human exposure to vibration are dependent on, among other things, the time of day. This assessment only considers the period in which construction is expected to normally occur (i.e. 0700-1800 hrs Monday to Friday and 0700-1300 hrs on Saturday).

The vibration criteria are separately specified for the following types of vibration characteristics:

- Continuous: vibration that continues uninterrupted for a period such as the duration of a day
- Impulsive: vibration that comprises a rapid build up to a peak followed by several cycles of progressively reducing vibration
- Intermittent: vibration that comprises interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly.

The types of activities associated with the construction of a wind farm may include both continuous and impulsive vibration sources operating over interrupted periods of a working day. It is therefore expected that vibration would be typically classified as intermittent according to the NSW DEC Vibration Guideline, but may be continuous or impulsive on occasion.

Table 42 summarises the preferred and maximum values for acceptable human exposure to continuous and impulsive vibration. It is noted that the NSW DEC Vibration Guideline provides criteria for the assessment of continuous and impulsive vibration in the form of the weighted acceleration values. Given that empirical vibration data is more readily available in the form peak particle velocity (PPV) data, the criteria are reproduced here in the form of equivalent PPV values sourced from Appendix C of the NSW DEC Vibration Guideline. This is consistent with related guidance contained in BS 5228-2:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Vibration* (BS 5228-2) which states:

> *… for construction, it is considered more appropriate to provide guidance in terms of the PPV, since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage. Furthermore, since many of the empirical vibration predictors yield a result in terms of PPV, it is necessary to understand what the consequences might be of any predicted levels in terms of human perception and disturbance.*

Table 42: Preferred and maximum values for vibration during daytime (mm/s) 1-80Hz (PPV) – Residences

Type	Preferred Values	Maximum Values
Continuous	0.28	0.56
Impulsive	8.6	17

Table 43 summarises the preferred and maximum values for acceptable human exposure to intermittent vibration. The NSW DEC Vibration Guideline recommends the assessment of intermittent vibration on the basis of a more complex parameter referred to as the vibration dose value (VDV) which relates vibration magnitude to the duration of exposure.

Table 43: Vibration dose values for intermittent vibration during daytime ($m/s^{1.75}$) 1-80Hz

Location	Preferred Values	Maximum Values
Residences	0.2	0.4

C9 Construction traffic noise

There is no Victorian guidance document in relation to the assessment of construction traffic noise levels on public roads.

In the absence of Victorian guidance in relation to the assessment of construction traffic noise levels on public roads, and to provide an indication of potential impact from traffic associated with the construction of the wind farm, construction traffic noise levels have been estimated in accordance with BS 5228--1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise* (BS 5228-1)

APPENDIX D WIND TURBINE NOISE ASSESSMENT STAGES

The management of environmental noise from a wind farm project involves assessments and checks at multiple stages of the project, starting from the project inception and carrying through into the operational stage of the project.

The key stages of the environmental noise management process for a wind farm are summarised in Table 44. The project is currently at the pre-consent assessment stage shaded in green. This overall process illustrates the additional assessment stages which would follow if the project is granted a planning permit.

Table 44: Wind turbine noise assessment stages (current stage shaded green)

Stage	Description
Preliminary noise assessment	Involves: identifying sensitive receivers, assessing existing noise conditions and modelling noise levels for alternative wind turbine layouts and turbine sizes Primary purpose: informing the preliminary design development and determining if, and where, background noise surreys are required
Pre-consent noise assessment	Involves: assessing the wind turbine layout proposed in the planning application, accounting for a candidate model that is representative of the envelope of turbines that is being applied for Primary purpose: demonstrating whether the proposed wind farm can be designed and operated within the noise requirements which apply in Victoria – provides information to support the relevant authorities' consideration of the planning application
Detailed design & turbine procurement	Involves: noise modelling to check minor turbine location changes and establishing noise obligations in the turbine supply contract Primary purpose: to verifying that minor turbine locations are carried out within the noise requirements, and that the turbine supply contract includes noise control clauses that address the requirement of the EP Regulations
Pre-construction noise assessment	Involves: modelling the final wind turbine layout and selected model and assessing compliance with the noise requirements of the EP Regulations Primary purpose: to provide evidence to the responsible authority demonstrating that noise has been addressed during the detailed design and turbine procurement, and that the wind farm can be designed to comply with the operational noise requirement
Noise management plan	Involves: identifying controls to minimise the risk of harm to the to the environment and human health as a result of wind turbine noise, so far as reasonably practicable. This includes documenting the locations and procedures that will be used to measure, analyse and assess wind turbine noise levels after the wind farm starts operating, and ongoing controls for the life of the project Primary purpose: to document how the general environmental duty under the EP Act would be fulfilled with respect to wind turbine noise, and to enable verification of the proposed testing by an independent environmental auditor before the wind farm commences operation
Post-construction noise assessment	Involves: measuring noise levels around the development site after the wind farm commences operating, as specified in the noise management plan. Primary purpose: to assess whether noise levels in practice are compliant with the noise requirements established in the EP Regulations

Stage	Description
Operational noise investigations	Involves: recording and monitoring any complaints relating to noise and, where necessary, conducting noise measurements to assess whether noise levels in practice remain compliant with noise requirements, as specified in the noise management plan Primary purpose: address normal planning permit requirements for the management of complaints, and for the wind farm to remain compliant with the noise requirements for the duration of the project's life
Annual statements	Involves: providing a statement in accordance with the EP Regulations to the Authority within 4 months of the end of each financial year, as specified in the noise management plan. Primary purpose: address a range of noise related matters, including verification that the wind farm remains compliant with the applicable noise limits.
Routine noise monitoring	Involves: commissioning of noise monitoring to verify compliance with the applicable limits, within 3 months of the fifth anniversary of a wind farm commencing operation, and every subsequent 5 years, engaging an independent auditor to review the noise monitoring report, and submitting the findings to the Authority for review, as specified in the noise management plan.

APPENDIX E NOISE PREDICTION MODEL

E1 Key noise prediction elements

Key elements of the method used for predicting construction and operational noise from the project are summarised in Table 45 and Table 46, respectively.

Table 45: Operational noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLANnoise version 9.1
Method	ISO 9613-2 Specific to wind turbine noise predictions, adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (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 to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the wind turbine. • Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each wind turbine. Further discussion of terrain screening effects is provided below. Source heights are set at 2 m for batteries and inverters and 5 m for transformers.
Terrain data	10 m cell size raster elevation data, downloaded from ELVIS
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 -0.2 dB and +0.2 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 G, 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. 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[23] 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.
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 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 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.

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

Table 46: Construction noise prediction elements

Detail	Description
Method	AS 2436
Source characterisation	Each source of construction noise is modelled as a point source of sound. The total sound of the component of construction activities being modelled is then calculated on the basis of simultaneous operation of all elements and summing the contribution of each.
Terrain data	Flat terrain
Ground conditions	Arithmetic average of the hard and soft ground prediction methods.
Receiver heights	1.5 m above ground level

E2 Wind turbine noise prediction overview

In Australia, wind turbine noise predictions are typically calculated using ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2:1996) with a set of conservative assumptions tailored to wind farm assessment, as detailed in 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).

A revised version of the standard, ISO 9613-2:2024, 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.[24] 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, MDA is reviewing the implementation of ISO-9613-2:2024 in SoundPLANnoise. This is a standard quality assurance process undertaken by MDA before using any revised noise modelling standard.

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 6808:2010 *Acoustics – Wind farm noise*, the South Australian EPA *Wind farms environmental noise guidelines* and the Queensland *Planning Guideline - State code 23: Wind farm development*.

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

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

To calculate far-field noise levels according to the ISO 9613-2, the noise emissions of each wind turbine are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- geometric divergence
- air absorption
- reflecting obstacles
- screening
- vegetation
- ground reflections.

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

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

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2:1996 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 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). It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methodologies.

A range of measurement and prediction studies[25, 26, 27] 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.

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.

[25] 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.

[26] 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.

[27] 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 adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLANnoise 9.1 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the site to evaluate the path between each wind turbine and receiver pairing, and then subsequently applies the adjustments to each wind turbine's predicted noise contribution where appropriate.

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

As an example of this, the ISO 9613-2:1996 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 conducted 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 all wind turbines are operating simultaneously at their maximum noise emissions and that each receiver is simultaneously downwind of every wind turbine at all times (in contrast to NZS 6808 compliance procedures which are based on assessing noise levels for a range of wind directions, consistent with broader Victorian noise assessment policies which do not evaluate compliance based solely on downwind noise levels).

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

E3 Wind turbine noise prediction 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[28]. 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.

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.

[28] 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

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.

APPENDIX F RECEIVER COORDINATES

The following table sets out the 218 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 wind turbine and land zoning.

See site map in Figure 3 of Section 5.1.

(Reference v054 supplied by the proponent on 7 May 2024).

Table 47: Receiver coordinates within 5 km of the proposed wind turbines– MGA2020 zone 54

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine	Land zoning
Non-stakeholder receivers						
D3	636,153	5,774,034	115	4,828	T46	FZ
D4	635,516	5,775,008	109	4,334	T46	FZ
D5	638,656	5,774,126	117	4,298	T46	FZ
D36	635,828	5,780,862	132	1,831	T39	FZ
D37	634,807	5,783,584	131	1,996	T25	FZ
D39	634,133	5,784,996	136	1,574	T25	FZ
D41	628,729	5,791,720	139	3,631	T1	FZ
D42	628,036	5,793,837	159	4,763	T6	FZ
D50	629,174	5,795,424	159	4,210	T6	FZ
D198	635,987	5,796,958	148	3,081	T32	FZ
D199	636,458	5,796,606	144	2,678	T32	FZ
D200	637,052	5,796,683	146	2,796	T32	FZ
D202	639,064	5,795,701	132	3,067	T32	FZ
D205	640,481	5,794,744	129	1,649	T72	FZ
D242	634,345	5,780,346	122	3,398	T39	FZ
D243	633,952	5,778,689	121	4,272	T46	FZ
D290	626,996	5,789,227	131	4,913	T1	FZ
D292	629,392	5,787,947	130	2,925	T2	FZ
D293	629,082	5,787,722	130	3,287	T2	FZ
D294	630,677	5,788,818	140	1,531	T2	FZ
D295	629,557	5,789,592	140	2,329	T1	FZ
D296	630,352	5,791,247	140	2,034	T1	FZ
D299	633,385	5,786,842	140	1,988	T15	FZ
D300	630,779	5,786,797	131	2,422	T2	FZ
D301	631,006	5,786,667	131	2,407	T2	FZ
D305	629,604	5,785,225	120	4,382	T2	FZ

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine	Land zoning
D306	630,808	5,785,586	130	3,462	T2	FZ
D307	630,292	5,784,456	124	4,703	T2	FZ
D314	633,477	5,783,638	123	2,794	T25	FZ
D315	632,562	5,783,622	123	3,560	T25	FZ
D316	631,928	5,783,610	127	4,128	T25	FZ
D319	629,411	5,790,652	140	2,570	T1	FZ
D336	643,539	5,776,846	120	1,654	T95	FZ
D337	641,824	5,776,994	120	1,542	T90	FZ
D339	639,742	5,776,991	120	2,084	T46	FZ
D341	636,588	5,778,086	124	1,660	T46	FZ
D345	636,747	5,779,043	129	1,607	T46	FZ
D346	647,030	5,779,559	112	3,593	T103	FZ
D347	648,207	5,779,039	116	4,793	T104	FZ
D351	647,570	5,780,188	114	3,906	T109	FZ
D352	646,535	5,780,648	112	2,792	T109	FZ
D358	648,316	5,782,921	115	4,678	T106	FZ
D367	643,362	5,786,992	124	2,132	T83	FZ
D368	644,035	5,787,401	116	2,915	T83	FZ
D372	645,635	5,789,995	133	3,316	T107	FZ
D399	631,400	5,796,513	148	3,567	T6	FZ
D400	630,109	5,792,074	140	2,803	T1	FZ
D401	629,198	5,796,692	167	4,977	T6	FZ
D402	644,056	5,789,694	131	2,497	T107	FZ
D404	638,575	5,794,136	130	2,021	T36	FZ
D413	636,197	5,782,273	135	1,552	T39	FZ
D414	630,743	5,786,843	131	2,407	T2	FZ
D419	639,519	5,777,423	121	1,638	T46	FZ
D420	639,580	5,777,057	120	1,922	T46	FZ
D421	639,514	5,777,286	120	1,719	T46	FZ
D424	643,204	5,786,989	126	1,990	T83	FZ
D425	643,113	5,787,489	128	2,033	T80	FZ
D426	643,081	5,787,386	128	2,008	T81	FZ
D431	644,165	5,776,780	113	2,068	T95	FZ

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine	Land zoning
D432	644,587	5,776,701	114	2,423	T95	FZ
D434	644,994	5,776,037	119	3,175	T95	FZ
D435	645,609	5,779,492	105	2,184	T103	FZ
D436	645,648	5,778,690	117	2,236	T104	FZ
D437	640,471	5,777,187	120	2,122	T90	FZ
D445	641,380	5,794,784	130	1,744	T72	FZ
D465	643,621	5,776,878	119	1,666	T95	FZ
D468	645,404	5,776,077	116	3,392	T104	FZ
D469	645,005	5,775,799	115	3,357	T95	FZ
D470	645,234	5,774,940	107	4,170	T95	FZ
D476	642,103	5,774,958	120	3,422	T95	FZ
D477	642,401	5,776,118	128	2,228	T95	FZ
D482	633,457	5,796,614	144	3,471	T6	FZ
D487	632,970	5,797,966	156	4,756	T6	TZ
D488	633,089	5,797,775	153	4,572	T6	TZ
D489	633,141	5,797,816	152	4,618	T6	TZ
D490	633,295	5,797,860	150	4,677	T6	TZ
D492	633,203	5,797,714	151	4,522	T6	TZ
D493	633,261	5,797,710	150	4,523	T6	TZ
D494	633,600	5,798,080	154	4,938	T6	FZ
D495	633,486	5,797,713	145	4,557	T6	TZ
D496	633,491	5,797,751	146	4,595	T6	TZ
D497	633,511	5,797,806	148	4,653	T6	TZ
D498	633,519	5,797,850	149	4,697	T6	TZ
D499	633,585	5,797,839	150	4,698	T6	TZ
D500	633,586	5,797,816	149	4,675	T6	TZ
D501	633,644	5,797,807	149	4,677	T6	TZ
D502	633,639	5,797,735	147	4,605	T6	TZ
D503	633,856	5,797,836	150	4,750	T32	TZ
D504	633,912	5,797,789	149	4,680	T32	TZ
D505	633,911	5,797,829	150	4,713	T32	TZ
D506	633,829	5,797,632	148	4,545	T6	TZ
D507	633,749	5,797,638	147	4,533	T6	TZ

