Warracknabeal
Energy Park

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Attachment A.9: Preliminary Environmental Noise Assessment

Warracknabeal Energy Park

Preliminary Environmental Noise Assessment

M220300RP1 Revision D

Tuesday, 21 March 2023

Document Information

Project	Warracknabeal Energy Park
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Revision Table

Report revision	Date	Description	Author	Reviewer
0	20 June 2022	Draft issue	Andrea Hempshall / Tom Evans	Xun Li
A	30 June 2022	For Issue	Andrea Hempshall / Tom Evans	Xun Li
B	1 August 2022	Minor Amendments	Andrea Hempshall / Tom Evans	Xun Li
C	23 November 2022	Minor Amendments	Andrea Hempshall / Tom Evans	Xun Li
D	21 March 2023	Updated Project information	Andrea Hempshall	Tom Evans

Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
Environment Protection Regulations	The Regulations objectives of these Regulations are to further the purposes of, and give effect to, the Environment Protection Act 2017.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second.
L_{A90}	The A-weighted noise level exceeded for 90% of the measurement time. The L_{90} level is used to assess both background noise and wind turbine noise under NZS 6808:2010.
L_{Aeq}	Equivalent Noise Level—Energy averaged A-weighted noise level over the measurement time.
L_W	Sound Power Level – a measure of the acoustic output of a source, independent of distance and referenced to 10^{-12} W.
NZS 6808:2010	New Zealand Standard NZS 6808:2010 *Acoustics – Wind farm noise*.
Special audible characteristics	Special Audible Characteristics are unusual characteristics of wind farm sound that make it more likely to cause adverse community response at lower sound levels. Special audible characteristics are defined by NZS 6808:2010 to include tonality, impulsiveness and amplitude modulation.

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1 Introduction

Warracknabeal Energy Park Pty Ltd (WAEP) is proposing development of the Warracknabeal Energy Park (the Project). The Project will consist of wind turbines installed across two separate project areas northwest and southwest of the town of Warracknabeal in Yarriambiack Shire. The wind turbines will be supported by transmission infrastructure and Battery Energy Storage Systems (BESS).

WAEP has developed an indicative 211 turbine layout for the purposes of preliminary assessments for the Project. Resonate has been engaged to undertake a preliminary noise assessment of the Project for the purposes of informing a referral under the *Environment Effects Act 1978* to the Department of Transport and Planning (DTP).

This report presents a preliminary noise assessment of the Project, including:

- identification of noise sources associated with the Project
- identification of applicable legislation, policies and guidelines relating to noise emissions during construction and operation
- preliminary wind turbine noise predictions and assessment against applicable noise limits
- recommendations for further assessment during future planning of the Project.

2 Project description

2.1 Site description

The Project is proposed to consist of wind turbines constructed across two project areas with a tip height of up to 280 m above ground level. The Project site is located across agricultural land, which is relatively flat with a change in height of approximately 25 m across the 35 km north to south extent of the Project site boundary.

The two project areas are located near the township of Warracknabeal in Victoria's Wimmera Region. For the indicative layout, 153 turbines are proposed to the north-west and the remaining 58 proposed to the south-west of Warracknabeal. The wind turbines will be supported by:

- Two internal substations (Collector Stations), one of which will also serve as a Terminal Station, providing connection into the electricity grid.
- BESS at each Collector Station.
- Approximately 23 km of new overhead (33 kV) powerlines providing connection from the wind turbines to the Collector Stations.
- Approximately 34 km of new overhead (220 kV or 500 kV) powerlines providing connection between the two Collector Stations and onwards to Murra Warra Terminal Station.
- Up to six permanent weather monitoring masts.
- Two Operations and Maintenance (O&M) facilities.
- Approximately 210 km of unsealed, all weather access tracks.
- Up to four temporary concrete batching plants.
- A number of temporary site compounds and laydown areas.

The primary noise sources associated with the Project will involve:

- Temporary noise associated with construction and decommissioning.
- Operational wind turbine noise.
- Operational ancillary infrastructure noise from the BESS and Collector Stations.

An indicative layout of the site is shown in Figure 1, with indicative wind turbine coordinates included in Appendix A. The positions of the wind turbines are subject to change within the site boundary during future design development. At this stage, the location of the ancillary infrastructure has not been confirmed.

2.2 Noise-sensitive locations

WAEP has provided information on identified noise-sensitive locations around the site as shown on Figure 1, with coordinates tabulated in Appendix B.

The noise-sensitive locations are located within a Farming Zone as defined by the Yarriambiack Planning Scheme. The township of Warracknabeal includes noise-sensitive locations within other zoning, including Rural Living Zones, but these zones are located over 3.5 km from the proposed site boundary and are therefore well outside of the predicted 35 dB L_{A90} noise contour from the Project as documented in this report.

A number of involved landowner houses have also been identified within the site boundary as shown on Figure 1, and with coordinates tabulated in Appendix B.

WARRACKNABEAL ENERGY PARK

Yarriambiack Shire, VIC
Figure 1: Site map

PROJECT NUMBER	M220300
DRAWN BY	AH
DATE	March 2023
CLIENT	WEP
AERIAL IMAGERY	(c) Google

Legend

- Site Boundary
- Elevation Contour
- Project Turbine (Indicative)
- Murra Warra WF Stage 1 Turbine
- Murra Warra WF Stage 2 Turbine

House

- Involved landowner
- Noise-sensitive location

0 2 4 6 8 10 km

Datum GDA20 MGA Zone 54

Resonate

2.3 Wind turbine model

At this preliminary stage of the Project, the wind turbine model that will be used has not been confirmed. Based on the information supplied by WAEP, it is understood that the turbines will have a tip height of up to 280 m above ground and a rotor diameter of up to 200 m.

In the absence of a selected wind turbine model, a typical turbine has been selected for this assessment that is considered representative of the typical range of modern wind turbine sound power levels. The selected turbine is a Vestas V162-6.2MW wind turbine. Sound power levels have been based on Vestas specification documents[1] supplied by WAEP.

The overall sound power levels with hub height wind speed for the Vestas V162-6.2MW are summarised in Table 1, with this preliminary assessment based on the model both with and without serrated trailing edges (STE)[2]. STE are one example of noise reduction mechanisms available to wind farm operators and have been included in this assessment to demonstrate the typical effect of such mechanism. As a cautious approach, a 1 dB uncertainty factor has been applied to specified sound power levels for both options and is incorporated into the levels presented in Table 1.

Table 1 Wind turbine sound power levels with wind speed

Turbine	Sound power level in dB L_{WA} for hub height wind speed in m/s							
	3	4	5	6	7	8	9	≥ 10
V162-6.2MW without STE	97.7	97.9	98.1	100.0	103.0	105.8	108.1	108.6
V162-6.2MW with STE	94.9	95.1	95.3	97.2	100.2	103.0	105.3	105.8

As is normal for modern pitch-controlled wind turbines, the sound power levels for the Vestas V162-6.2MW wind turbine increase from the cut-in wind speed before levelling off at a wind speed close to the wind speed at which the turbines reach rated power. This noise assessment has been based on the maximum sound power level, with the assumed sound power level spectrum, and incorporating the 1 dB uncertainty factor based on the supplied specification, presented in Table 2.

Table 2 Wind turbine sound power level spectrum

Turbine	Sound power level in dB L_{WA} at octave band centre frequency in Hz									Overall
	31.5	63	125	250	500	1000	2000	4000	8000	dB L_{WA}
V162-6.2MW without STE	74.9	87.4	96.2	101.7	103.9	102.9	98.5	91.0	79.9	108.6
V162-6.2MW with STE	76.7	87.1	94.6	99.2	100.9	99.8	95.7	88.8	79.0	105.8

The modelled sound power levels are considered representative of the typical range of modern wind turbines, which generally vary in sound power level from approximately 104 to 109 dB L_{WA}.

[1] *Third octave noise emission – EnVentus V162-6.2 MW 50/60 Hz* issued by Vestas, reference 0105-5200_00 dated 21 April 2021.
[2] STEs can be attached to wind turbine blades to reduce trailing edge turbulence and, as a result, reduce sound power levels in the order of 2-3 dB.

2.4 Murra Warra Wind Farm

The Project site is located north-east of another wind farm project, Murra Warra Wind Farm, which is comprised of two stages. Stage 1 is currently in operation and Stage 2 is under construction and commissioning. The northernmost Stage 2 turbine is approximately 5 km from the southern end of the WAEP boundary.