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine	Land zoning
D508	633,691	5,797,640	146	4,523	T6	TZ
D509	633,668	5,797,646	146	4,524	T6	TZ
D510	633,646	5,797,652	145	4,525	T6	TZ
D511	633,685	5,797,575	144	4,458	T6	TZ
D512	633,680	5,797,542	144	4,425	T6	TZ
D513	633,815	5,797,565	147	4,478	T6	TZ
D514	633,892	5,797,622	148	4,551	T6	TZ
D515	633,892	5,797,692	148	4,612	T32	TZ
D516	633,913	5,797,753	149	4,650	T32	TZ
D517	633,782	5,797,808	150	4,707	T6	TZ
D518	633,465	5,797,489	143	4,332	T6	TZ
D519	633,475	5,797,577	144	4,421	T6	TZ
D520	633,479	5,797,614	145	4,458	T6	TZ
D521	633,388	5,797,552	145	4,383	T6	TZ
D523	633,392	5,797,609	147	4,440	T6	TZ
D524	633,407	5,797,678	147	4,510	T6	TZ
D525	633,202	5,797,571	149	4,379	T6	TZ
D526	633,173	5,797,475	146	4,280	T6	TZ
D527	633,124	5,797,664	151	4,465	T6	TZ
D529	633,438	5,797,901	150	4,735	T6	TZ
D530	633,361	5,797,790	149	4,615	T6	TZ
D531	633,430	5,797,968	152	4,800	T6	RLZ
D532	633,486	5,797,663	145	4,507	T6	TZ
D533	633,421	5,797,793	147	4,626	T6	TZ
D534	633,418	5,797,759	147	4,593	T6	TZ
D535	633,473	5,797,537	144	4,382	T6	TZ
D538	636,171	5,773,925	114	4,920	T46	FZ
D548	647,621	5,776,334	105	4,885	T104	TZ
D549	647,577	5,776,281	105	4,875	T104	TZ
D550	647,608	5,776,125	105	4,984	T104	TZ
D551	647,672	5,776,226	105	4,985	T104	TZ
D568	647,789	5,777,141	115	4,684	T104	FZ
D574	646,630	5,780,638	114	2,886	T109	FZ

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine	Land zoning
D575	647,195	5,776,697	120	4,335	T104	FZ
D577	644,725	5,775,270	112	3,610	T95	FZ
D579	633,696	5,779,226	120	4,467	T39	FZ
D593	633,490	5,797,768	147	4,612	T6	TZ
D609	628,873	5,795,779	165	4,655	T6	FZ
D610	633,787	5,797,843	150	4,741	T6	TZ
D613	633,364	5,797,683	148	4,510	T6	TZ
D614	633,255	5,797,889	151	4,701	T6	TZ
D615	633,277	5,797,847	150	4,661	T6	TZ
D616	633,499	5,797,831	148	4,676	T6	TZ
D617	633,383	5,797,905	151	4,732	T6	TZ
D620	641,579	5,779,470	127	1,069	T89	FZ
D622	640,002	5,779,485	122	1,051	T63	FZ
D623	643,441	5,776,542	126	1,891	T95	FZ
Stakeholder receivers outside the project boundary						
D38 (S)	634,118	5,783,402	124	2,513	T25	FZ
D201 (S)	637,617	5,796,354	141	2,644	T32	FZ
D208 (S)	645,490	5,793,469	136	2,985	T107	FZ
D340 (S)	636,785	5,777,078	124	1,950	T46	FZ
D362 (S)	639,380	5,784,803	134	1,533	T43	FZ
D433 (S)	645,443	5,776,525	119	3,066	T104	FZ
D478 (S)	644,468	5,794,331	128	2,856	T107	FZ
Stakeholder receivers within the project boundary						
D32 (S)	636,850	5,778,945	129	1,475	T46	FZ
D34 (S)	637,257	5,779,660	130	1,380	T50	FZ
D35 (S)	636,378	5,781,156	135	1,218	T39	FZ
D40 (S)	634,988	5,787,652	137	1,446	T15	FZ
D197 (S)	634,878	5,793,424	127	846	T19	FZ
D203 (S)	639,014	5,795,331	132	2,827	T32	FZ
D206 (S)	644,686	5,793,854	130	2,607	T107	FZ
D297 (S)	631,265	5,787,970	140	1,228	T2	FZ
D298 (S)	633,627	5,787,802	141	1,010	T15	FZ
D338 (S)	642,174	5,777,409	122	1,096	T95	FZ

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest turbine, m	Nearest turbine	Land zoning
D343 (S)	639,462	5,778,522	128	1,052	T48	FZ
D344 (S)	636,841	5,778,781	128	1,431	T46	FZ
D355 (S)	640,386	5,782,525	134	1,533	T88	FZ
D356 (S)	637,617	5,783,106	131	1,533	T43	FZ
D357 (S)	642,347	5,783,026	126	837	T102	FZ
D359 (S)	642,078	5,784,531	130	1,669	T83	FZ
D361 (S)	639,708	5,785,297	131	1,180	T57	FZ
D366 (S)	637,867	5,786,585	127	1,329	T33	FZ
D377 (S)	646,731	5,791,253	133	3,852	T107	FZ
D378 (S)	637,997	5,791,680	131	848	T40	FZ
D379 (S)	638,503	5,792,638	130	1,419	T110	FZ
D380 (S)	639,676	5,792,323	126	557	T64	FZ
D381 (S)	646,498	5,792,859	133	3,681	T107	FZ
D395 (S)	638,601	5,793,314	129	1,786	T36	FZ
D396 (S)	638,160	5,792,382	132	1,526	T34	FZ
D397 (S)	637,086	5,789,899	128	982	T44	FZ
D398 (S)	641,799	5,789,551	121	1,467	T77	FZ
D403 (S)	645,039	5,792,149	130	2,115	T107	FZ
D417 (S)	635,962	5,784,411	135	1,036	T25	FZ
D418 (S)	644,469	5,779,694	117	1,036	T103	FZ
D422 (S)	637,552	5,786,570	123	1,037	T33	FZ
D423 (S)	637,533	5,786,478	123	1,043	T35	FZ
D428 (S)	634,915	5,793,690	131	1,103	T19	FZ
D429 (S)	634,807	5,793,806	133	1,183	T19	FZ
D430 (S)	634,802	5,793,733	132	1,111	T19	FZ
D438 (S)	638,164	5,779,757	127	516	T50	FZ
D441 (S)	637,189	5,789,832	126	871	T44	FZ
D442 (S)	637,035	5,789,854	128	1,024	T44	FZ
D444 (S)	641,877	5,789,629	121	1,577	T77	FZ
D446 (S)	639,602	5,777,711	123	1,558	T46	FZ
D447 (S)	642,135	5,777,506	122	1,002	T90	FZ
D448 (S)	642,462	5,787,298	124	1,389	T81	FZ

(S) Stakeholder receiver

APPENDIX G WIND TURBINE COORDINATES

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

See site map in Figure 3 of Section 5.1.

(Layout reference v183 and supplied by the proponent on 8 May 2025).

Table 48: Turbine coordinates – MGA2020 zone 54

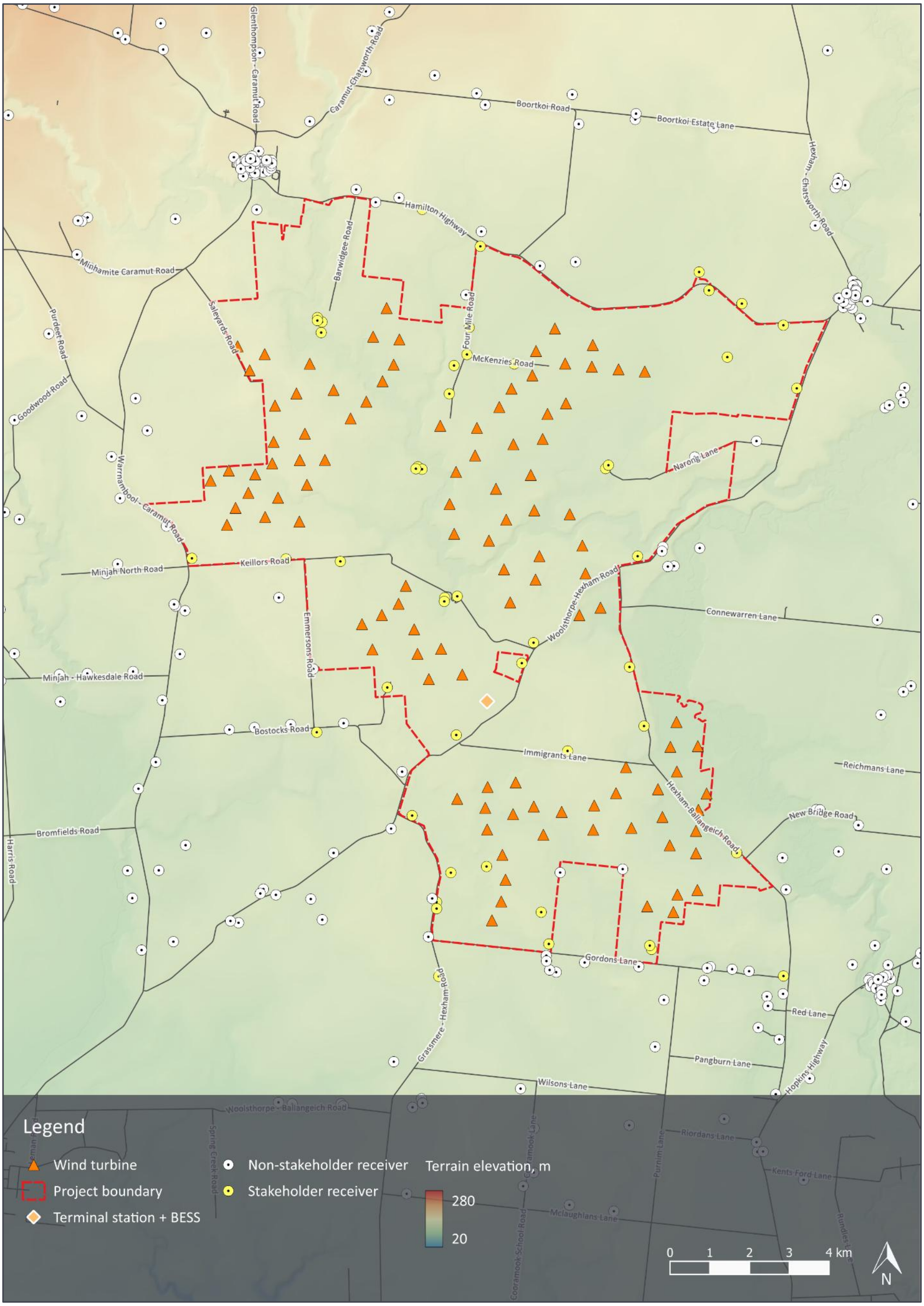
Turbine	Easting, m	Northing, m	Terrain elevation, m	Turbine	Easting, m	Northing, m	Terrain elevation, m
T1	631,862	5,789,892	140	T54	638,544	5,790,092	129
T2	632,200	5,788,753	143	T55	639,032	5,781,819	130
T3	632,333	5,790,112	136	T56	638,618	5,779,397	130
T4	633,171	5,788,889	140	T57	639,187	5,786,346	131
T5	632,443	5,789,164	141	T58	639,084	5,787,185	129
T6	632,757	5,793,217	145	T59	639,221	5,788,428	129
T7	632,789	5,789,521	138	T60	639,230	5,791,268	127
T8	632,990	5,789,976	132	T61	639,448	5,781,185	128
T9	633,021	5,792,595	150	T62	639,523	5,790,309	124
T10	633,424	5,792,977	145	T63	639,642	5,780,462	125
T11	633,436	5,790,223	136	T64	640,111	5,792,009	128
T12	633,526	5,789,350	132	T65	639,861	5,786,879	128
T13	633,505	5,790,760	138	T66	639,995	5,787,460	127
T14	633,600	5,791,667	140	T67	639,941	5,788,617	120
T15	634,023	5,788,719	136	T68	640,139	5,781,006	129
T16	634,158	5,791,938	142	T69	639,911	5,789,511	121
T17	634,274	5,789,629	140	T70	640,243	5,792,613	127
T18	634,305	5,790,915	140	T71	640,267	5,790,395	125
T19	634,541	5,792,663	134	T72	640,754	5,793,147	126
T20	634,134	5,790,261	141	T73	640,430	5,791,017	127
T21	634,766	5,790,223	138	T75	640,904	5,785,913	122
T22	635,097	5,791,963	135	T76	640,902	5,780,505	130
T23	635,429	5,786,042	134	T77	640,826	5,788,463	122
T24	635,477	5,791,222	135	T78	640,967	5,781,114	132
T25	635,650	5,785,388	133	T79	640,910	5,791,252	126
T26	635,943	5,786,238	133	T80	641,092	5,787,655	128
T27	635,899	5,791,618	132	T81	641,126	5,786,951	125
T28	636,381	5,786,493	131	T82	641,620	5,792,130	127
T29	636,175	5,793,239	132	T83	641,447	5,786,069	116
T30	636,339	5,792,104	125	T84	641,535	5,781,388	130
T31	636,775	5,785,204	130	T86	641,679	5,792,672	127

Turbine	Easting, m	Northing, m	Terrain elevation, m
T32	636,561	5,793,934	130
T33	636,593	5,786,933	131
T34	636,646	5,792,503	127
T35	636,732	5,785,827	130
T36	636,831	5,793,126	129
T37	637,019	5,784,553	131
T38	637,377	5,785,295	130
T39	637,536	5,781,503	130
T40	637,717	5,790,893	132
T41	637,825	5,788,915	128
T42	637,891	5,788,158	122
T43	637,866	5,784,612	131
T44	638,038	5,789,709	129
T45	638,239	5,780,683	126
T46	638,212	5,778,399	129
T47	638,320	5,781,750	123
T48	638,475	5,778,854	129
T49	638,634	5,790,779	130
T50	638,580	5,780,023	127
T51	638,914	5,781,027	126
T52	638,753	5,787,932	130
T53	638,227	5,781,232	122

Turbine	Easting, m	Northing, m	Terrain elevation, m
T87	639,013	5,789,221	120
T88	641,827	5,782,024	121
T89	641,865	5,780,489	125
T90	642,134	5,778,497	124
T91	640,955	5,792,252	128
T92	642,286	5,792,020	126
T93	642,595	5,781,417	119
T94	642,799	5,779,990	117
T95	642,781	5,778,309	125
T96	642,662	5,780,714	112
T97	642,975	5,782,460	105
T98	642,912	5,778,743	127
T101	643,098	5,781,831	110
T102	643,169	5,783,075	105
T103	643,445	5,779,748	117
T104	643,421	5,778,825	124
T105	643,480	5,780,308	111
T106	643,666	5,782,434	105
T107	642,941	5,791,923	124
T108	643,576	5,780,833	110
T109	643,809	5,781,229	108
T110	639,566	5,791,709	127