Stage 1 of Murra Warra Wind Farm consists of 61 Senvion 3.7M144 wind turbines, with a hub height of 139 m above ground and a rotor diameter of 144 m. Stage 2, when completed, will consist of 38 GE 158-5.5 MW turbines, with a hub height of 141 m above ground and a rotor diameter of 158 m.

Table 3 summarises the maximum stated sound power levels for the Murra Warra Wind Farm, including a +1 dB uncertainty adjustment. The Senvion sound power levels are based on a Marshall Day Acoustics Acoustic Compliance Report[3] prepared for Stage 1 of the Murra Warra Wind Farm, and the GE sound power levels are based on data previously provided to Resonate on other projects.

Table 3 Murra Warra Wind Farm wind turbine sound power level spectra

Turbine	Sound power level in dB L_{WA} at octave band centre frequency in Hz									Overall
	31.5	63	125	250	500	1000	2000	4000	8000	dB L_{WA}
Senvion 3.7M144	78.5	88.6	95.9	101.5	101.7	99.7	97.9	90.2	75.9	107.0
GE 158 5.5MW	79.2	88.2	93.6	98.2	100.7	102.3	100.1	92.7	77.2	107.0

[3] Marshall Day Acoustics, 25 November 2019, *Murra Warra Wind Farm – Stage 1, Acoustic Compliance Report – Round 1*, RP 001 20181019

3 Legislation, policy and guidelines

3.1 Environment Protection Act 2017

Section 25(1) of the Environment Protection Act 2017 (the Act) sets forth the General Environmental Duty (GED), which states:

> A person who is engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste must minimise those risks, so far as reasonably practicable.

A wind farm operator has an obligation to understand the risks associated with noise and to take reasonably practicable steps to minimise those risks. Environment Protection Authority (EPA) Victoria has released a range of subordinate legislation and guidelines to support the Act. Compliance with these subordinate legislation and guidelines would be expected to assist in meeting the GED.

3.2 Environment Protection Regulations

The *Environment Protection Regulations* are subordinate legislation that support the Act. They prescribe requirements with respect to wind turbine noise and ancillary infrastructure noise from the Project.

3.2.1 Wind turbine noise

The *Environment Protection Regulations*, as amended by the *Environment Protection Amendment (Interim) Regulations 2021*, state that any wind energy facility with an authorising document issued on or after 1 January 2011, or amended to do so, must achieve compliance with the noise limits as set out in NZS 6808:2010. Wind farm noise that exceeds the noise limit is defined to be unreasonable noise under the Environment Protection Act.

By achieving compliance with the NZS 6808:2010 noise limits, as well as the other relevant requirements of the *Environment Protection Regulations*, Regulation 131C advises that a wind farm operator is able to demonstrate compliance with the GED with respect to wind turbine noise emissions.

The requirement to comply with the NZS 6808:2010 noise limits does not apply at dwellings with which an appropriate agreement is in place between the landowner and wind farm operator under Regulation 131A (involved landowner houses). In this case, the noise limit is increased to 45 dB L_{A90} or the background sound level plus 5 dB, whichever is the greater when assessed in accordance with NZS 6808:2010.

3.2.2 Ancillary infrastructure noise

Under the *Environment Protection Regulations*, the assessment of noise from commercial, industrial and trade premises at noise-sensitive areas must be carried out in accordance with the EPA Victoria Noise Protocol,[4] both in terms of establishing noise limits as noise-sensitive areas and in terms of the measurement of noise from the subject premises. These requirements and the Noise Protocol noise limits apply to ancillary infrastructure noise from the Project.

Noise-sensitive areas for ancillary infrastructure noise are defined in the *Environment Protection Regulations* as:

- The area within 10 m of the external walls of dwellings (including residential care facilities but excluding caretaker's houses), residential buildings and noise-sensitive residential uses.

[4] EPA Victoria Publication 1826.4 *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues*

- The area within 10 m outside the external walls of any dormitories, wards, bedrooms and living rooms of caretaker's houses, hospitals, hotels, motels, residential hotels specialist disability accommodation, corrective institutions, tourist establishments, retirement villages and residential villages.
- The area within 10 m outside the external walls of classrooms or other rooms in which learning occurs at childcare centres, kindergartens, primary schools and secondary schools.
- Within the boundary of tourist establishments, campgrounds and caravan parks that are located in rural areas.

The *Environment Protection Regulations* also define Day, Evening and Night time periods for the assessment of ancillary infrastructure noise, reproduced in Table 4.

Table 4 Noise Protocol time periods

Time period	Details
Day	Weekdays and Saturdays, 7 am to 6 pm
Evening	Weekdays and Saturdays, 6 pm to 10 pm Sundays and public holidays, 7 am to 10 pm
Night	10 pm to 7 am any day

3.3 Wind Farm Guidelines

The DTP (previously Department of Environment, Land, Water and Planning) *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria* (Wind Farm Guidelines, November 2021) are the relevant planning guidelines for wind farms in Victoria and state that, with respect to operational noise:

> A wind energy facility must comply with the noise limits in the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (the Standard).

This requirement is equivalent to that imposed by the *Environment Protection Regulations*.

With respect to involved landowner houses, the DTP Wind Farm Guidelines recommend a base noise target of 45 dB L_{A90}, consistent with the requirements of the *Environment Protection Regulations*.

3.4 Yarriambiack Planning Scheme

Clause 52.32 of the Yarriambiack Planning Scheme addresses wind energy facilities such as the proposed Warracknabeal Energy Park. In particular, Clause 52.32-6 states that the responsible authority should consider the following decision guidelines:

- The Wind Farm Guidelines
- NZS 6808:2010

3.5 NZS 6808:2010

NZS 6808:2010 defines acceptable limits for wind farm noise at noise-sensitive locations as:

- For most locations:
  - a base noise limit of 40 dB L_{A90} or
  - the background noise level plus 5 dB

  whichever is the greater for the given hub height wind speed.
- For locations in High Amenity areas and for low wind speed conditions:
  - a base noise limit of 35 dB L_{A90} or
  - the background noise level plus 5 dB

whichever is the greater for the given hub height wind speed.
For locations in High Amenity areas at higher wind speed conditions, the same noise limits apply as for all other locations (i.e. base limit of 40 dB L_{A90}).

With respect to High Amenity areas, the definition of High Amenity areas is relevant to the New Zealand planning system and not directly translatable to Victorian planning schemes. However, the approach of the Victorian Civil and Administrative Tribunal (VCAT) in their determination on the Cherry Tree Wind Farm was that areas allocated for farming use would not be considered to be High Amenity. The Wind Farm Guidelines reference the Cherry Tree Wind Farm decision with respect to High Amenity areas.

Further Victorian guidance was provided by the Planning Panel for the Golden Plains Wind Farm, where it was deemed that noise-sensitive land uses located in a Township Zone and Low Density Residential Zone should be deemed High Amenity, but that those noise-sensitive land uses in Farming Zones were not High Amenity areas for the purposes of NZS 6808:2010.

The Yarriambiack Planning Scheme defines the area in which the Project and nearest noise-sensitive locations are located as a Farming Zone. As per Section 2.2, there are Rural Living Zones within Warracknabeal township, but these are well separated from the site and well outside of the predicted 35 dB L_{A90} noise contour that NZS 6808:2010 advises is the boundary for the consideration of High Amenity areas. Therefore, based on the previous VCAT decision, the High Amenity condition is not considered applicable to this site. As such, the minimum applicable base limit of 40 dB L_{A90} has been adopted in this assessment.

3.6 Noise Protocol

The Noise Protocol defines procedures for determining the applicable noise limits for ancillary infrastructure under the *Environment Protection Regulations*.

In regional areas away from significant sources of noise, the noise limits are established through reference to the land zoning. The ancillary infrastructure for the Project and the nearest noise sensitive locations are located in Farming Zones. Where this occurs, the noise limits detailed in Table 5 are derived in accordance with Noise Protocol procedures for utilities.

Table 5 Ancillary infrastructure noise limits

Time	Times	Noise Limit, dB $L_{Aeq,30min}$
Day	Weekdays and Saturdays, 7 am to 6 pm	45
Evening	Weekdays and Saturdays, 6 pm to 10 pm Sundays and public holidays, 7 am to 10 pm	39
Night	10 pm to 7 am any day	34

3.7 EPA Victoria Publication 1834

The *Environment Protection Regulations* do not apply to noise generated during construction of the Project.