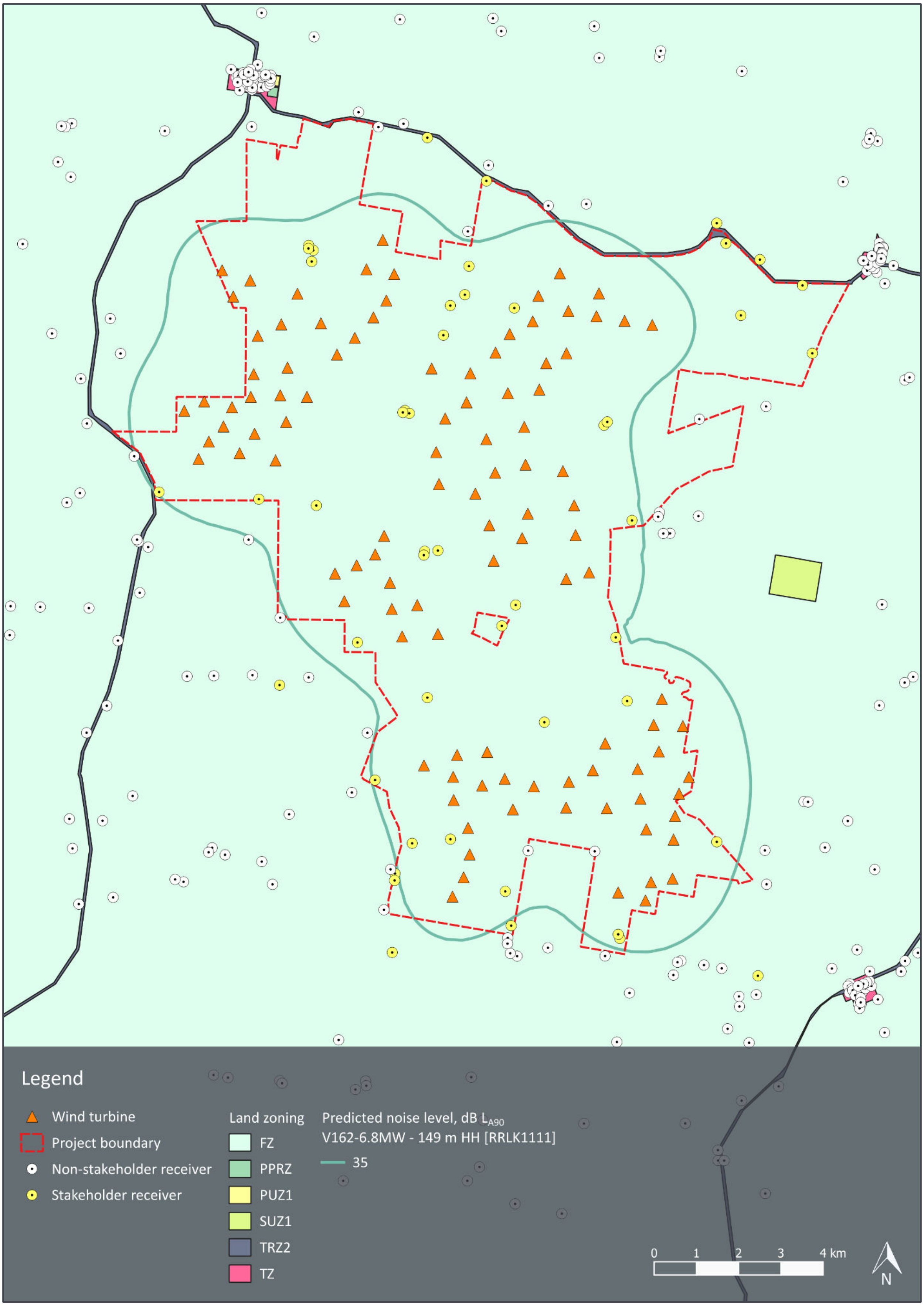
APPENDIX H SITE TOPOGRAPHY

Figure 19: Terrain elevation map for the project and surrounding area



APPENDIX I ZONING MAP

Figure 20: Zoning map for the project and surrounding area



APPENDIX J TABULATED PREDICTED NOISE LEVEL DATA

Table 49: Predicted operational wind turbine noise levels, dB L_{A90}

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
Non-stakeholder receivers												
D3	13.9	13.9	14.9	18.2	21.4	23.2	23.2	23.3	23.7	24.0	24.2	24.4
D4	14.7	14.7	15.7	19.0	22.2	24.0	24.0	24.1	24.5	24.8	25.0	25.2
D5	15.3	15.3	16.3	19.6	22.8	24.6	24.6	24.7	25.1	25.4	25.6	25.8
D36	22.4	22.4	23.4	26.7	29.9	31.7	31.7	31.8	32.2	32.5	32.7	32.9
D37	22.6	22.6	23.6	26.9	30.1	31.9	31.9	32.0	32.4	32.7	32.9	33.1
D39	23.8	23.8	24.8	28.1	31.3	33.1	33.1	33.2	33.6	33.9	34.1	34.3
D41	17.7	17.7	18.7	22.0	25.2	27.0	27.0	27.1	27.5	27.8	28.0	28.2
D42	15.3	15.3	16.3	19.6	22.8	24.6	24.6	24.7	25.1	25.4	25.6	25.8
D50	15.5	15.5	16.5	19.8	23.0	24.8	24.8	24.9	25.3	25.6	25.8	26.0
D198	18.2	18.2	19.2	22.5	25.7	27.5	27.5	27.6	28.0	28.3	28.5	28.7
D199	19.0	19.0	20.0	23.3	26.5	28.3	28.3	28.4	28.8	29.1	29.3	29.5
D200	18.8	18.8	19.8	23.1	26.3	28.1	28.1	28.2	28.6	28.9	29.1	29.3
D202	20.1	20.1	21.1	24.4	27.6	29.4	29.4	29.5	29.9	30.2	30.4	30.6
D205	22.9	22.9	23.9	27.2	30.4	32.2	32.2	32.3	32.7	33.0	33.2	33.4
D242	18.6	18.6	19.6	22.9	26.1	27.9	27.9	28.0	28.4	28.7	28.9	29.1
D243	16.8	16.8	17.8	21.1	24.3	26.1	26.1	26.2	26.6	26.9	27.1	27.3
D290	15.1	15.1	16.1	19.4	22.6	24.4	24.4	24.5	24.9	25.2	25.4	25.6
D292	19.0	19.0	20.0	23.3	26.5	28.3	28.3	28.4	28.8	29.1	29.3	29.5
D293	18.1	18.1	19.1	22.4	25.6	27.4	27.4	27.5	27.9	28.2	28.4	28.6
D294	24.3	24.3	25.3	28.6	31.8	33.6	33.6	33.7	34.1	34.4	34.6	34.8
D295	20.5	20.5	21.5	24.8	28.0	29.8	29.8	29.9	30.3	30.6	30.8	31.0
D296	22.2	22.2	23.2	26.5	29.7	31.5	31.5	31.6	32.0	32.3	32.5	32.7
D299	24.3	24.3	25.3	28.6	31.8	33.6	33.6	33.7	34.1	34.4	34.6	34.8
D300	20.4	20.4	21.4	24.7	27.9	29.7	29.7	29.8	30.2	30.5	30.7	30.9
D301	20.6	20.6	21.6	24.9	28.1	29.9	29.9	30.0	30.4	30.7	30.9	31.1
D305	16.6	16.6	17.6	20.9	24.1	25.9	25.9	26.0	26.4	26.7	26.9	27.1
D306	18.5	18.5	19.5	22.8	26.0	27.8	27.8	27.9	28.3	28.6	28.8	29.0
D307	16.8	16.8	17.8	21.1	24.3	26.1	26.1	26.2	26.6	26.9	27.1	27.3
D314	20.1	20.1	21.1	24.4	27.6	29.4	29.4	29.5	29.9	30.2	30.4	30.6

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
D315	18.7	18.7	19.7	23.0	26.2	28.0	28.0	28.1	28.5	28.8	29.0	29.2
D316	17.9	17.9	18.9	22.2	25.4	27.2	27.2	27.3	27.7	28.0	28.2	28.4
D319	19.9	19.9	20.9	24.2	27.4	29.2	29.2	29.3	29.7	30.0	30.2	30.4
D336	22.4	22.4	23.4	26.7	29.9	31.7	31.7	31.8	32.2	32.5	32.7	32.9
D337	23.2	23.2	24.2	27.5	30.7	32.5	32.5	32.6	33.0	33.3	33.5	33.7
D339	21.6	21.6	22.6	25.9	29.1	30.9	30.9	31.0	31.4	31.7	31.9	32.1
D341	21.9	21.9	22.9	26.2	29.4	31.2	31.2	31.3	31.7	32.0	32.2	32.4
D345	23.8	23.8	24.8	28.1	31.3	33.1	33.1	33.2	33.6	33.9	34.1	34.3
D346	18.2	18.2	19.2	22.5	25.7	27.5	27.5	27.6	28.0	28.3	28.5	28.7
D347	15.7	15.7	16.7	20.0	23.2	25.0	25.0	25.1	25.5	25.8	26.0	26.2
D351	17.3	17.3	18.3	21.6	24.8	26.6	26.6	26.7	27.1	27.4	27.6	27.8
D352	19.9	19.9	20.9	24.2	27.4	29.2	29.2	29.3	29.7	30.0	30.2	30.4
D358	15.9	15.9	16.9	20.2	23.4	25.2	25.2	25.3	25.7	26.0	26.2	26.4
D367	22.4	22.4	23.4	26.7	29.9	31.7	31.7	31.8	32.2	32.5	32.7	32.9
D368	20.7	20.7	21.7	25.0	28.2	30.0	30.0	30.1	30.5	30.8	31.0	31.2
D372	18.0	18.0	19.0	22.3	25.5	27.3	27.3	27.4	27.8	28.1	28.3	28.5
D399	16.6	16.6	17.6	20.9	24.1	25.9	25.9	26.0	26.4	26.7	26.9	27.1
D400	20.6	20.6	21.6	24.9	28.1	29.9	29.9	30.0	30.4	30.7	30.9	31.1
D401	14.2	14.2	15.2	18.5	21.7	23.5	23.5	23.6	24.0	24.3	24.5	24.7
D402	20.9	20.9	21.9	25.2	28.4	30.2	30.2	30.3	30.7	31.0	31.2	31.4
D404	24.0	24.0	25.0	28.3	31.5	33.3	33.3	33.4	33.8	34.1	34.3	34.5
D413	23.9	23.9	24.9	28.2	31.4	33.2	33.2	33.3	33.7	34.0	34.2	34.4
D414	20.4	20.4	21.4	24.7	27.9	29.7	29.7	29.8	30.2	30.5	30.7	30.9
D419	23.1	23.1	24.1	27.4	30.6	32.4	32.4	32.5	32.9	33.2	33.4	33.6
D420	21.9	21.9	22.9	26.2	29.4	31.2	31.2	31.3	31.7	32.0	32.2	32.4
D421	22.7	22.7	23.7	27.0	30.2	32.0	32.0	32.1	32.5	32.8	33.0	33.2
D424	22.9	22.9	23.9	27.2	30.4	32.2	32.2	32.3	32.7	33.0	33.2	33.4
D425	23.0	23.0	24.0	27.3	30.5	32.3	32.3	32.4	32.8	33.1	33.3	33.5
D426	23.1	23.1	24.1	27.4	30.6	32.4	32.4	32.5	32.9	33.2	33.4	33.6
D431	21.0	21.0	22.0	25.3	28.5	30.3	30.3	30.4	30.8	31.1	31.3	31.5
D432	19.9	19.9	20.9	24.2	27.4	29.2	29.2	29.3	29.7	30.0	30.2	30.4
D434	17.7	17.7	18.7	22.0	25.2	27.0	27.0	27.1	27.5	27.8	28.0	28.2

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
D435	22.2	22.2	23.2	26.5	29.7	31.5	31.5	31.6	32.0	32.3	32.5	32.7
D436	21.2	21.2	22.2	25.5	28.7	30.5	30.5	30.6	31.0	31.3	31.5	31.7
D437	22.1	22.1	23.1	26.4	29.6	31.4	31.4	31.5	31.9	32.2	32.4	32.6
D445	22.4	22.4	23.4	26.7	29.9	31.7	31.7	31.8	32.2	32.5	32.7	32.9
D465	22.4	22.4	23.4	26.7	29.9	31.7	31.7	31.8	32.2	32.5	32.7	32.9
D468	17.2	17.2	18.2	21.5	24.7	26.5	26.5	26.6	27.0	27.3	27.5	27.7
D469	17.2	17.2	18.2	21.5	24.7	26.5	26.5	26.6	27.0	27.3	27.5	27.7
D470	15.5	15.5	16.5	19.8	23.0	24.8	24.8	24.9	25.3	25.6	25.8	26.0
D476	17.3	17.3	18.3	21.6	24.8	26.6	26.6	26.7	27.1	27.4	27.6	27.8
D477	20.3	20.3	21.3	24.6	27.8	29.6	29.6	29.7	30.1	30.4	30.6	30.8
D482	18.0	18.0	19.0	22.3	25.5	27.3	27.3	27.4	27.8	28.1	28.3	28.5
D487	15.5	15.5	16.5	19.8	23.0	24.8	24.8	24.9	25.3	25.6	25.8	26.0
D488	15.8	15.8	16.8	20.1	23.3	25.1	25.1	25.2	25.6	25.9	26.1	26.3
D489	15.8	15.8	16.8	20.1	23.3	25.1	25.1	25.2	25.6	25.9	26.1	26.3
D490	15.8	15.8	16.8	20.1	23.3	25.1	25.1	25.2	25.6	25.9	26.1	26.3
D492	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D493	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D494	15.6	15.6	16.6	19.9	23.1	24.9	24.9	25.0	25.4	25.7	25.9	26.1
D495	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D496	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D497	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D498	15.9	15.9	16.9	20.2	23.4	25.2	25.2	25.3	25.7	26.0	26.2	26.4
D499	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D500	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D501	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D502	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D503	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D504	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
D505	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D506	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
D507	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D508	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
D509	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D510	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D511	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
D512	16.5	16.5	17.5	20.8	24.0	25.8	25.8	25.9	26.3	26.6	26.8	27.0
D513	16.5	16.5	17.5	20.8	24.0	25.8	25.8	25.9	26.3	26.6	26.8	27.0
D514	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
D515	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D516	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
D517	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D518	16.5	16.5	17.5	20.8	24.0	25.8	25.8	25.9	26.3	26.6	26.8	27.0
D519	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D520	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D521	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D523	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
D524	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D525	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
D526	16.3	16.3	17.3	20.6	23.8	25.6	25.6	25.7	26.1	26.4	26.6	26.8
D527	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D529	15.8	15.8	16.8	20.1	23.3	25.1	25.1	25.2	25.6	25.9	26.1	26.3
D530	15.9	15.9	16.9	20.2	23.4	25.2	25.2	25.3	25.7	26.0	26.2	26.4
D531	15.7	15.7	16.7	20.0	23.2	25.0	25.0	25.1	25.5	25.8	26.0	26.2
D532	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
D533	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D534	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D535	16.4	16.4	17.4	20.7	23.9	25.7	25.7	25.8	26.2	26.5	26.7	26.9
D538	13.8	13.8	14.8	18.1	21.3	23.1	23.1	23.2	23.6	23.9	24.1	24.3
D548	14.2	14.2	15.2	18.5	21.7	23.5	23.5	23.6	24.0	24.3	24.5	24.7
D549	14.2	14.2	15.2	18.5	21.7	23.5	23.5	23.6	24.0	24.3	24.5	24.7
D550	14.1	14.1	15.1	18.4	21.6	23.4	23.4	23.5	23.9	24.2	24.4	24.6
D551	14.2	14.2	15.2	18.5	21.7	23.5	23.5	23.6	24.0	24.3	24.5	24.7
D568	15.0	15.0	16.0	19.3	22.5	24.3	24.3	24.4	24.8	25.1	25.3	25.5
D574	19.7	19.7	20.7	24.0	27.2	29.0	29.0	29.1	29.5	29.8	30.0	30.2

Receiver	Hub-height wind speed, m/s											
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
D575	15.4	15.4	16.4	19.7	22.9	24.7	24.7	24.8	25.2	25.5	25.7	25.9
D577	16.5	16.5	17.5	20.8	24.0	25.8	25.8	25.9	26.3	26.6	26.8	27.0
D579	16.8	16.8	17.8	21.1	24.3	26.1	26.1	26.2	26.6	26.9	27.1	27.3
D593	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D609	14.8	14.8	15.8	19.1	22.3	24.1	24.1	24.2	24.6	24.9	25.1	25.3
D610	16.0	16.0	17.0	20.3	23.5	25.3	25.3	25.4	25.8	26.1	26.3	26.5
D613	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D614	15.7	15.7	16.7	20.0	23.2	25.0	25.0	25.1	25.5	25.8	26.0	26.2
D615	15.8	15.8	16.8	20.1	23.3	25.1	25.1	25.2	25.6	25.9	26.1	26.3
D616	15.9	15.9	16.9	20.2	23.4	25.2	25.2	25.3	25.7	26.0	26.2	26.4
D617	15.8	15.8	16.8	20.1	23.3	25.1	25.1	25.2	25.6	25.9	26.1	26.3
D620	29.1	29.1	30.1	33.4	36.6	38.4	38.4	38.5	38.9	39.2	39.4	39.6
D622	28.4	28.4	29.4	32.7	35.9	37.7	37.7	37.8	38.2	38.5	38.7	38.9
D623	21.3	21.3	22.3	25.6	28.8	30.6	30.6	30.7	31.1	31.4	31.6	31.8
Stakeholder receivers outside the project boundary												
D38 (S)	20.9	20.9	21.9	25.2	28.4	30.2	30.2	30.3	30.7	31.0	31.2	31.4
D201 (S)	19.3	19.3	20.3	23.6	26.8	28.6	28.6	28.7	29.1	29.4	29.6	29.8
D208 (S)	17.5	17.5	18.5	21.8	25.0	26.8	26.8	26.9	27.3	27.6	27.8	28.0
D340 (S)	20.0	20.0	21.0	24.3	27.5	29.3	29.3	29.4	29.8	30.1	30.3	30.5
D362 (S)	26.1	26.1	27.1	30.4	33.6	35.4	35.4	35.5	35.9	36.2	36.4	36.6
D433 (S)	18.0	18.0	19.0	22.3	25.5	27.3	27.3	27.4	27.8	28.1	28.3	28.5
D478 (S)	18.4	18.4	19.4	22.7	25.9	27.7	27.7	27.8	28.2	28.5	28.7	28.9

Receiver	Hub-height wind speed, m/s											
	4	5	6	7	8	9	10	11	12	13	14	15
Stakeholder receivers within the project boundary												
D32 (S)	24.1	24.1	25.1	28.4	31.6	33.4	33.4	33.5	33.9	34.2	34.4	34.6
D34 (S)	26.6	26.6	27.6	30.9	34.1	35.9	35.9	36.0	36.4	36.7	36.9	37.1
D35 (S)	24.8	24.8	25.8	29.1	32.3	34.1	34.1	34.2	34.6	34.9	35.1	35.3
D40 (S)	26.8	26.8	27.8	31.1	34.3	36.1	36.1	36.2	36.6	36.9	37.1	37.3
D197 (S)	28.5	28.5	29.5	32.8	36.0	37.8	37.8	37.9	38.3	38.6	38.8	39.0
D203 (S)	21.0	21.0	22.0	25.3	28.5	30.3	30.3	30.4	30.8	31.1	31.3	31.5
D206 (S)	18.7	18.7	19.7	23.0	26.2	28.0	28.0	28.1	28.5	28.8	29.0	29.2
D297 (S)	24.8	24.8	25.8	29.1	32.3	34.1	34.1	34.2	34.6	34.9	35.1	35.3
D298 (S)	27.8	27.8	28.8	32.1	35.3	37.1	37.1	37.2	37.6	37.9	38.1	38.3
D338 (S)	26.1	26.1	27.1	30.4	33.6	35.4	35.4	35.5	35.9	36.2	36.4	36.6
D343 (S)	27.1	27.1	28.1	31.4	34.6	36.4	36.4	36.5	36.9	37.2	37.4	37.6
D344 (S)	23.9	23.9	24.9	28.2	31.4	33.2	33.2	33.3	33.7	34.0	34.2	34.4
D355 (S)	27.4	27.4	28.4	31.7	34.9	36.7	36.7	36.8	37.2	37.5	37.7	37.9
D356 (S)	26.4	26.4	27.4	30.7	33.9	35.7	35.7	35.8	36.2	36.5	36.7	36.9
D357 (S)	29.5	29.5	30.5	33.8	37.0	38.8	38.8	38.9	39.3	39.6	39.8	40.0
D359 (S)	24.8	24.8	25.8	29.1	32.3	34.1	34.1	34.2	34.6	34.9	35.1	35.3
D361 (S)	27.1	27.1	28.1	31.4	34.6	36.4	36.4	36.5	36.9	37.2	37.4	37.6
D366 (S)	29.0	29.0	30.0	33.3	36.5	38.3	38.3	38.4	38.8	39.1	39.3	39.5
D377 (S)	16.2	16.2	17.2	20.5	23.7	25.5	25.5	25.6	26.0	26.3	26.5	26.7
D378 (S)	29.5	29.5	30.5	33.8	37.0	38.8	38.8	38.9	39.3	39.6	39.8	40.0
D379 (S)	27.3	27.3	28.3	31.6	34.8	36.6	36.6	36.7	37.1	37.4	37.6	37.8
D380 (S)	32.9	32.9	33.9	37.2	40.4	42.2	42.2	42.3	42.7	43.0	43.2	43.4
D381 (S)	16.1	16.1	17.1	20.4	23.6	25.4	25.4	25.5	25.9	26.2	26.4	26.6
D395 (S)	25.8	25.8	26.8	30.1	33.3	35.1	35.1	35.2	35.6	35.9	36.1	36.3
D396 (S)	27.7	27.7	28.7	32.0	35.2	37.0	37.0	37.1	37.5	37.8	38.0	38.2
D397 (S)	29.0	29.0	30.0	33.3	36.5	38.3	38.3	38.4	38.8	39.1	39.3	39.5
D398 (S)	26.3	26.3	27.3	30.6	33.8	35.6	35.6	35.7	36.1	36.4	36.6	36.8
D403 (S)	19.6	19.6	20.6	23.9	27.1	28.9	28.9	29.0	29.4	29.7	29.9	30.1
D417 (S)	28.1	28.1	29.1	32.4	35.6	37.4	37.4	37.5	37.9	38.2	38.4	38.6
D418 (S)	27.7	27.7	28.7	32.0	35.2	37.0	37.0	37.1	37.5	37.8	38.0	38.2
D422 (S)	29.5	29.5	30.5	33.8	37.0	38.8	38.8	38.9	39.3	39.6	39.8	40.0

Receiver	Hub-height wind speed, m/s											
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
D423 (S)	29.6	29.6	30.6	33.9	37.1	38.9	38.9	39.0	39.4	39.7	39.9	40.1
D428 (S)	27.3	27.3	28.3	31.6	34.8	36.6	36.6	36.7	37.1	37.4	37.6	37.8
D429 (S)	26.8	26.8	27.8	31.1	34.3	36.1	36.1	36.2	36.6	36.9	37.1	37.3
D430 (S)	27.1	27.1	28.1	31.4	34.6	36.4	36.4	36.5	36.9	37.2	37.4	37.6
D438 (S)	32.6	32.6	33.6	36.9	40.1	41.9	41.9	42.0	42.4	42.7	42.9	43.1
D441 (S)	29.4	29.4	30.4	33.7	36.9	38.7	38.7	38.8	39.2	39.5	39.7	39.9
D442 (S)	28.8	28.8	29.8	33.1	36.3	38.1	38.1	38.2	38.6	38.9	39.1	39.3
D444 (S)	26.1	26.1	27.1	30.4	33.6	35.4	35.4	35.5	35.9	36.2	36.4	36.6
D446 (S)	24.0	24.0	25.0	28.3	31.5	33.3	33.3	33.4	33.8	34.1	34.3	34.5
D447 (S)	26.6	26.6	27.6	30.9	34.1	35.9	35.9	36.0	36.4	36.7	36.9	37.1
D448 (S)	25.5	25.5	26.5	29.8	33.0	34.8	34.8	34.9	35.3	35.6	35.8	36.0

(S) Stakeholder receiver

APPENDIX K DIRECTIONAL SENSITIVITY ANALYSIS

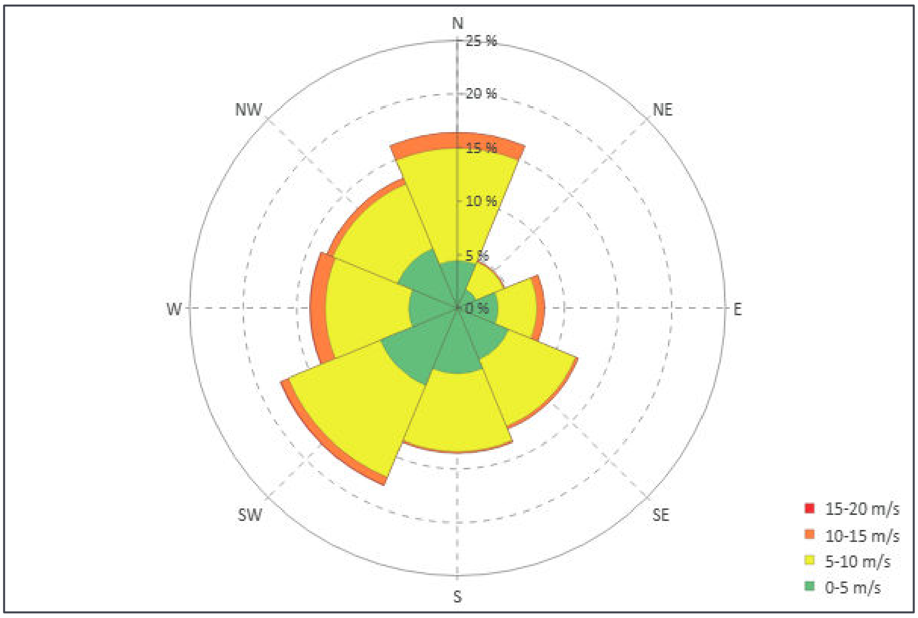
The noise prediction method outlined in Section 4.2.2 for modelling downwind conditions is based on the assumption that sound from the wind farm propagates equally in all directions. In practice, sound propagation will vary with wind direction.

In order to provide some context to the predicted noise levels presented in Section 9.4, directional modelling has been carried out using the UK Institute of Acoustics guidance on the change in sound propagation with wind direction. The resulting predicted directional noise levels were reviewed, together with the prevalence of different wind speeds and directions based on historical wind data provided by the Proponent.[29]

K1 Historical wind data

The Proponent provided historical wind data measured at 120 m between 1 January 2004 and 8 December 2023 from met mast DRY02, located within the site. A wind rose is presented in Figure 21 and the prevalence of hub height wind speeds above and below 15 m/s (hub height wind speed at which the candidate wind turbine model reaches maximum noise emissions) is presented in Table 50 for each wind direction octant.[30]

Figure 21: Historical data wind rose



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[29] Delaire, C, Adcock, J (2024) *Directional wind turbine noise prediction plots and prevalence histograms for community consultation*, INTER-NOISE 2024, Nantes, France. (weblink)

[30] For reference, a wind direction labelled as N (North) represents a wind directed from the north to the south (i.e. a northerly wind), whereas a direction labelled as S (South) represents a wind directed from the south to the north wind (i.e. a southerly wind).

Table 50: Prevalence of hub height wind speeds above and below 8 m/s

Wind direction	< 15 m/s	≥ 15 m/s
N	11.8%	1.9%
NE	7.9%	0.2%
E	7.6%	0.1%
SE	10.0%	0.1%
S	15.0%	0.1%
SW	14.2%	0.5%
W	14.9%	1.5%
NW	12.3%	1.9%
Total	93.7%	6.3%

The prevalence of wind conditions derived from the historical wind data was used to give an indication of the frequency of occurrence of the range of predicted noise levels for each of the assessed receivers. This information is illustrated in the form of histograms in Appendix K3.

K2 Directional modelling

The prediction method detailed in Section 4.2.2, using ISO 9613-2, yields a predicted wind turbine noise level for a scenario in which each receiver is simultaneously downwind of every wind turbine. Winds that are outside of the downwind direction range for each receiver will result in lower wind turbine noise levels than predicted using the ISO 9613-2 method.

The directional modelling carried out using the UK Institute of Acoustics guidance is based on downwind propagation conditions occurring over a very broad range of wind directions. Specifically, a wind direction within a range of ±80 degrees of a wind blowing directly from a wind turbine to a receiver is considered to result in downwind sound propagation conditions. During cross wind conditions, marginal reductions in sound level are then factored into the calculation. For wind directions ranging from cross wind to upwind, further reductions are progressively factored into the calculation until a minimum level is reached when the wind is blowing directly from a receiver to a wind turbine.

The directional results are plotted in Appendix K3 to illustrate the variation in noise level with wind direction.

K3 Predicted noise levels – directional plots and prevalence histograms

This section presents predicted noise level information for a selection of assessed non-stakeholder receivers and receivers representative of the 3 nearest townships as follows:

- **Directional plots:** A directional noise prediction plot which demonstrates the change in the highest predicted wind farm noise levels (i.e. at hub height winds speeds equal to or greater than 15 m/s) with changes in wind direction.[31]
- **Prevalence histograms:** A chart to illustrate the predicted frequency of occurrence of the range of predicted wind turbine noise levels for each receiver, accounting for changes in both wind speed and direction, and the frequency of occurrence of different wind speeds and directions from the historical data provided by the Proponent.

Note that prevalence histograms indicate a wider range of noise levels than illustrated by the directional plots, on account of the directional plots being restricted to wind speeds equal to or greater than 8 m/s at hub height (i.e. direction is the only variable accounted for in the directional plots), whereas the prevalence histograms account for variations in wind speeds and directions.