EPA Victoria Publication 1834 *Civil Construction, Building and Demolition Guide* provides guidance to eliminate or reduce the risk of harm to human health and the environment during construction works through good environmental practice. Planning and managing works in accordance with the guidance would assist in managing noise during construction in accordance with the GED.

Working hours defined by EPA Victoria Publication 1834 are reproduced in Table 6.

Table 6 Working hours

Time period	Details
Normal Working Hours	7 am – 6 pm Monday to Friday 7 am – 1 pm Saturdays
Weekend / Evening	6 pm – 10 pm Monday to Friday 1 pm – 10 pm Saturdays 7 am – 10 pm Sundays and public holidays
Night	10 pm – 7 am any day

Where reasonably practicable, the Project should aim to constrain works to Normal Working Hours when noise impacts would be expected to be lower. However, it is recognised that this will not always be reasonably practicable, and EPA Victoria Publication 1834 specify categories of works that may be conducted outside of Normal Working Hours. These are:

- Unavoidable works: Works that must be conducted outside of Normal Working Hours due to practicability requirements. This might involve works that would pose a risk to life or property if conducted during Normal Working Hours or that may risk a major traffic hazard during daytime hours. For the Project, this may include works such as:
  - oversized deliveries
  - concrete pours
  - crane lifts that require low wind speeds.
- Managed-impact works: Works where the noise emissions are managed through actions specified in a noise and vibration management plan to minimise impacts on sensitive receivers. Managed-impact works do no have intrusive characteristics such as impulsive noise or tonal movement alarms.
- Low-noise impact works: Works that have been approved by a local authority that are inherently quiet and unobtrusive. For example, manual painting, internal fitouts, and cabling. Low-noise impact works do no have intrusive characteristics such as impulsive noise or tonal movement alarms.

EPA Victoria Publication 1834 states that justified out of hours managed-impact and low-noise impact works should comply with the construction noise criteria shown in Table 7 at residential premises. The background noise level used should be assessed at the time of impact.

Table 7 Construction noise criteria for managed-impact and low-noise impact works

Time period	Construction noise criteria, dB L_{Aeq}
Weekend / Evening	Noise level not to exceed background noise by: • 10 dB or more for up to 18 months after project commencement • 5 dB or more after 18 months after project commencement.
Night	Noise to be inaudible within a habitable room of any residential premises. While this is not intended to be a measurable criterion in dB, inaudibility may be assessed during a planning stage using a criterion of ‘Background + 0 dB.’

Note that the criteria in Table 7 are not intended to apply to unavoidable works. However, unavoidable works should still be conducted in a manner that does not result in unreasonable noise.

4 Preliminary noise assessment

4.1 Construction noise

Given the preliminary stage of the Project, construction methodologies and schedules have not been developed.

In general, construction noise from wind farm and ancillary infrastructure construction is able to be managed acceptably given the distance between major construction works and noise-sensitive locations. Appropriate procedures should be implemented in accordance with EPA Victoria Publication 1834, through:

- planning the site layout to minimise site access routes and construction compounds near noise-sensitive locations as much as possible
- identifying and implementing measures on site to reduce the level and duration of construction noise at noise-sensitive locations
- scheduling work during Normal Working Hours where feasible
- implementing procedures to reduce the risk of harm from noise generated during necessary works outside of Normal Working Hours so far as reasonably practicable
- implementing appropriate community consultation measures to notify noise-sensitive locations of planned works and maintaining an effective complaint response procedure.

It is recommended that a Construction Noise Management Plan be developed prior to commencement of the works and implemented throughout construction. The Construction Noise Management Plan should be developed in accordance with EPA Victoria Publication 1834.

4.2 Wind turbine noise

Preliminary wind turbine noise predictions are based on an industry standard wind farm noise prediction methodology, the indicative wind turbine model, and the proposed layout. The predictions have also considered cumulative noise from Murra Warra Wind Farm.

4.2.1 Wind farm noise prediction methodology

To predict wind farm noise levels from both Warracknabeal Energy Park and Murra Warra Wind Farm, an environmental noise model has been developed in SoundPlan version 8.2 environmental noise prediction software. The noise model implements the ISO 9613-2:1996[5] prediction algorithm.

In accordance with standard prediction procedures for wind farm noise, predictions have been undertaken on the basis of the following parameters:

- topographical contours sourced from Datashare Victoria and as shown on Figure 1
- ground absorption factor of 50% representing mixed reflective and absorptive ground
- wind turbine and residence locations as per the coordinates detailed in Appendix A
- 180 m hub height Project turbines with a rotor diameter of 200 m and sound power levels as per Table 2
- wind turbine details for Murra Warra Wind Farm as per Section 2.4
- a +3 dB correction applied to the predicted noise levels from any wind turbine where concave topography is predicted between it and the receiver location as defined by the UK Institute of Acoustics *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (Good Practice Guide)
- temperature of 10˚C and relative humidity of 70%

[5] International Standard ISO 9613-2, 1996, *Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation*

- topographical shielding limited to 2 dB, assessed based on the wind turbine tip height.

The air absorption values from ISO 9613-2:1996 have been adopted for the purposes of predicting noise levels from Warracknabeal Energy Park. Air absorption is dependent on the assumed temperature and humidity and therefore the relevant air absorption values for this assessment are shown in Table 8.

Table 8 Air absorption attenuation coefficients

Conditions	Atmospheric attenuation in dB/km for octave band centre frequency in Hz							
	63	125	250	500	1000	2000	4000	8000
Temperature 10˚C Rel humidity 70%	0.1	0.4	1.0	1.9	3.7	9.7	32.8	117

This methodology is in accordance with that recommended by the UK Institute of Acoustics Good Practice Guide with the exceptions that:

- The Good Practice Guide recommends a receiver height of 4 m above ground rather than 1.5 m above ground. A receiver height of 4 m above ground would increase predicted noise levels by approximately 1.5 dB.
- The Good Practice Guide recommends that 2 dB be subtracted from predicted noise levels to adjust predicted L_{eq} noise levels to the assessed L_{90} noise levels. This has not been adopted for this assessment.

Given that the above two changes effectively negate each other, the predicted noise levels using the adopted methodology are considered to be consistent with the IoA Good Practice Guide. It is also noted that this methodology has been shown to accurately predicted downwind noise levels for Australian sites with relatively flat topography.[6] A discussion of uncertainty with respect to the adopted noise prediction methodology is provided in Appendix C.

4.2.2 Predicted Project noise levels at noise-sensitive locations

Preliminary predicted Project wind turbine noise levels for each noise-sensitive location are presented in Appendix B. A noise contour map showing the wind turbine noise predictions is included as Figure 2.

Based on the preliminary wind farm noise predictions from the Project, a total of 31 noise-sensitive locations were identified within the 35 dB L_{A90} predicted noise contour for the turbines without STE, reducing to 15 when the turbines with STE are used for the predictions. The predicted noise levels at these locations are shown in Table 9. The highest predicted noise level at any of these locations is 40.0 dB L_{A90} without STE and 37.8 dB L_{A90} with STE, such that predicted noise levels at all locations are compliant with the applicable noise limit.

It is noted that these predictions are based on preliminary wind turbine selections that are considered to be representative of the current range of turbines, and this is reflected in the range of predicted wind farm noise levels. As the Project develops and further information on the likely wind turbine type becomes available, this assessment will need to be updated to reflect the further information.

[6] Evans T & Cooper J, 2012, *Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms*, Acoustics Australia, vol. 40, no. 1, pp 28-36.

WARRACKNABEAL ENERGY PARK

Yarriambiack Shire, VIC
Figure 2: Predicted Project wind turbine noise contours

PROJECT NUMBER	M220300
DRAWN BY	AH
DATE	March 2023
CLIENT	WEP
AERIAL IMAGERY	(c) Google

Legend

- Site Boundary
- Project Turbine (Preliminary)

House

- Involved landowner
- Noise-sensitive location

Predicted noise level with STE, LA90

- 35 dB
- 40 dB
- 45 dB

Predicted noise level without STE, LA90

- 35 dB
- 40 dB
- 45 dB

0 1.5 3 4.5 6 7.5 km

Datum GDA20 MGA Zone 54

Resonate

Table 9 Noise-sensitive locations with predicted Project noise levels within 5 dB of noise limit

House ID	Predicted Project noise level, dB L_{A90}		Minimum noise limit, dB L_{A90}	Compliance?
	V162 without STE	V162 with STE		
Y34 - a	35.4	33.0	40	✓
AA29 - b	35.3	32.8	40	✓
AA32 - j	39.4	36.9	40	✓
AA36 - i	36.7	34.2	40	✓
AA60 - c	39.1	36.6	40	✓
AD27 - m	39.7	37.1	40	✓
AE35 - g	39.7	37.2	40	✓
AE50 - a	37.7	35.3	40	✓
AE50 - c	38.0	35.6	40	✓
AF25 - g	37.7	34.9	40	✓
AF36 - d	35.5	33.2	40	✓
AF46 - e	36.5	34.2	40	✓
AF53 - a	37.6	35.3	40	✓
AF53 - b	37.8	35.5	40	✓
AF63 - a	35.3	33.0	40	✓
AG56 - d	39.1	36.7	40	✓
AG61 - c	39.2	36.8	40	✓
AG62 - a	38.7	36.3	40	✓
AG62 - b	38.6	36.2	40	✓
AH41 - a	37.2	34.8	40	✓
AI33 - a	38.7	36.2	40	✓
AJ60 - b	35.7	33.4	40	✓
AL58 - m	35.6	33.3	40	✓
AL58 - o	35.3	33.1	40	✓
AO55 - c	40.0	37.8	40	✓
AP52 - b	39.0	36.6	40	✓
AQ44 - c	36.2	33.9	40	✓
AQ53 - c	36.9	34.6	40	✓
AR48 - a	35.6	33.3	40	✓
AS51 - a	35.2	32.9	40	✓
AS52 - b	36.1	33.8	40	✓

As the Project progresses, and subject to landowner consent, it will be necessary to consider background noise monitoring at locations within the predicted 35 dB L_{A90} noise contour in accordance with NZS 6808:2010 in order to:

- establish if noise limits higher than the minimum applicable 40 dB L_{A90} noise limit apply at any wind speeds across the normal operating range of the wind turbines
- establish a robust set of background noise measurements against which operational noise emissions from the Project can be assessed.

Clause 7.1.5 of NZS 6808:2010 allows for noise-sensitive locations with a similar background noise environment to be grouped, such that it would not necessarily be required for background noise monitoring to be conducted at all noise-sensitive locations within the 35 dB L_{A90} contour.

4.2.3 Predicted Project noise levels at involved landowner houses

The predicted Project noise levels at involved landowner houses are shown in Table 10, and compared against the recommended noise level of 45 dB L_{A90} for involved landowners. The predicted wind turbine noise levels, based on the preliminary wind turbine selection, comply with 45 dB L_{A90} at all involved landowner locations for the predictions both with and without STE.

Table 10 Predicted Project noise levels at involved landowner houses

House ID	Predicted Project noise level, dB L_{A90}		Recommended noise level, dB L_{A90}	Compliance?
	V162 without STE	V162 with STE		
AC59 - c	44.9	42.3	45	✓
AF32 - e	43.9	41.3	45	✓
AG35 - c	38.2	35.8	45	✓
AG35 - d	39.1	36.6	45	✓
AI45 - e	41.9	39.4	45	✓
AJ53 - d	41.8	39.4	45	✓
AK33 - a	31.5	29.5	45	✓
AK34 - a	31.5	29.5	45	✓
AK37 - e	28.6	27.0	45	✓
AL35 - b	28.9	27.2	45	✓
AN55 - d	41.3	38.8	45	✓

4.2.4 Cumulative predicted noise levels

Table 11 presents predicted cumulative noise levels for Warracknabeal Energy Park and Murra Warra Wind Farm at the 31 noise-sensitive locations within the 35 dB contour from the Project. The predictions are conservative as they assume that the noise-sensitive locations will be simultaneously downwind of each site, which is not possible for those noise-sensitive locations between the two sites that are most likely to experience the higher cumulative noise effects.

A cumulative noise contour map is included as Figure 3.

Table 11 Cumulative predicted noise levels with Murra Warra Wind Farm

House ID	Predicted cumulative noise level, dB L_{A90}		Minimum noise limit, dB L_{A90}	Compliance?
	V162 without STE	V162 with STE		
Y34 - a	35.4	33.0	40	✓
AA29 - b	35.3	33.1	40	✓
AA32 - j	39.4	36.9	40	✓
AA36 - i	36.7	34.3	40	✓
AA60 - c	39.1	36.6	40	✓
AD27 - m	39.7	37.3	40	✓
AE35 - g	39.7	37.2	40	✓
AE50 - a	37.7	35.3	40	✓
AE50 - c	38.0	35.6	40	✓
AF25 - g	37.7	35.5	40	✓
AF36 - d	35.5	33.3	40	✓
AF46 - e	36.5	34.2	40	✓
AF53 - a	37.6	35.3	40	✓
AF53 - b	37.8	35.5	40	✓
AF63 - a	35.3	33.0	40	✓
AG56 - d	39.1	36.7	40	✓
AG61 - c	39.2	36.8	40	✓
AG62 - a	38.7	36.3	40	✓
AG62 - b	38.6	36.2	40	✓
AH41 - a	37.2	34.8	40	✓
AI33 - a	38.7	36.3	40	✓
AJ60 - b	35.7	33.4	40	✓
AL58 - m	35.6	33.3	40	✓
AL58 - o	35.3	33.1	40	✓
AO55 - c	40.0	37.8	40	✓
AP52 - b	39.0	36.6	40	✓
AQ44 - c	36.2	33.9	40	✓
AQ53 - c	36.9	34.6	40	✓
AR48 - a	35.6	33.3	40	✓
AS51 - a	35.2	32.9	40	✓
AS52 - b	36.1	33.8	40	✓

WARRACKNABEAL ENERGY PARK

Yarriambiack Shire, VIC
Figure 3: Predicted cumulative wind turbine noise contours with Murra Warra Wind Farm

PROJECT NUMBER	M220300
DRAWN BY	AH
DATE	March 2023
CLIENT	WEP
AERIAL IMAGERY	(c) Google

Legend

- Site Boundary
- Project Turbine (Preliminary)
- Murra Warra WF Stage 1 Turbine
- Murra Warra WF Stage 2 Turbine

House

- Involved landowner
- Noise-sensitive location

Predicted wind turbine noise level with STE, LA90

- 35 dB
- 40 dB
- 45 dB

Predicted wind turbine noise level without STE, LA90

- 35 dB
- 40 dB
- 45 dB

0 2 4 6 8 10 km

Datum GDA20 MGA Zone 54

Resonate

It can be seen that the predicted noise levels remain compliant with the applicable noise limit, and that the cumulative effect of the two sites is marginal, with a maximum predicted increase of 0.3 dB without STE and 0.6 dB with STE (at AF25 - g) above the predicted noise level with the Project alone. As such, it is expected that the two sites will be able to operate and cumulative noise levels remain compliant with the applicable noise limits.

4.2.5 Special audible characteristics

NZS 6808:2010 advises that, if wind turbine noise levels exhibit special audible characteristics such as tonality, impulsiveness and amplitude modulation, then a penalty should be applied to the noise level. The predictions shown in this assessment are based on the wind turbine noise levels at residences containing no characteristics that would attract a penalty in accordance with NZS 6808:2010.

Special audible characteristics are not possible to assess in detail at this preliminary stage as information is generally not available from turbine manufacturers. In the relatively unusual event that special audible characteristics are detectable at residences, the occurrence will also involve a complex relationship between the wind turbine noise and the background noise environment that is best assessed through measurements.

Special audible characteristics from wind farms at residences are, in our experience, a relatively uncommon occurrence in Australia and, where they have occurred, they have generally occurred infrequently and under specific conditions. As such, it is considered reasonable to assume that they will not occur for the purposes of this preliminary noise assessment.

Should the Project be approved, special audible characteristics would need to be considered during any post-construction compliance monitoring for the Warracknabeal Energy Park, as is required by NZS 6808:2010. In the event that special audible characteristics are detected, the site will need to achieve compliance with the noise limits including the appropriate penalty for the detected characteristics when assessed in accordance with NZS 6808:2010.

4.3 Ancillary infrastructure noise

The proposed location and the nature of the ancillary infrastructure is yet to be confirmed.