The prevalence of wind turbine noise levels at each receiver is summarised in Table 50 for a range of nominal reference noise levels.

Table 51: Prevalence of wind turbine noise levels

Receiver	≥40 dB L_{A90}	≥35 dB L_{A90}	≥30 dB L_{A90}	≥25 dB L_{A90}	≥20 dB L_{A90}
D36	0%	0%	15%	53%	82%
D37	0%	0%	20%	55%	80%
D39	0%	0%	31%	62%	89%
D294	0%	0%	34%	65%	90%
D296	0%	0%	13%	42%	81%
D299	0%	0%	36%	63%	91%
D337	0%	0%	35%	61%	84%
D341	0%	0%	18%	51%	78%
D345	0%	0%	31%	62%	88%
D402	0%	0%	17%	51%	75%
D404	0%	0%	35%	64%	91%
D413	0%	0%	33%	63%	91%
D419	0%	0%	34%	61%	83%
D426	0%	0%	39%	61%	87%
D435	0%	0%	32%	55%	80%
D445	0%	0%	22%	55%	86%
D465	0%	0%	30%	57%	81%

[31] For reference, a wind direction of 0° represents a wind directed from the north to the south (i.e. a northerly wind), whereas a direction of 180° represents a wind directed from the south to the north wind (i.e. a southerly wind).

Receiver	≥40 dB L_{A90}	≥35 dB L_{A90}	≥30 dB L_{A90}	≥25 dB L_{A90}	≥20 dB L_{A90}
D620	0%	55%	67%	96%	96%
D622	0%	48%	67%	96%	96%
Receivers representative of nearby townships					
D393 [a]	0%	0%	0%	0%	38%
D512 [b]	0%	0%	0%	13%	37%
D551 [c]	0%	0%	0%	0%	40%

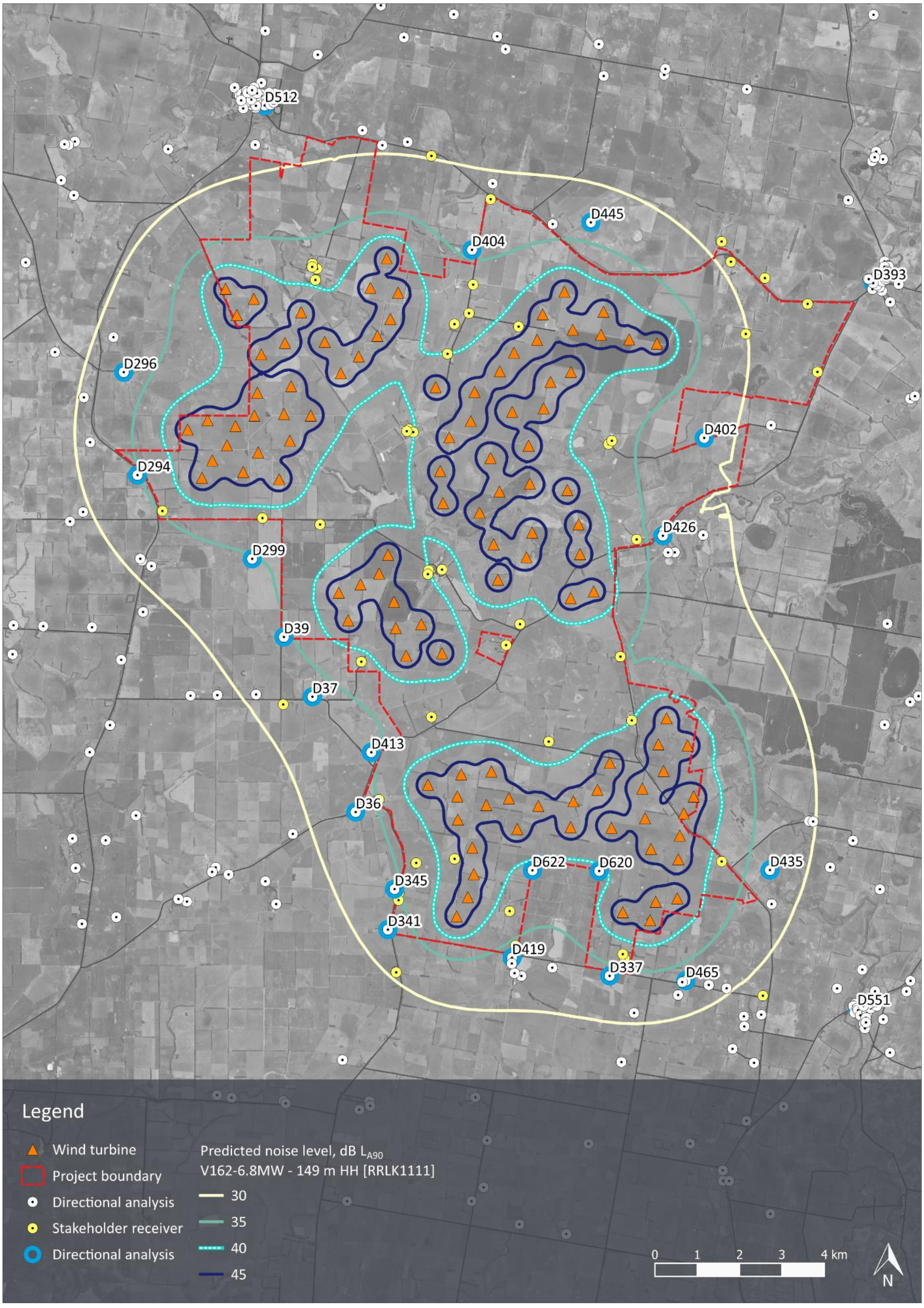
a Representative of the Hexham township

b Representative of the Caramut township

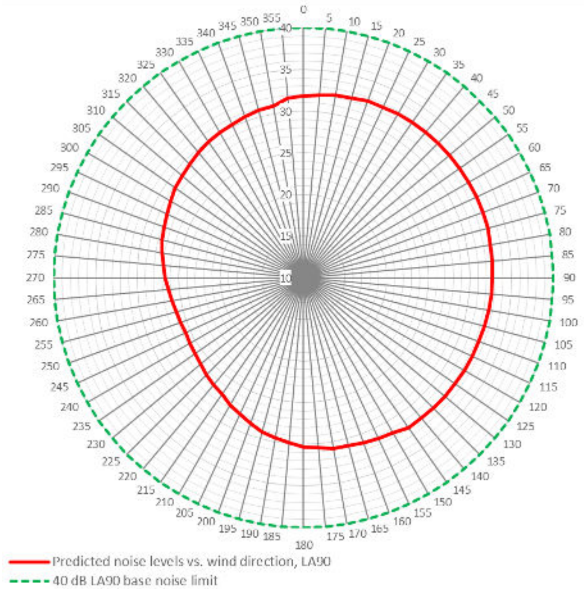
c Representative of the Ellerslie township

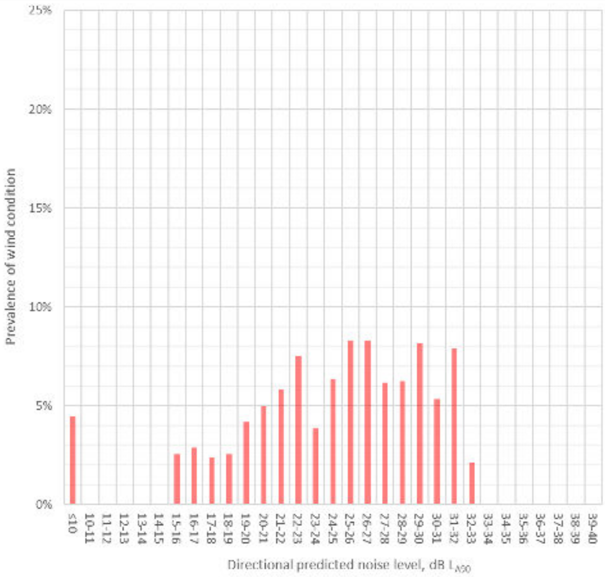
The above receivers are presented in Figure 22, together with highest predicted wind turbine noise contours (as shown in Figure 9). To confirm, the predicted noise contours shown in Figure 22 do not include adjustment for directional effects but are presented to contextualise the directional plots provided in the subsequent figures.

Figure 22: Receivers where directional analysis was undertaken

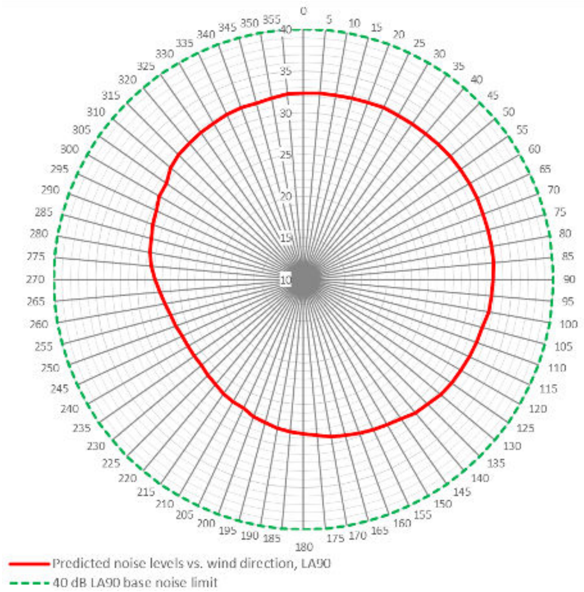


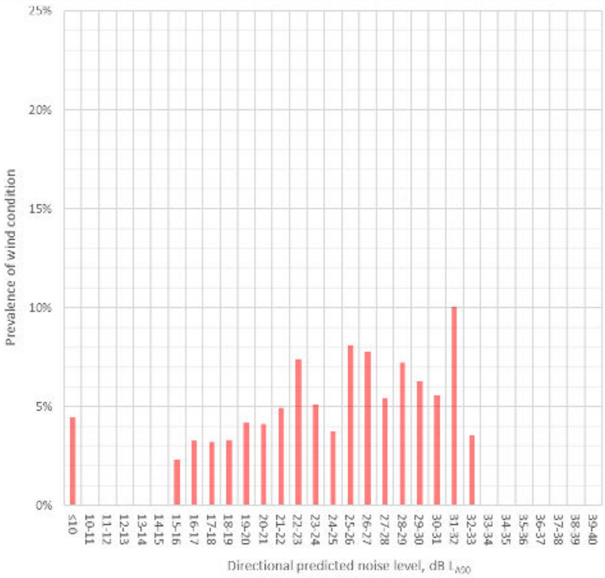
Receiver D36



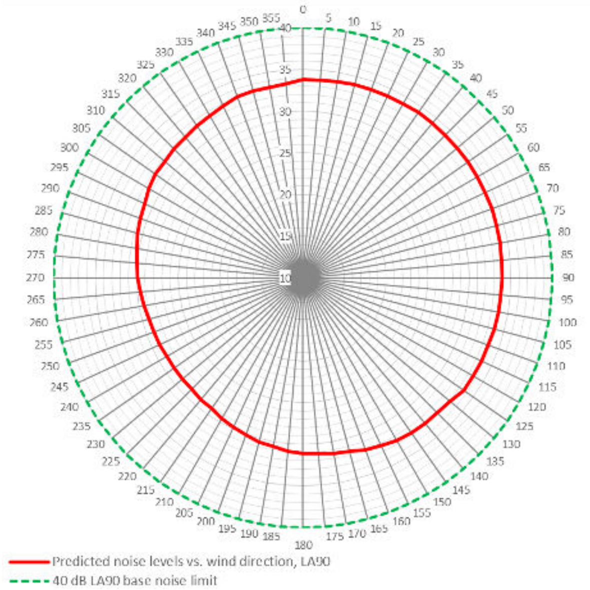


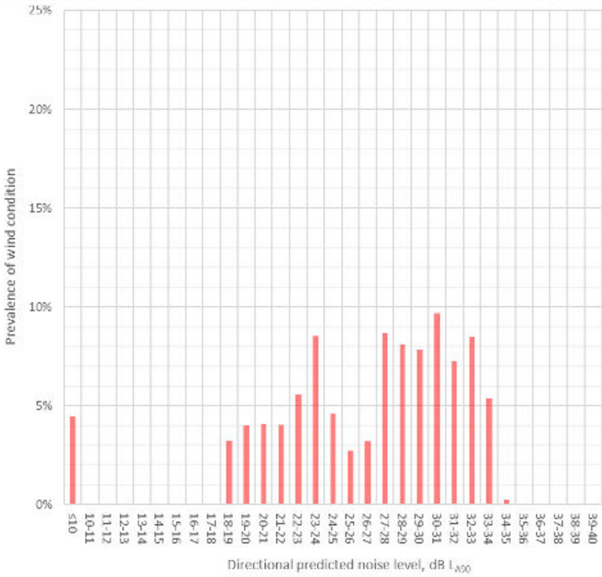
Receiver D37



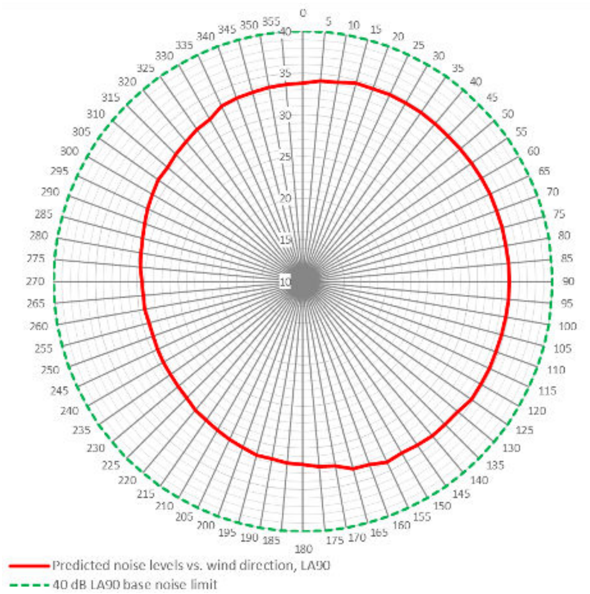


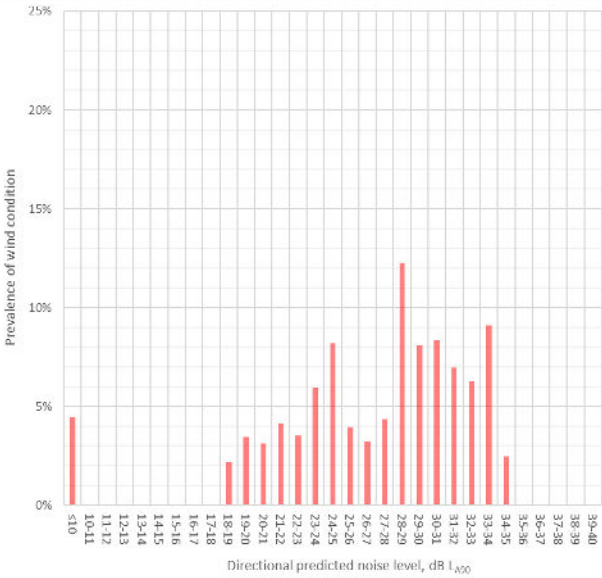
Receiver D39



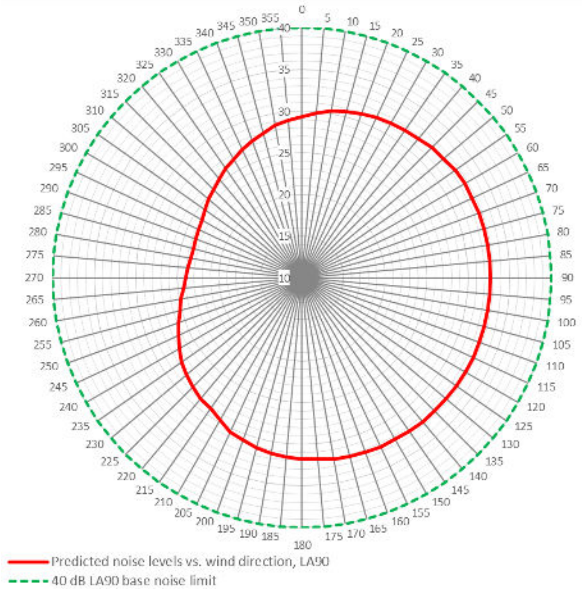


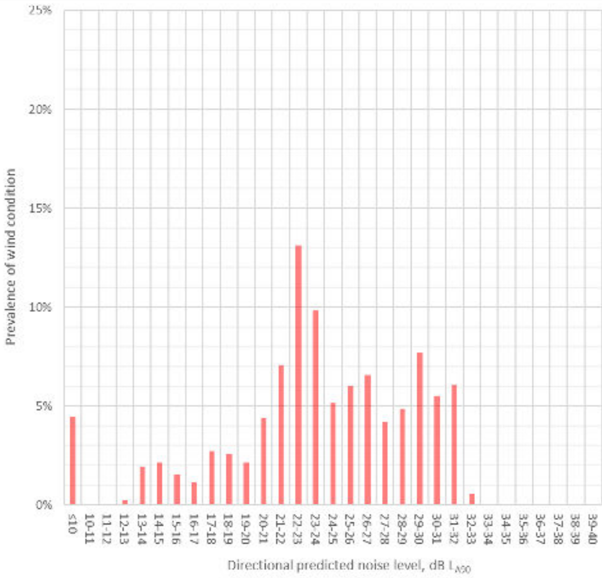
Receiver D294



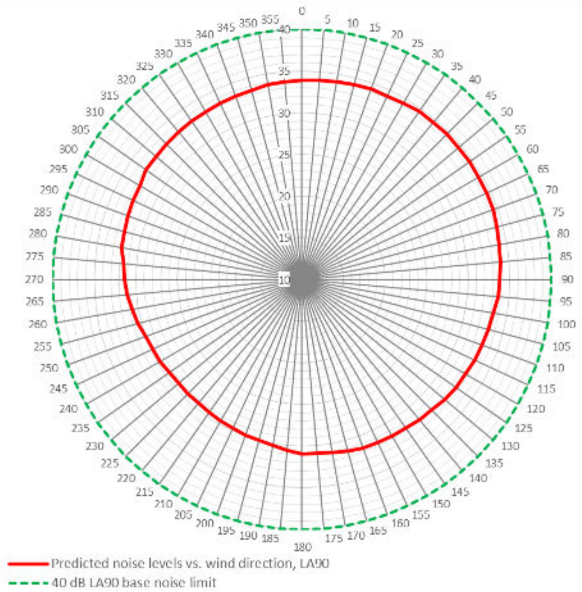


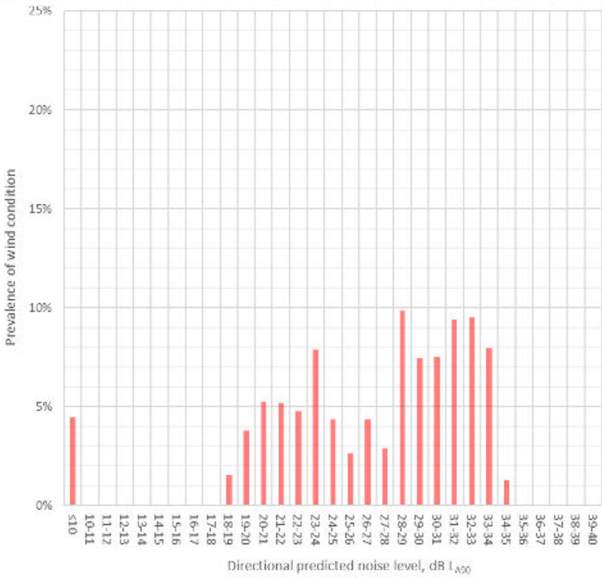
Receiver D296



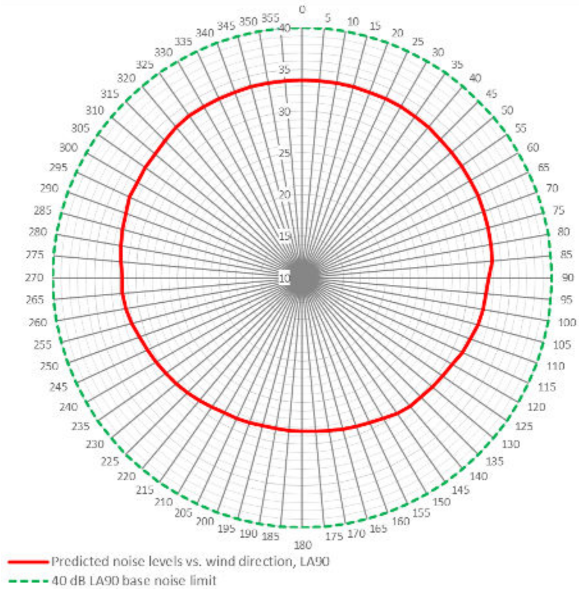


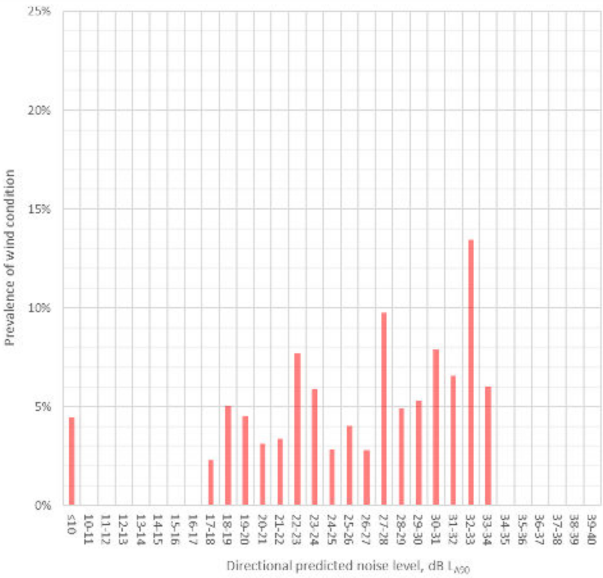
Receiver D299



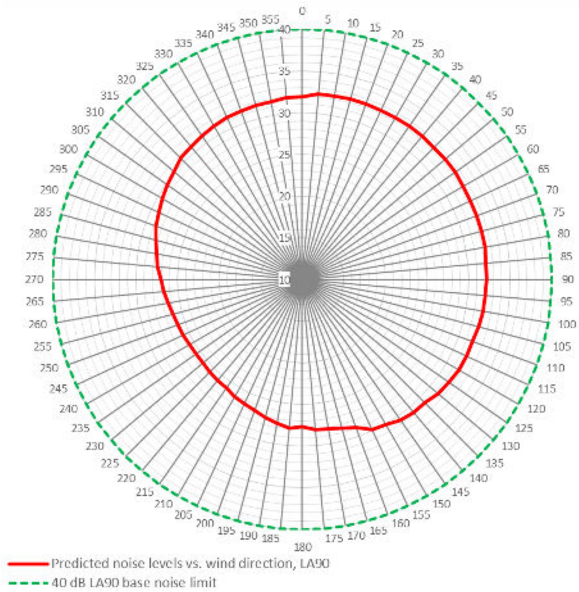


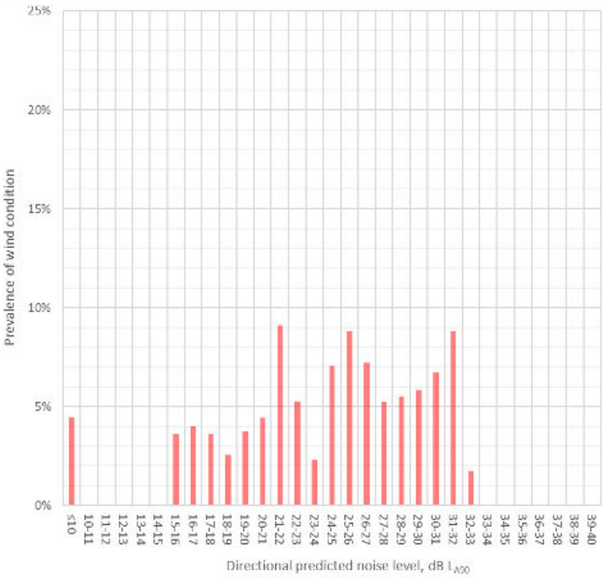
Receiver D337



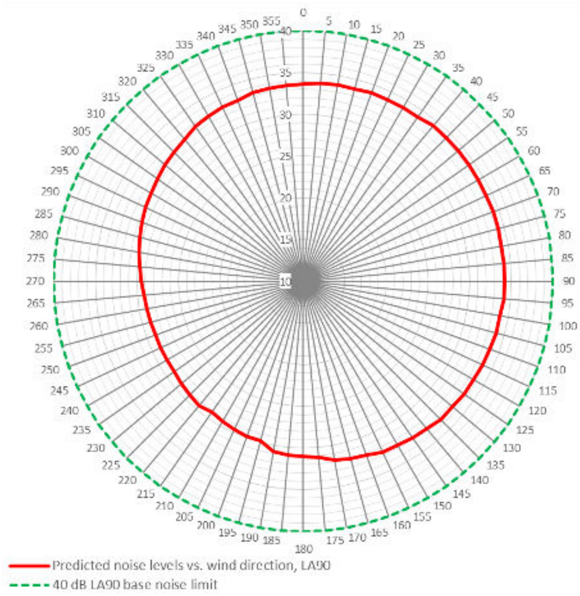


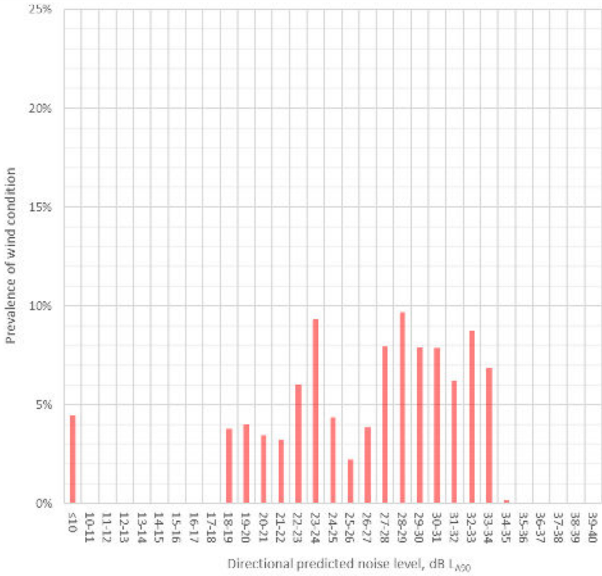
Receiver D341



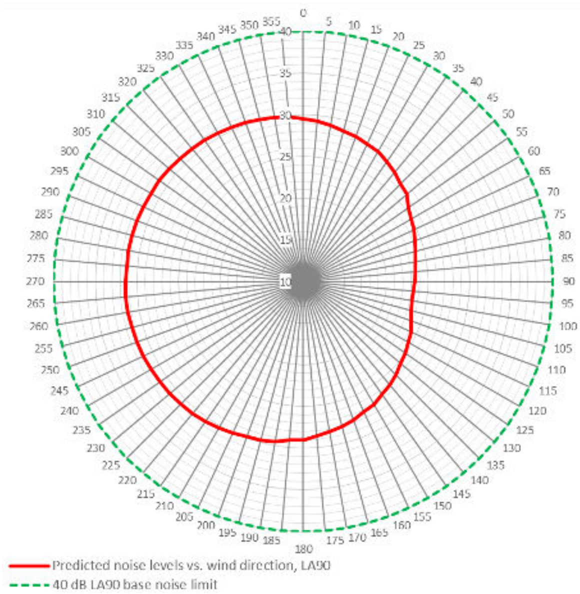


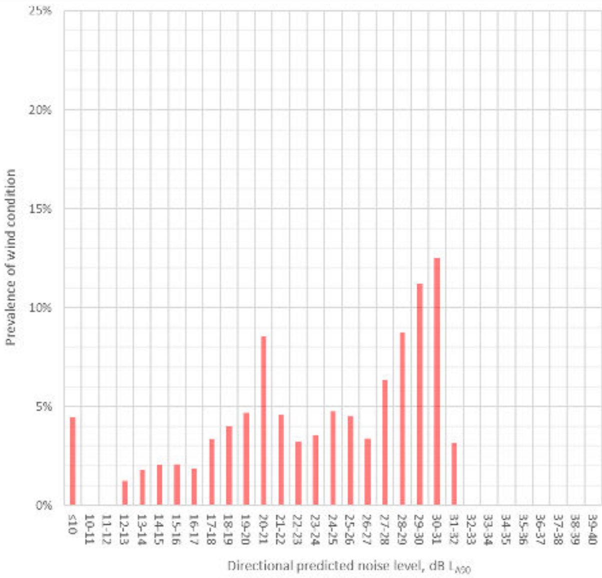
Receiver D345



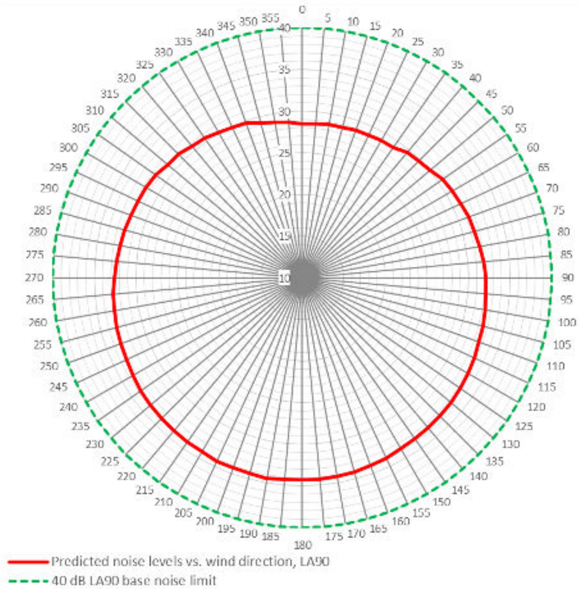


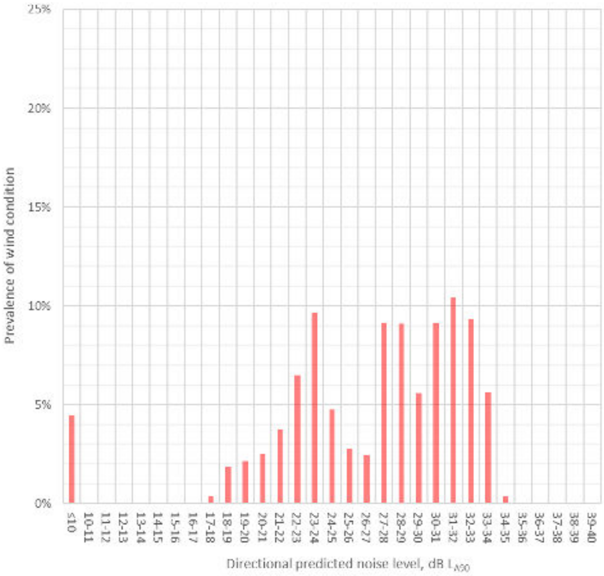