In general, and given the relatively large extent of land available, it is expected that ancillary infrastructure will be able to be installed to reduce noise levels so far as reasonably practicable and to achieve compliance with the applicable noise limits through consideration of the following:

- locating ancillary infrastructure as far away from noise-sensitive locations as reasonably practicable
- selection of quieter ancillary infrastructure equipment.

As the Project progresses, it will be necessary for a noise assessment to be conducted to confirm that the predicted noise levels can achieve compliance with the requirements of the *Environment Protection Regulations*. If necessary, contingency measures would be available in the form of shielding structures around key noise sources at ancillary infrastructure sites.

5 Conclusion

This report presents a preliminary noise assessment of the Warracknabeal Energy Park, to inform future planning processes.

Based on a preliminary assessment of wind turbine noise levels against applicable noise limits, and based on a conservative wind turbine selection, it is considered that the wind farm will be able to achieve compliance with the applicable noise limits derived from the *Environment Protection Regulations* and NZS 6808:2010 without a need for further noise control mechanisms. The assessment also shows that additional noise control mechanisms, such as the use of serrated edges on blades, could result in further reductions in noise levels at receivers. Compliance is also predicted including consideration of cumulative noise from the Murra Warra Wind Farm.

As the Project progresses, it is expected that this noise assessment will be updated to consider:

- construction noise
- wind turbine noise reflecting updated design information for the Project
- ancillary infrastructure noise.

Appendix A – Wind turbine layout coordinates

Table A1 Assessed Project wind turbine locations

Turbine	Coordinates (GDA20 MGA Zone 54)		Turbine	Coordinates (GDA20 MGA Zone 54)	
	Easting	Northing		Easting	Northing
T001	612350	6011500	T107	622754	5997543
T002	613006	6011490	T108	623554	5997531
T003	610692	6010723	T109	624360	5997019
T004	612338	6010699	T110	625586	5997001
T005	612994	6010689	T111	618413	5996607
T006	613807	6010380	T112	619328	5996594
T007	614624	6010320	T113	620228	5996580
T008	611246	6010289	T114	621028	5996568
T009	612324	6009740	T115	621940	5996555
T010	612980	6009731	T116	622739	5996543
T011	613797	6009718	T117	623539	5996531
T012	614615	6009706	T118	615352	5995652
T013	615432	6009694	T119	618398	5995607
T014	616436	6009679	T120	619314	5995594
T015	611024	6009621	T121	620213	5995580
T016	610664	6008836	T122	621013	5995568
T017	612310	6008811	T123	621925	5995555
T018	612966	6008801	T124	622725	5995543
T019	613784	6008789	T125	623524	5995531
T020	614601	6008777	T126	624264	5995283
T021	616422	6008750	T127	616195	5994640
T022	610993	6008192	T128	619399	5994592
T023	611530	6007710	T129	620198	5994580
T024	612294	6007699	T130	620998	5994568
T025	612950	6007689	T131	621910	5994555
T026	613767	6007677	T132	622710	5994543
T027	614585	6007665	T133	623510	5994531
T028	615402	6007653	T134	624557	5994516
T029	617203	6007626	T135	618552	5993768

Turbine	Coordinates (GDA20 MGA Zone 54)		Turbine	Coordinates (GDA20 MGA Zone 54)	
	Easting	Northing		Easting	Northing
T030	617853	6007617	T136	615924	5993614
T031	616390	6006638	T137	617715	5993587
T032	617188	6006626	T138	619383	5993563
T033	617841	6006617	T139	620183	5993551
T034	621916	6006327	T140	620983	5993539
T035	623434	6006305	T141	616765	5993535
T036	622716	6005845	T142	621895	5993525
T037	616376	6005638	T143	622694	5993513
T038	623887	6005635	T144	623496	5993501
T039	617175	6005627	T145	624212	5993491
T040	621474	6005065	T146	616752	5992631
T041	616361	6004638	T147	621881	5992555
T042	617161	6004627	T148	622681	5992543
T043	617807	6003953	T149	623481	5992532
T044	616346	6003639	T150	624290	5992520
T045	619532	6003591	T151	617698	5992425
T046	620332	6003579	T152	616739	5991718
T047	621132	6003568	T153	617680	5991263
T048	622043	6003554	T154	608431	5984163
T049	622770	6003543	T155	609279	5984058
T050	616433	6002637	T156	608419	5983348
T051	619548	6002591	T157	610753	5983312
T052	620317	6002580	T158	611647	5983298
T053	621117	6002568	T159	612542	5983284
T054	622028	6002554	T160	614135	5983260
T055	622828	6002542	T161	614929	5983247
T056	616379	6001638	T162	616544	5983165
T057	617116	6001627	T163	615807	5982939
T058	617774	6001617	T164	608247	5982407
T059	618717	6001603	T165	610738	5982305
T060	619502	6001592	T166	611632	5982292

Turbine	Coordinates (GDA20 MGA Zone 54)		Turbine	Coordinates (GDA20 MGA Zone 54)	
	Easting	Northing		Easting	Northing
T061	620302	6001580	T167	612526	5982278
T062	621102	6001568	T168	613326	5982265
T063	622014	6001554	T169	614913	5982241
T064	622814	6001542	T170	615796	5982227
T065	623485	6001532	T171	614007	5982185
T066	614655	6000663	T172	610722	5981306
T067	615631	6000649	T173	611616	5981292
T068	616301	6000639	T174	612511	5981278
T069	617101	6000627	T175	613310	5981266
T070	618472	6000607	T176	615781	5981227
T071	619388	6000593	T177	616663	5981214
T072	620287	6000580	T178	610170	5980407
T073	621087	6000568	T179	611164	5980392
T074	621999	6000554	T180	612496	5980371
T075	622799	6000543	T181	613296	5980359
T076	623600	6000531	T182	614090	5980347
T077	626138	6000401	T183	614884	5980334
T078	614641	5999663	T184	615767	5980321
T079	615616	5999649	T185	616649	5980307
T080	616287	5999639	T186	610153	5979314
T081	617086	5999627	T187	612518	5979278
T082	619373	5999593	T188	613279	5979266
T083	626866	5999588	T189	614073	5979254
T084	620273	5999580	T190	614867	5979241
T085	621073	5999568	T191	615750	5979226
T086	621985	5999556	T192	616632	5979214
T087	624397	5999519	T193	617581	5979199
T088	625623	5999501	T194	612891	5978772
T089	613950	5998847	T195	613264	5978266
T090	614805	5998661	T196	614058	5978254
T091	615601	5998649	T197	614852	5978241

Turbine	Coordinates (GDA20 MGA Zone 54)		Turbine	Coordinates (GDA20 MGA Zone 54)	
	Easting	Northing		Easting	Northing
T092	616272	5998639	T198	615734	5978228
T093	617072	5998627	T199	616780	5978212
T094	618442	5998607	T200	617566	5978199
T095	619358	5998593	T201	612623	5977674
T096	620258	5998580	T202	613334	5977470
T097	621058	5998568	T203	614042	5977254
T098	621969	5998555	T204	614836	5977242
T099	622769	5998543	T205	615719	5977228
T100	623569	5998531	T206	616601	5977214
T101	614511	5997749	T207	614027	5976254
T102	618428	5997607	T208	614821	5976242
T103	619343	5997593	T209	615703	5976228
T104	620243	5997580	T210	616586	5976214
T105	621043	5997568	T211	617446	5976201
T106	621954	5997555			

Appendix B – House locations and predicted wind turbine noise level

Table B1 Involved stakeholder locations and predicted wind turbine noise level

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AC59 - c	611742	6008496	T017	650	44.9	42.3
AF32 - e	614478	5981221	T182	956	43.9	41.3
AG35 - c	615834	5984292	T162	1331	38.2	35.8
AG35 - d	615845	5984142	T162	1201	39.1	36.6
AI45 - e	617184	5994448	T141	1004	41.9	39.4
AJ53 - d	618305	6002797	T043	1259	41.8	39.4
AK33 - a	619276	5982879	T162	2748	31.5	29.5
AK34 - a	619031	5983506	T162	2510	31.5	29.5
AK37 - e	619635	5986619	T162	4635	28.6	27.0
AL35 - b	620057	5984260	T162	3679	28.9	27.2
AN55 - d	622468	6004864	T036	1013	41.3	38.8

Table B2 Noise-sensitive locations and predicted wind turbine noise level

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
K52 - i	593666	6001675	T016	18445	14.9	14.4
L52 - b	594403	6001715	T016	17752	15.5	15.0
M52 - d	595442	6001001	T016	17121	16.3	15.7
M59 - b	595392	6008190	T016	15286	15.4	14.7
N52 - a	596639	6001436	T016	15857	17.0	16.4
N54 - d	596269	6003335	T016	15410	16.6	16.0
N57 - b	596960	6006902	T016	13840	16.7	16.1
O60 - a	597037	6009959	T016	13673	16.3	15.6
O62 - b	597044	6011924	T003	13701	15.8	15.1
Q27 - f	599695	5976084	T164	10635	18.2	17.3

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
Q28 - a	599789	5977525	T164	9765	18.8	17.9
Q56 - a	599115	6005234	T016	12098	18.5	17.7
Q57 - d	599201	6006854	T016	11634	18.4	17.7
R28 - c	600916	5977807	T164	8654	20.0	19.0
R30 - o	600666	5979290	T164	8196	20.3	19.2
R31 - c	600560	5980644	T164	7886	20.5	19.4
R32 - l	600670	5981654	T164	7614	20.8	19.7
R33 - j	600167	5982114	T164	8085	20.3	19.2
R36 - c	600810	5985445	T154	7728	20.8	19.8
R38 - a	600417	5987529	T154	8692	20.1	19.2
R38 - b	600444	5987592	T154	8693	20.1	19.2
R47 - e	600982	5996804	T089	13128	19.6	18.9
R53 - d	600147	6002827	T022	12101	19.3	18.5
S23 - b	601779	5972945	T186	10521	18.5	17.5
S31 - a	601012	5980040	T164	7611	20.8	19.7
S35 - a	601389	5984647	T154	7058	21.5	20.4
S41 - i	601143	5990309	T154	9533	20.1	19.3
S60 - c	601398	6009979	T003	9324	19.9	18.9
S62 - e	601211	6011644	T003	9526	19.3	18.4
S65 - h	601372	6014589	T003	10090	18.4	17.5
T22 - i	602717	5971922	T186	10485	18.6	17.6
T22 - o	602952	5971888	T186	10344	18.7	17.7
T29 - d	602778	5978168	T164	6919	22.2	21.0
T29 - f	602799	5978173	T164	6899	22.3	21.0
T32 - a	602155	5981410	T164	6172	22.5	21.2
T45 - g	602395	5994956	T089	12193	20.5	19.7
T50 - a	602956	5999762	T089	11032	21.1	20.2
T53 - g	602379	6002675	T022	10229	20.9	20.0
T53 - i	602433	6002072	T022	10523	20.9	20.0
T56 - h	602563	6005700	T016	8687	21.3	20.3

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
U25 - a	603209	5974107	T186	8679	20.4	19.3
U32 - j	603176	5981159	T164	5222	23.9	22.4
U45 - h	603344	5994143	T154	11202	21.1	20.3
U49 - a	603053	5998025	T089	10928	21.1	20.2
U64 - c	603235	6013154	T003	7844	20.8	19.6
V22 - a	604731	5971996	T186	9108	20.3	19.1
V26 - a	604686	5975004	T186	6962	22.5	21.2
V29 - b	604494	5978640	T164	5316	24.7	23.2
V32 - c	604180	5981606	T164	4144	25.7	24.1
V35 - b	604375	5984775	T154	4102	25.7	24.1
V40 - h	604291	5989553	T154	6796	22.6	21.5
V47 - a	604346	5996405	T089	9910	21.9	21.0
V49 - i	604445	5998278	T089	9522	22.1	21.2
V53 - f	604833	6002549	T022	8354	23.0	21.9
V59 - f	604492	6008476	T016	6183	23.6	22.3
V60 - a	604263	6009944	T003	6476	23.2	21.8
V69 - g	604521	6018763	T003	10136	18.3	17.3
W25 - a	605262	5974010	T186	7215	22.3	21.1
W26 - a	605107	5975176	T186	6526	23.1	21.8
W31 - a	605430	5980391	T164	3463	27.5	25.7
W37 - g	605156	5986887	T154	4260	25.2	23.7
W48 - b	605843	5997812	T089	8173	23.2	22.2
X21 - a	606865	5970166	T207	9400	20.3	19.2
X29 - c	606434	5978775	T186	3758	28.1	26.3
X34 - c	606515	5983855	T154	1940	32.8	30.5
X44 - c	606918	5993222	T118	8777	23.7	22.6
X45 - a	606266	5994981	T089	8602	23.3	22.2
X50 - f	606141	5999551	T089	7840	23.7	22.6
X61 - f	606622	6010579	T003	4073	26.9	25.2
X66 - i	606182	6015893	T003	6861	21.8	20.6

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
Y20 - j	607124	5969717	T207	9507	20.0	18.9
Y34 - a	607012	5983874	T154	1448	35.4	33.0
Y42 - c	607615	5991873	T154	7753	24.3	23.1
Y44 - a	607070	5993230	T118	8629	23.8	22.7
Y52 - d	607050	6001659	T089	7450	25.0	23.7
Y55 - c	607599	6004688	T022	4878	26.8	25.3
Y65 - c	607020	6014189	T003	5050	24.4	22.9
Z17 - a	608798	5966713	T207	10880	18.1	17.1
Z19 - a	608875	5968586	T207	9238	19.9	18.8
Z20 - h	608642	5969899	T207	8330	21.2	20.0
Z24 - a	608381	5973122	T201	6222	24.6	23.1
Z26 - g	608966	5975104	T186	4375	27.8	26.0
Z28 - i	608693	5977684	T186	2188	31.6	29.5
Z30 - f	608413	5979468	T186	1746	34.1	31.9
Z40 - c	608645	5989942	T154	5783	25.5	24.2
Z58 - b	608895	6007434	T022	2230	32.8	30.6
Z58 - g	608942	6007396	T022	2200	32.9	30.7
Z60 - g	608450	6009921	T003	2381	32.4	30.3
Z65 - c	608233	6014136	T003	4206	26.2	24.5
AA29 - b	609601	5978053	T186	1377	35.1	32.8
AA32 - j	609379	5981968	T164	1215	39.4	36.9
AA36 - i	609285	5985263	T155	1205	36.6	34.2
AA36 - t	609353	5985807	T155	1751	33.8	31.5
AA41 - a	609010	5990406	T154	6270	25.6	24.3
AA42 - a	609137	5991983	T136	6981	25.4	24.2
AA43 - a	609121	5992134	T136	6962	25.4	24.2
AA47 - f	609550	5996577	T089	4951	27.0	25.5
AA60 - c	609815	6009694	T016	1207	39.1	36.6
AA63 - a	609015	6012969	T003	2803	29.6	27.6
AB17 - a	610455	5966643	T207	10253	18.6	17.6

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AB22 - a	610350	5971961	T207	5652	24.9	23.3
AB26 - a	610946	5975299	T201	2907	31.4	29.4
AB40 - f	610284	5989189	T155	5228	27.0	25.5
AB48 - f	610630	5997427	T089	3611	29.0	27.4
AB69 - a	610007	6018345	T001	7235	21.8	20.6
AB69 - f	610127	6018345	T001	7198	21.8	20.6
AC18 - a	611105	5967835	T207	8912	20.1	19.0
AC36 - k	611547	5985344	T158	2048	34.6	32.3
AC37 - b	611205	5986679	T155	3252	30.8	28.9
AC44 - b	611139	5993044	T136	4819	27.7	26.2
AC47 - j	611160	5996463	T101	3590	29.5	27.8
AC48 - a	611977	5997978	T089	2156	32.7	30.6
AC56 - c	611030	6005334	T023	2429	32.9	30.8
AD22 - a	612706	5971540	T207	4895	25.8	24.2
AD25 - c	612564	5974060	T207	2637	31.3	29.2
AD27 - m	612651	5976453	T201	1221	39.5	37.1
AD40 - i	612749	5989503	T152	4564	28.4	26.8
AD40 - o	612789	5989589	T152	4487	28.4	26.8
AD48 - c	612042	5997989	T089	2092	32.9	30.8
AD50 - a	612006	5999070	T089	1956	33.3	31.2
AD55 - f	612992	6004679	T025	3011	33.7	31.7
AD67 - b	612846	6016771	T002	5283	24.9	23.3
AD71 - a	612590	6020621	T001	9124	19.9	18.9
AD71 - e	612725	6020558	T001	9066	20.0	19.0
AE19 - a	613190	5968142	T207	8155	21.0	19.8
AE35 - g	613447	5984091	T160	1079	39.7	37.2
AE37 - i	613561	5986360	T160	3152	31.6	29.7
AE40 - k	613425	5989581	T152	3944	28.9	27.3
AE50 - a	613123	5999766	T089	1236	37.7	35.3
AE50 - c	613198	5999814	T089	1225	38.0	35.6