Receiver D402



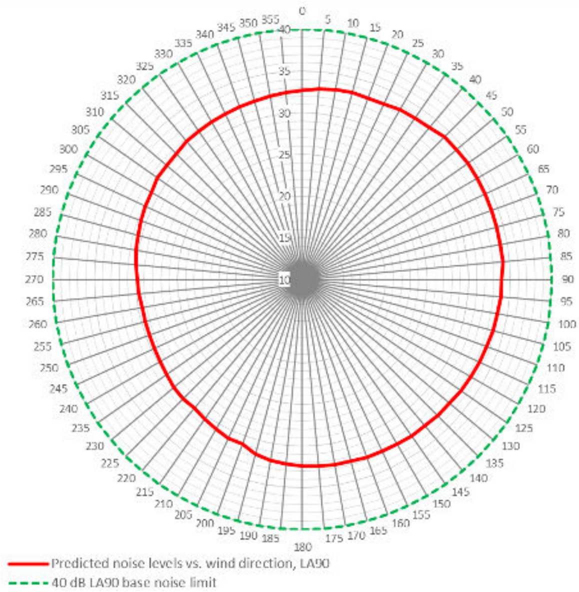


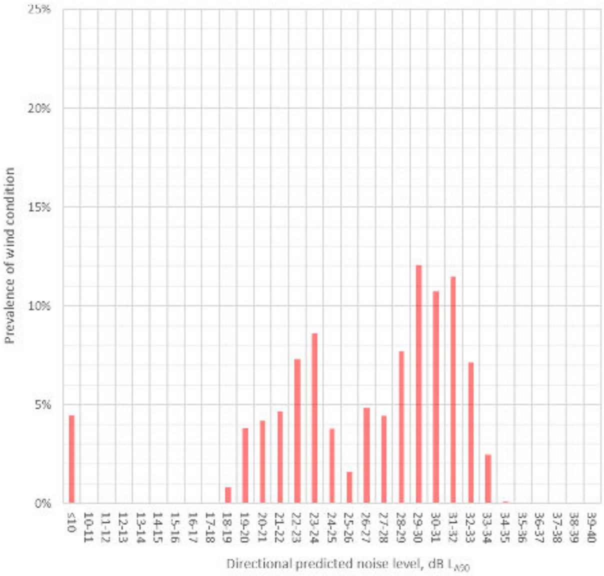
Receiver D404



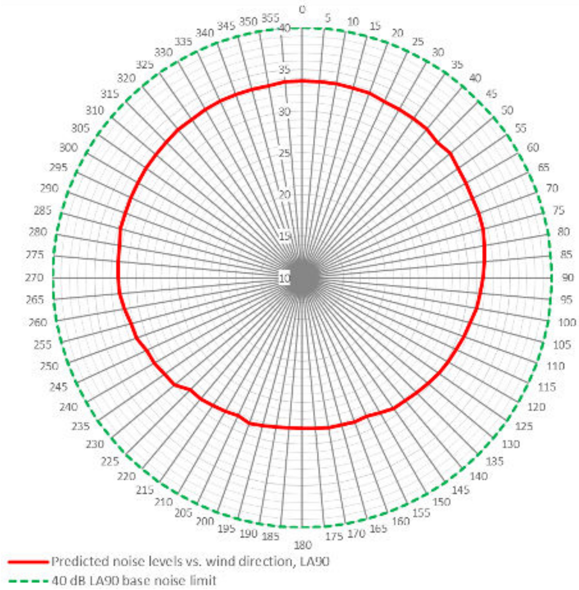


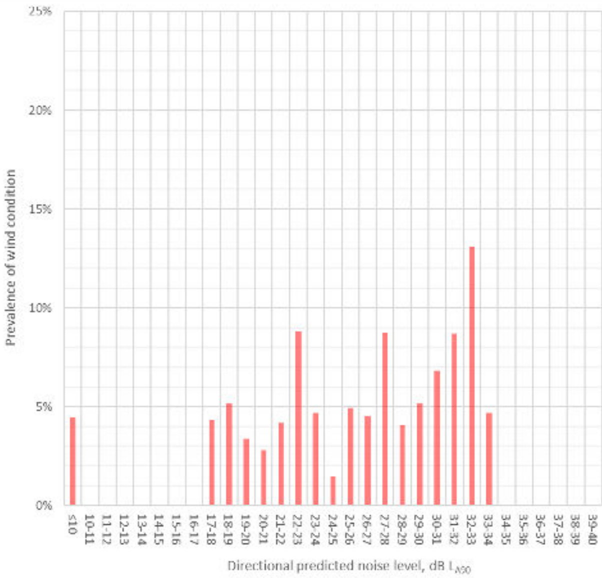
Receiver D413



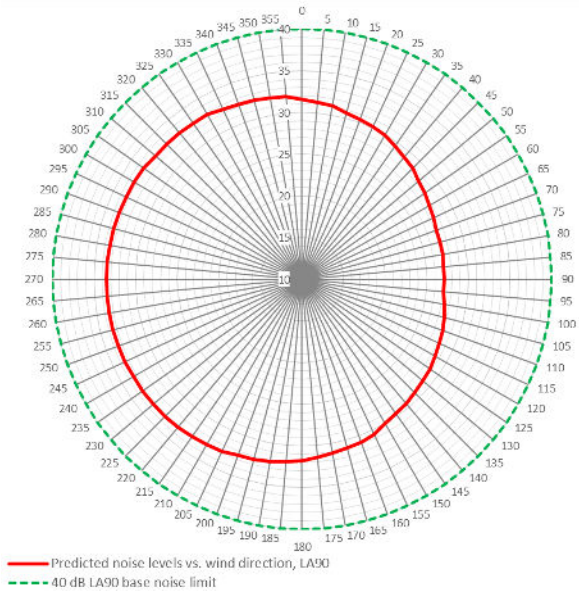


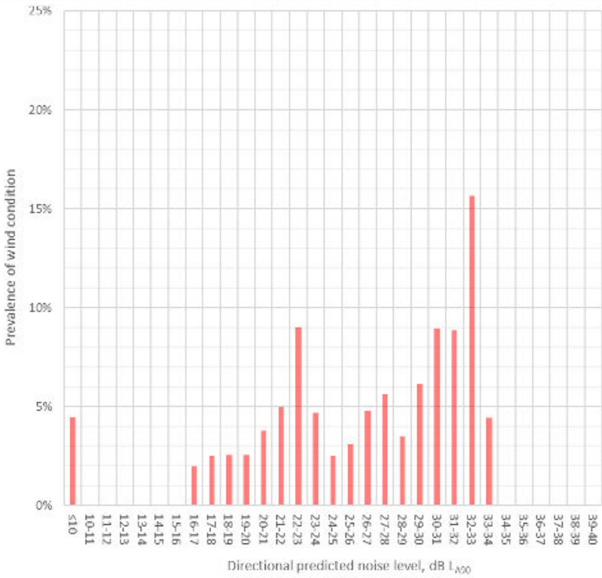
Receiver D419



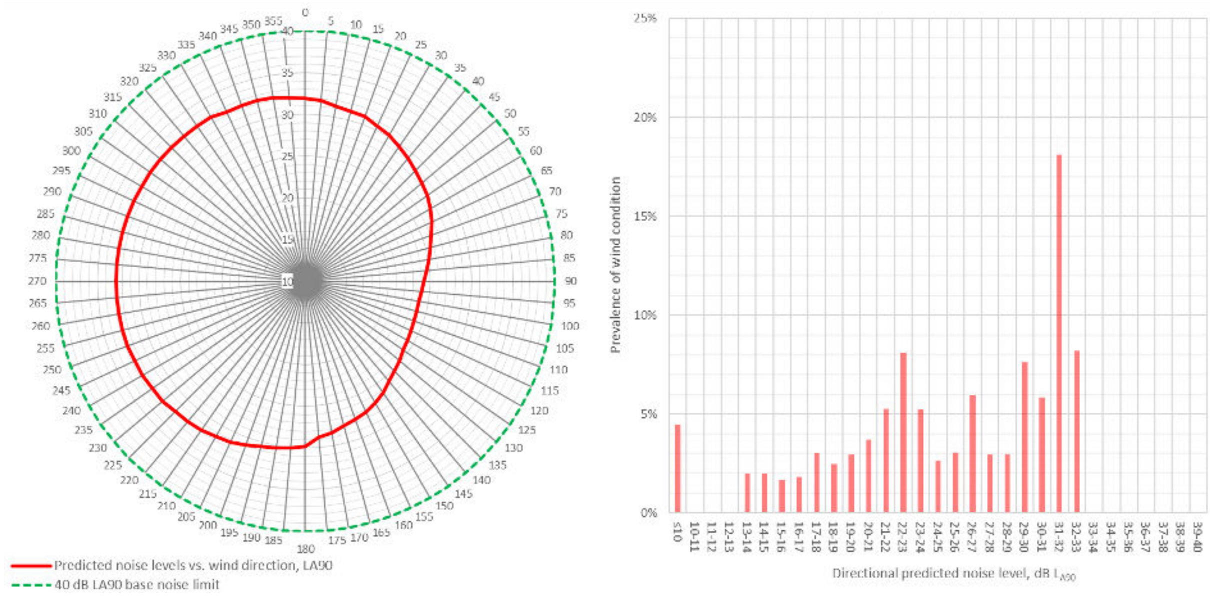


Receiver D426

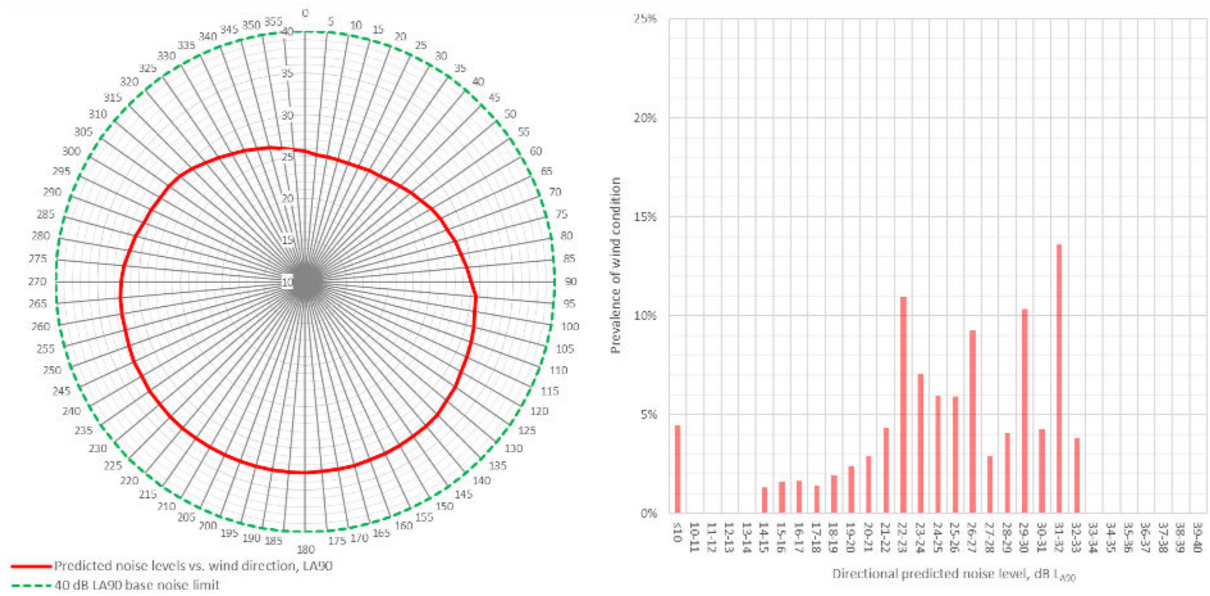




Receiver D435

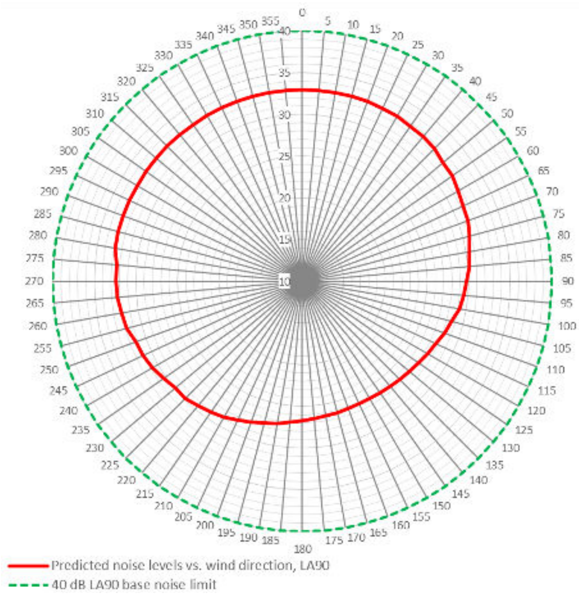


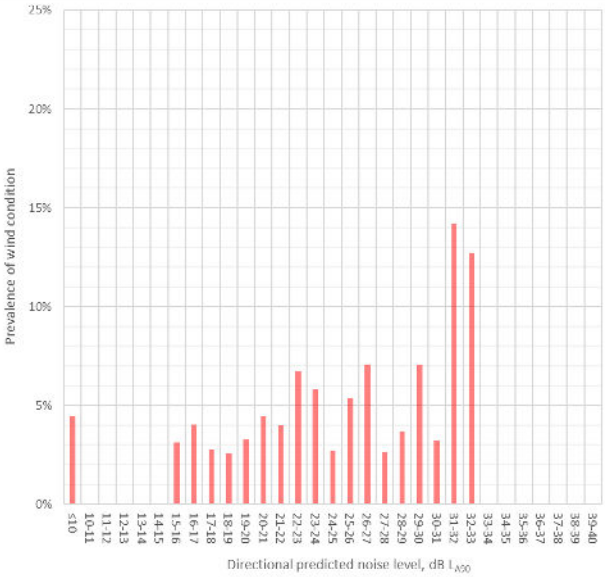
Receiver D445



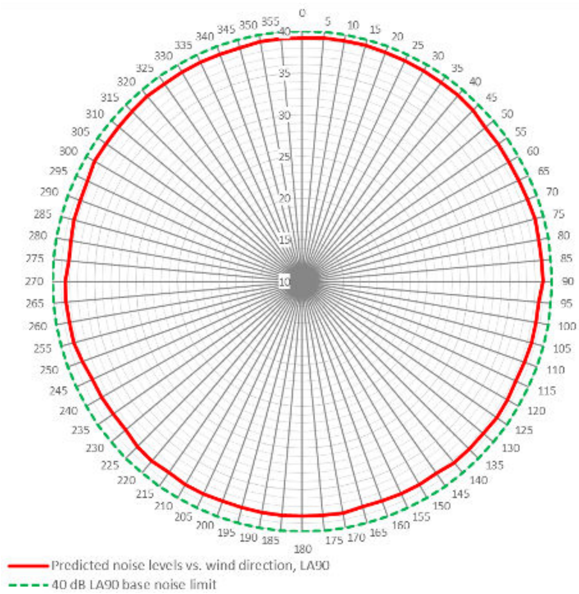
MARSHALL DAY Acoustics

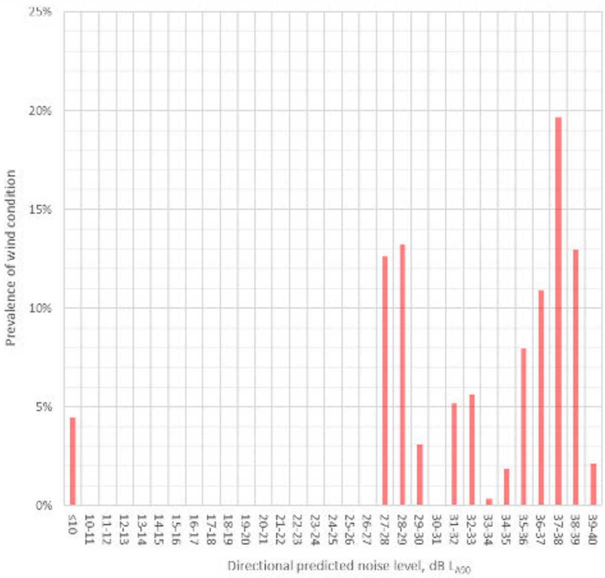
Receiver D465



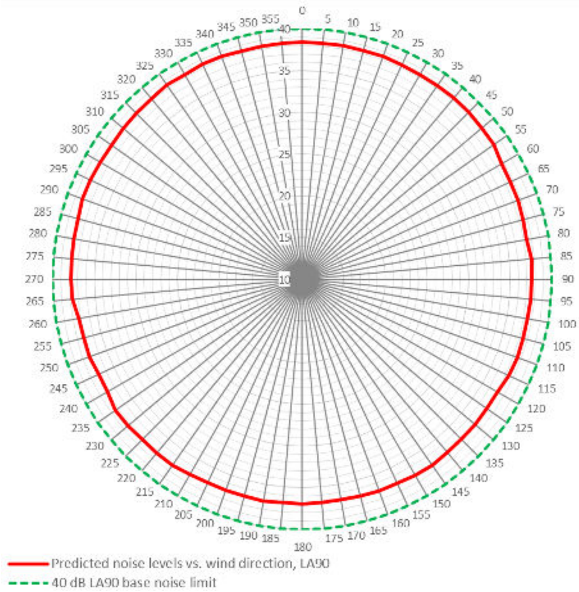


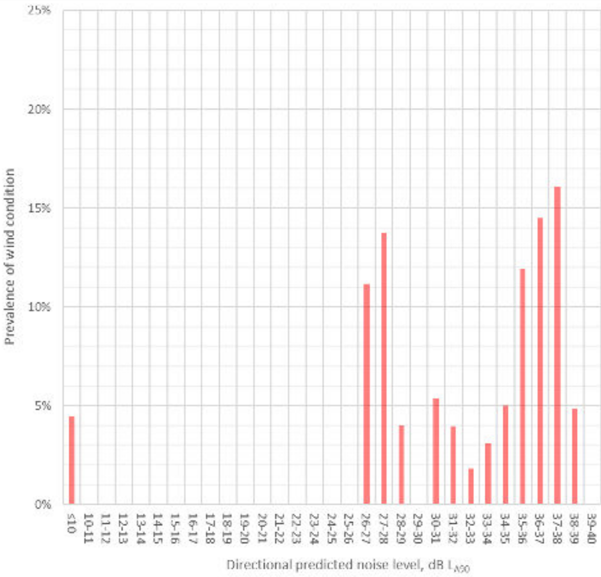
Receiver D620



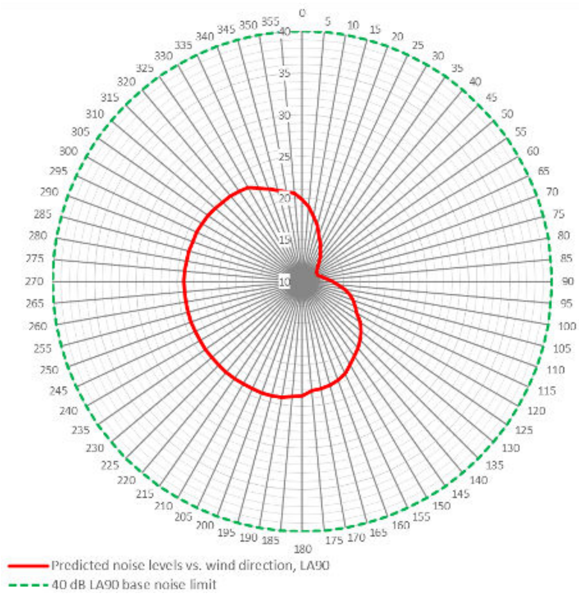


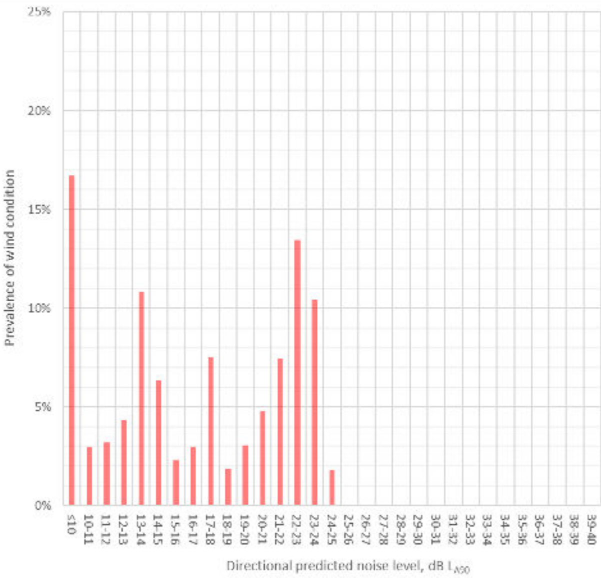
Receiver D622



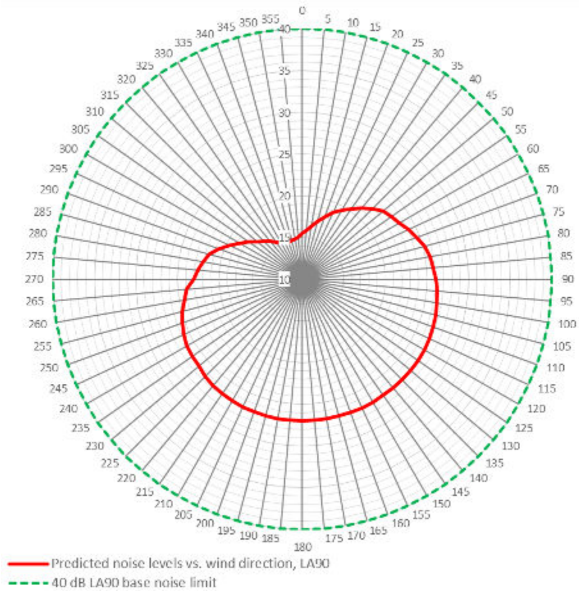


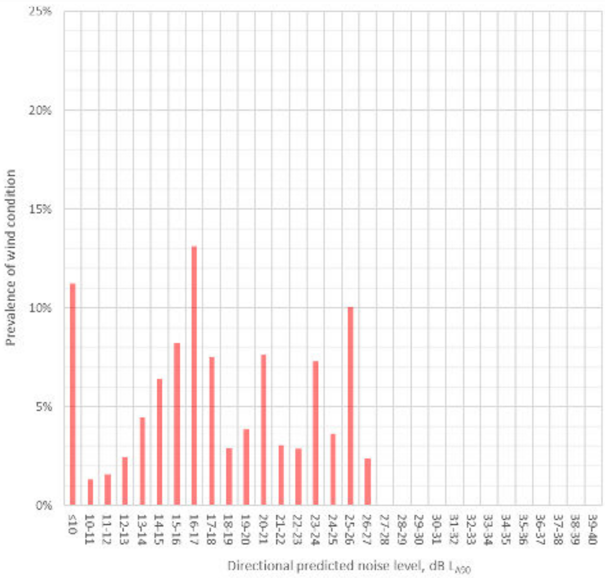
Receiver D393 (representative of Hexham)



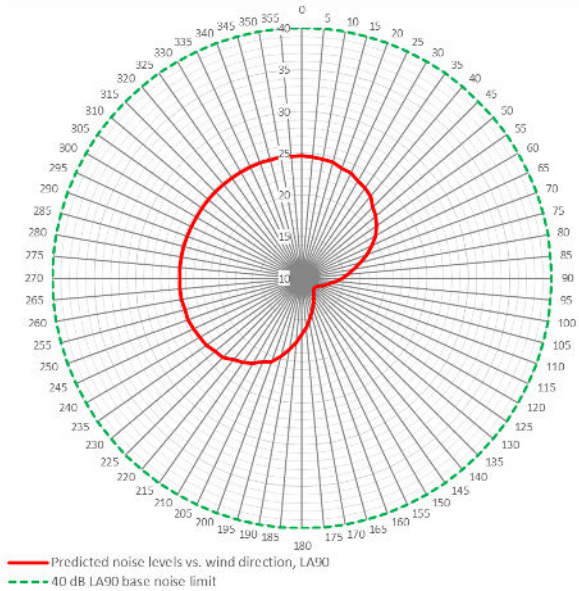