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AE67 - c	613038	6016785	T002	5295	24.9	23.3
AE71 - e	613438	6020412	T002	8932	20.2	19.2
AF25 - g	614797	5974879	T208	1362	37.4	34.9
AF36 - d	614123	5985056	T160	1796	35.4	33.2
AF39 - b	614790	5988784	T152	3522	29.7	28.0
AF39 - g	614852	5988487	T152	3742	29.6	27.9
AF39 - k	614882	5988761	T152	3492	29.8	28.1
AF46 - e	614144	5995814	T118	1218	36.5	34.2
AF53 - a	614660	6002403	T066	1740	37.6	35.3
AF53 - b	614759	6002417	T050	1688	37.8	35.5
AF63 - a	614851	6012354	T002	2037	35.3	33.0
AF65 - c	614365	6014174	T002	3008	30.2	28.2
AG22 - a	615095	5971150	T208	5099	25.8	24.1
AG40 - b	615132	5989606	T152	2654	31.0	29.1
AG56 - d	615215	6005185	T037	1246	39.1	36.7
AG61 - c	615653	6010945	T007	1203	39.2	36.8
AG62 - a	615660	6011052	T007	1268	38.7	36.3
AG62 - b	615673	6011065	T007	1287	38.6	36.2
AH20 - c	616779	5969590	T210	6627	22.9	21.5
AH41 - a	616669	5990515	T152	1205	37.2	34.8
AI20 - a	617715	5969630	T211	6577	22.7	21.3
AI33 - a	617441	5982300	T162	1247	38.6	36.2
AI39 - d	617990	5988880	T153	2403	31.4	29.5
AI64 - a	617872	6013959	T014	4514	27.4	25.7
AJ17 - a	618769	5966115	T211	10172	18.3	17.3
AJ22 - a	618373	5971907	T211	4393	25.9	24.3
AJ60 - b	618620	6009055	T030	1629	35.7	33.4
AJ67 - c	618344	6016956	T014	7523	23.1	21.9
AJ70 - a	618644	6019020	T002	9406	20.9	19.8
AK23 - a	619020	5972450	T211	4068	26.3	24.6

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AK26 - a	619623	5975641	T211	2249	31.2	29.1
AK61 - d	619771	6010425	T030	3400	30.6	28.7
AK62 - c	619714	6011737	T014	3870	28.7	27.0
AL30 - a	620628	5979623	T193	3076	30.2	28.2
AL39 - a	620929	5988979	T147	3701	30.6	28.8
AL58 - m	620784	6007275	T034	1476	35.6	33.3
AL58 - o	620857	6007395	T034	1504	35.3	33.1
AL60 - b	620158	6009522	T030	2990	31.5	29.5
AM16 - a	621612	5965566	T211	11423	16.8	15.9
AM27 - a	621580	5976989	T200	4193	27.5	25.8
AN18 - a	622810	5967041	T211	10616	17.5	16.6
AN22 - a	622768	5971663	T211	6995	21.6	20.4
AN29 - a	622134	5978271	T200	4569	26.9	25.2
AN31 - a	622264	5980493	T193	4858	26.7	25.2
AN39 - d	622591	5988822	T148	3722	30.0	28.2
AO23 - a	623629	5972986	T211	6969	21.8	20.6
AO28 - a	623752	5977507	T200	6225	24.2	22.8
AO29 - a	623784	5978640	T193	6228	24.5	23.1
AO35 - d	623089	5984333	T162	6648	25.7	24.4
AO55 - c	623131	6004694	T049	1206	40.0	37.8
AO59 - a	623791	6008207	T035	1936	32.5	30.4
AO60 - d	623607	6009915	T035	3615	28.2	26.5
AO61 - b	623172	6010482	T035	4185	27.6	25.9
AP18 - a	624607	5967877	T211	10980	17.3	16.4
AP18 - b	624689	5967195	T211	11557	16.7	15.9
AP25 - a	624957	5974636	T211	7673	21.6	20.4
AP27 - a	624816	5976959	T200	7356	22.7	21.5
AP35 - a	624642	5984514	T150	8013	24.6	23.4
AP35 - b	624883	5984208	T150	8333	24.4	23.2
AP39 - d	624485	5988758	T150	3766	29.0	27.2

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AP52 - b	624699	6001585	T065	1215	39.0	36.6
AQ39 - a	625026	5988724	T150	3866	28.5	26.8
AQ44 - c	625972	5993488	T134	1749	36.2	33.9
AQ53 - c	625008	6002195	T065	1661	36.9	34.6
AR18 - a	626300	5967384	T211	12496	16.0	15.2
AR27 - a	626173	5976595	T211	8736	21.3	20.2
AR31 - a	626755	5980786	T193	9310	21.9	20.9
AR40 - a	626334	5989454	T150	3684	28.3	26.6
AR40 - b	626369	5989457	T150	3701	28.3	26.6
AR40 - d	626721	5989436	T150	3926	27.8	26.2
AR42 - a	626019	5991729	T150	1901	33.4	31.3
AR42 - d	626049	5991019	T150	2312	31.8	29.8
AR48 - a	626962	5997256	T110	1399	35.6	33.3
AR56 - a	626187	6005700	T038	2302	31.3	29.3
AR57 - b	626789	6006673	T038	3082	28.9	27.2
AR57 - c	626873	6006535	T038	3119	28.9	27.1
AR57 - d	626883	6006628	T038	3157	28.8	27.0
AR57 - e	626929	6006582	T038	3186	28.7	27.0
AR61 - c	626553	6010614	T035	5320	24.6	23.3
AS45 - a	627279	5994487	T134	2723	32.4	30.4
AS48 - e	627326	5997124	T110	1744	34.1	32.0
AS51 - a	627651	6000766	T083	1416	35.2	32.9
AS51 - b	627733	6000796	T083	1487	34.7	32.5
AS51 - d	627805	6000971	T083	1672	34.0	31.7
AS52 - b	627094	6001160	T077	1221	36.1	33.8
AS54 - f	627843	6003605	T077	3629	29.3	27.6
AS57 - a	627014	6006531	T038	3254	28.6	26.9
AS57 - aa	627418	6006648	T038	3674	27.8	26.1
AS57 - ab	627420	6006572	T038	3655	27.8	26.2
AS57 - ac	627442	6006524	T038	3665	27.8	26.2

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AS57 - ad	627446	6006654	T038	3702	27.7	26.1
AS57 - ae	627446	6006690	T038	3712	27.7	26.0
AS57 - af	627466	6006779	T038	3758	27.6	25.9
AS57 - ag	627484	6006651	T038	3738	27.6	26.0
AS57 - ah	627501	6006653	T038	3755	27.6	26.0
AS57 - ai	627502	6006692	T038	3767	27.6	26.0
AS57 - aj	627526	6006656	T038	3780	27.6	25.9
AS57 - ak	627527	6006695	T038	3791	27.5	25.9
AS57 - al	627539	6006694	T038	3803	27.5	25.9
AS57 - am	627541	6006651	T038	3793	27.6	25.9
AS57 - an	627582	6006650	T038	3832	27.5	25.9
AS57 - ao	627597	6006757	T038	3876	27.4	25.8
AS57 - ap	627622	6006652	T038	3872	27.4	25.8
AS57 - aq	627646	6006651	T038	3894	27.4	25.8
AS57 - ar	627815	6006695	T038	4068	27.1	25.5
AS57 - as	627824	6006646	T038	4065	27.1	25.5
AS57 - at	627872	6006640	T038	4110	27.0	25.5
AS57 - au	627887	6006561	T038	4106	27.1	25.5
AS57 - av	627935	6006621	T038	4166	27.0	25.4
AS57 - aw	627937	6006641	T038	4173	26.9	25.4
AS57 - b	627064	6006449	T038	3280	28.6	26.9
AS57 - c	627087	6006340	T038	3277	28.6	26.9
AS57 - d	627088	6006520	T038	3321	28.5	26.8
AS57 - e	627153	6006464	T038	3370	28.4	26.7
AS57 - f	627158	6006651	T038	3425	28.2	26.5
AS57 - g	627163	6006781	T038	3471	28.1	26.4
AS57 - h	627199	6006780	T038	3505	28.0	26.4
AS57 - i	627224	6006654	T038	3489	28.1	26.4
AS57 - j	627239	6006526	T038	3468	28.2	26.5
AS57 - k	627243	6006772	T038	3544	28.0	26.3