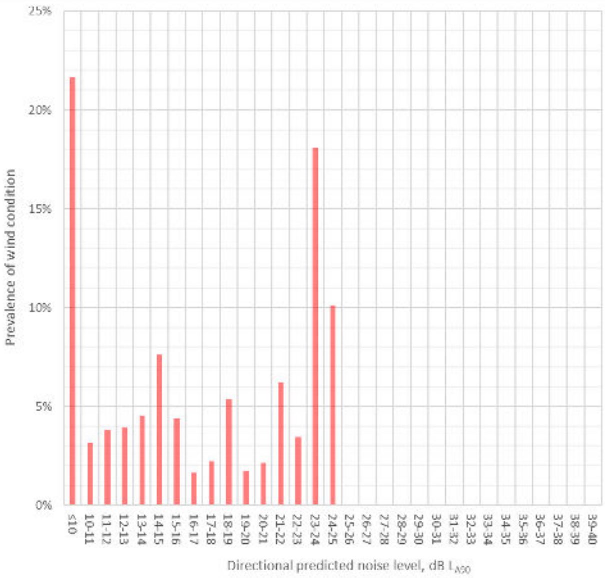
Receiver D512 (representation of Caramut township)





Receiver D551 (representative of the Ellerslie township)





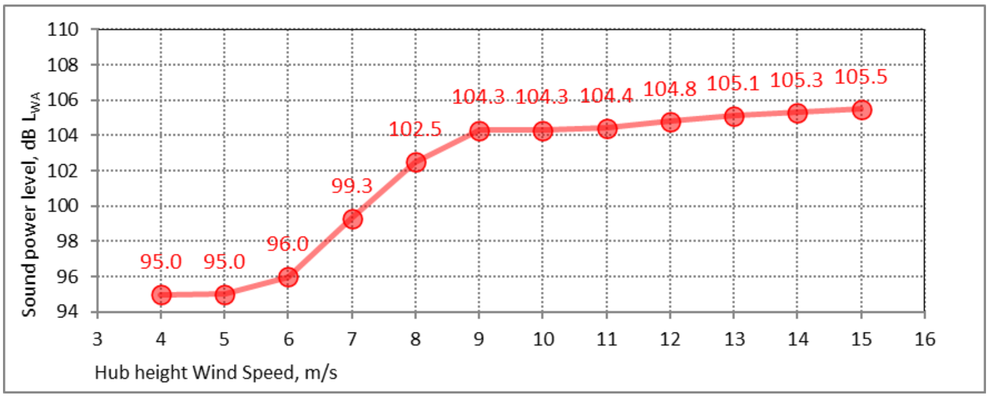
APPENDIX L NZS 6808 DOCUMENTATION

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

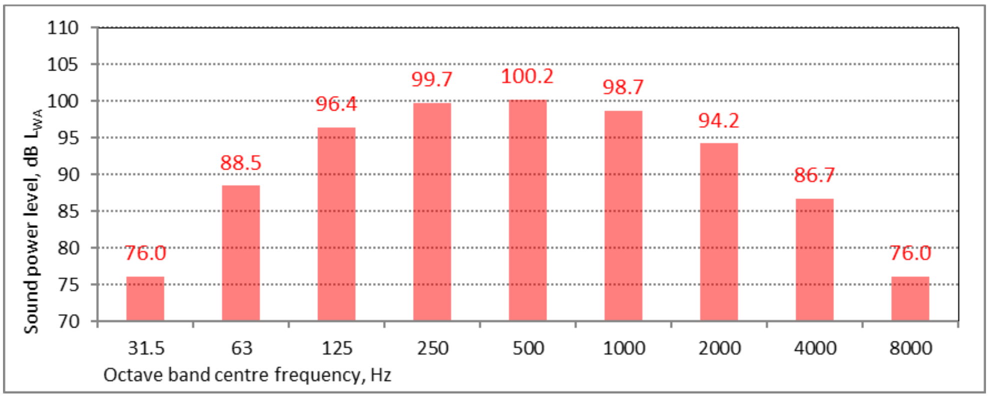
(b) Noise sensitive locations: See Section 5.1 and Appendix F

(c) Wind turbine sound power levels: See Section 9.3.1

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 22 of Section 9.2

(e) Turbine hub height: See Table 22 of Section 9.2

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

(g) Calculation procedure used: ISO 9613-2 prediction algorithm as implemented in SoundPLANnoise v9.1 (See Section 4.2.2 and Appendix E)

(h) Meteorological conditions assumed: See Table 45 of Appendix E

(i) Air absorption parameters:

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

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

(k) Predicted far-field wind farm sound levels: See Section 9.4 and Appendix J.