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AS57 - l	627250	6006456	T038	3462	28.2	26.5
AS57 - m	627261	6006702	T038	3539	28.0	26.3
AS57 - n	627282	6006778	T038	3582	27.9	26.2
AS57 - o	627283	6006648	T038	3544	28.0	26.3
AS57 - p	627298	6006695	T038	3572	27.9	26.3
AS57 - q	627302	6006651	T038	3564	28.0	26.3
AS57 - r	627307	6006525	T038	3534	28.1	26.4
AS57 - s	627315	6006579	T038	3556	28.0	26.3
AS57 - t	627323	6006748	T038	3612	27.8	26.2
AS57 - u	627357	6006692	T038	3628	27.8	26.2
AS57 - v	627361	6006575	T038	3599	27.9	26.3
AS57 - w	627361	6006659	T038	3623	27.9	26.2
AS57 - x	627363	6006525	T038	3588	28.0	26.3
AS57 - y	627364	6006771	T038	3658	27.8	26.1
AS57 - z	627403	6006777	T038	3697	27.7	26.0
AS58 - a	627079	6007210	T038	3560	27.8	26.2
AS58 - c	627139	6007053	T038	3549	27.9	26.2
AS58 - g	627224	6007057	T038	3628	27.7	26.1
AS62 - d	627174	6011887	T035	6719	22.9	21.8
AS62 - m	627954	6011058	T035	6560	23.1	21.9
AT50 - b	628290	5999560	T083	1424	34.0	31.7
AT51 - c	628516	6000917	T083	2119	31.6	29.6
AT58 - i	628632	6007549	T038	5117	25.3	23.9
AU30 - a	629556	5979438	T193	11978	19.6	18.8
AU33 - a	629612	5982229	T150	11585	20.5	19.6
AU39 - a	629798	5988108	T150	7056	23.4	22.3
AU47 - b	629723	5996794	T083	3995	28.3	26.6
AV27 - a	630294	5976996	T200	12785	18.4	17.6
AV35 - a	630624	5984809	T150	9979	21.0	20.1
AV52 - a	630738	6001996	T083	4560	26.1	24.6

ID	Coordinates (GDA20 MGA Zone 54)		Nearest turbine	Distance to nearest turbine, m	Predicted Project noise level, dB L_{A90}	
	Easting	Northing			V162 without STE	V162 with STE
AW30 - a	631047	5979744	T193	13477	18.8	18.0
AW38 - a	631673	5987556	T150	8897	21.6	20.6
AW47 - b	631285	5996017	T083	5681	25.6	24.2
AW50 - e	631809	5999576	T083	4942	25.2	23.8
AW50 - g	631841	5999395	T083	4978	25.2	23.8
AW56 - f	631656	6005590	T077	7575	23.2	22.0
AW58 - a	631478	6007609	T038	7843	22.3	21.2
AW58 - r	631728	6007469	T038	8053	22.2	21.1
AX41 - a	632354	5990944	T150	8216	22.7	21.6
AX45 - h	632683	5994761	T110	7442	23.6	22.4
AX51 - a	632767	6000087	T083	5921	23.9	22.7
AX51 - f	632919	6000130	T083	6077	23.7	22.5
AY41 - a	633166	5990530	T150	9096	21.7	20.8
AY54 - a	633539	6003458	T083	7714	22.2	21.1
AY56 - a	633467	6005994	T083	9199	21.3	20.3
BA52 - d	635292	6001793	T083	8710	20.9	19.9
BA52 - e	635368	6001649	T083	8748	20.9	19.9
BA56 - d	635139	6005568	T083	10208	20.0	19.1
BB45 - a	636426	5994222	T083	10963	20.0	19.1
BB57 - a	636295	6006229	T083	11532	19.0	18.2
BC49 - f	637171	5998684	T083	10344	19.6	18.7

Appendix C – Uncertainty in wind farm noise predictions

Introduction

Appendix C of NZS 6808:2010 recommends that an assessment of uncertainty be included in any noise assessment conducted under the Standard. The discussion in NZS 6808:2010 relates to measurement uncertainty, which is not relevant to this assessment. With regards to uncertainty at the design stage, Appendix C of NZS 6808:2010 states that compliance with the wind farm noise limits is assessed on the basis of the predicted wind farm noise level, regardless of the uncertainty. However, some discussion the uncertainty associated with the predicted noise levels can be provided at the design stage.

Uncertainty in the predicted wind farm noise levels are a result of two main factors:

- uncertainty inherent in the prediction methodology
- uncertainty in the assumed sound power levels of the wind turbines.

Uncertainty in other inputs, such as the position of wind turbines and the location of residences, may also exist but are likely to have an insignificant impact on the prediction uncertainty as small changes in position do not result in any noticeable change in predicted noise levels when the distance between source and receiver is over 1 km.

Uncertainty in predictions

ISO 9613-2:1996, the basis of the prediction methodology adopted in this report, provides a discussion on uncertainty and advises a typical accuracy of overall A-weighted noise levels of ±3 dB at distances of up to 1 km from the source. It does not advise on the accuracy of predictions at distances further than this.

Given that the nearest non-involved residences are slightly further than 1 km from the nearest wind turbines, this suggests that an accuracy in the order of ±3 dB could be expected for the wind farm noise predictions. However, it should also be noted that the ISO 9613-2 statement of accuracy is based on sources that are located less than 30 m above ground. As wind turbines are located much higher above ground than normal noise sources, there is less potential for the uncertainties associated with ground attenuation effects and topographic shielding to reduce the prediction accuracy for wind turbine noise.

In considering the above, it should be noted that the ISO 9613-2 accuracy in the order of ±3 dB is applicable to individual predictions – that is, the predicted wind farm noise level for a particular 10-minute period. Given the use of NZS 6808:2010, the following factors reduce the uncertainty of wind farm noise predictions or tend the predictions towards conservatism thereby reducing the likelihood of any under-prediction:

- NZS 6808:2010 requires that wind farm noise levels are assessed based on a large number of 10-minute data points (at least 1440 data points) that are correlated with wind speed, with an average noise level determined for each wind speed. In practice, this reduces the uncertainty associated with predictions due to the large number of data points that would be collected and averaged during any measurement campaign. A study performed on Australian wind farms that examined the difference between predicted noise levels using ISO 9613-2 and measured downwind noise levels in general accordance with NZS 6808:2010 found that the predictions were within ±1 dB for sloping or relatively flat sites when appropriate prediction parameters were used.[7]
- The predictions are based on downwind conditions – that is, where the residence is downwind of the nearest wind turbines. NZS 6808:2010 does not specifically require the assessment to be carried out for downwind

[7] Evans T & Cooper J, 2012, *Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms*, Acoustics Australia, vol. 40, no. 1, pp 28-36.

conditions unless measured noise levels are clearly higher under these conditions and so, if compliance measurements include periods where there are some crosswind or upwind conditions, then the measured noise level would be lower. This may increase the conservatism of the predictions.

Uncertainty in sound power levels

Sound power levels of wind turbines are quantified in accordance with measurement standard IEC 61400-11 Edition 3.0 *Wind turbines – Part 11: Acoustic noise measurement techniques* (IEC 61400-11). The measurement process includes quantification of the uncertainty in the sound power level at each wind speed as documented in IEC 61400-11, this uncertainty is typically small and in the order of 1 dB or lower.

A 1 dB uncertainty factor has been included in the assumed sound power levels in this noise assessment to account for this potential error. Additionally, given the preliminary stage of the Project, a turbine with a sound power level towards the upper end of the range of typical turbines has been adopted.

Summary

Given the methods by which wind turbine noise is measured in Victoria and previous assessments of wind turbine noise modelling accuracy, the uncertainty associated with the predicted noise levels is considered small. Assumptions in the prediction methodology tend to be conservative and therefore may offset any uncertainty, tending towards over prediction of noise levels at residences.

It is noted that Appendix C of NZS 6808:2010 states that compliance with the wind farm noise limits is assessed on the basis of the predicted wind farm noise level, regardless of the uncertainty.