Appendix J. Alberton Wind Farm, Noise Assessment (Marshall Day Acoustics, R02 19 April 2018)

MARSHALL DAY Acoustics

ALBERTON WIND FARM NOISE ASSESSMENT

Rp 002 R02 2015590ML | 19 April 2018

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Project:	**ALBERTON WIND FARM** **Noise Assessment**
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1.0 INTRODUCTION

This report, commissioned by Synergy Wind Pty Ltd (Synergy Wind), details the results of a noise assessment for the proposed Alberton Wind Farm, located within the Wellington Shire, Victoria.

The assessment has been undertaken in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* as required by the Victorian Government's *Policy and planning guidelines for development of wind energy facilities in Victoria* dated January 2016.

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

2.0 PROJECT DESCRIPTION

2.1 Wind farm layout

The Alberton Wind Farm is proposed to be located approximately 5 km west of Yarram in Victoria and comprises thirty-four (34) wind turbines.

A plan of the proposed layout is presented in Appendix B together with coordinates for the wind turbines and nearby residential receivers.

2.2 Wind turbines

2.2.1 Turbine type

A number of candidate turbine models have been selected for this project, detailed in Table 1 below.

Table 1: WTG manufacturer specifications

Detail	Senvion 3.4M140	Siemens SWT 3.3-130	Vestas V136-3.45	Siemens SWT-3.15-142	Siemens SWT-3.6-130	Gamesa G132-3.465	Vestas V136-3.6
Make	Senvion	Siemens	Vestas	Siemens	Siemens	Gamesa	Vestas
Model	3.4M140	SWT 3.3-130	V136	SWT-3.15-142	SWT-3.6-130	G132	V136-3.6
Rated power (MW)	3.4	3.3	3.45	3.15	3.6	3.465	3.6
Rotor Diameter (m)	140	130	136	142	130	132	136
Hub Height (m)	110	115	112	109	115	114	112
Serrated trailing edge	No	Yes	Yes	Information not available	Yes	Information not available	Yes
Highest sound Power L_{WA} dB	105.0*	107.0*	106.5*	105.9*	107.0*	107.3*	106.5*
Tonal audibility ($\Delta L_{a,k}$>0 dB)	No**	Information not available	Information not available	Information not available	Information not available	Information not available	Information not available

* Guaranteed sound power level, including a 1 dB margin to account for uncertainties (See Section 2.2.2)

** See Section 2.2.3

As a general point of context, it is important to note that the application for the proposed wind farm does not seek consent for a specific make or specification of turbine. The selection of a final proposed turbine would occur after consent for the project, and would be subject to detailed layout design work (e.g. micro-siting) and a tender process to procure the supply of turbines. The final turbine would be selected on the basis of achieving compliance with the planning permit noise limits at surrounding noise sensitive receiver locations.

Accordingly, at this stage in the project, the candidate turbine models referred to in the noise assessment is primarily for the purpose of assessing the viability of the wind farm achieving compliance with the applicable limits at surrounding receiver locations. The key objective is to demonstrate that the noise limits can be practically achieved, accounting for typical noise emission levels that are representative of the types of turbine options that may be considered for the site.

2.2.2 Sound power levels

Sound power levels used in the assessment have been sourced from the documents detailed in Table 2, for each of the candidate turbine models.

Table 2: Reference documents

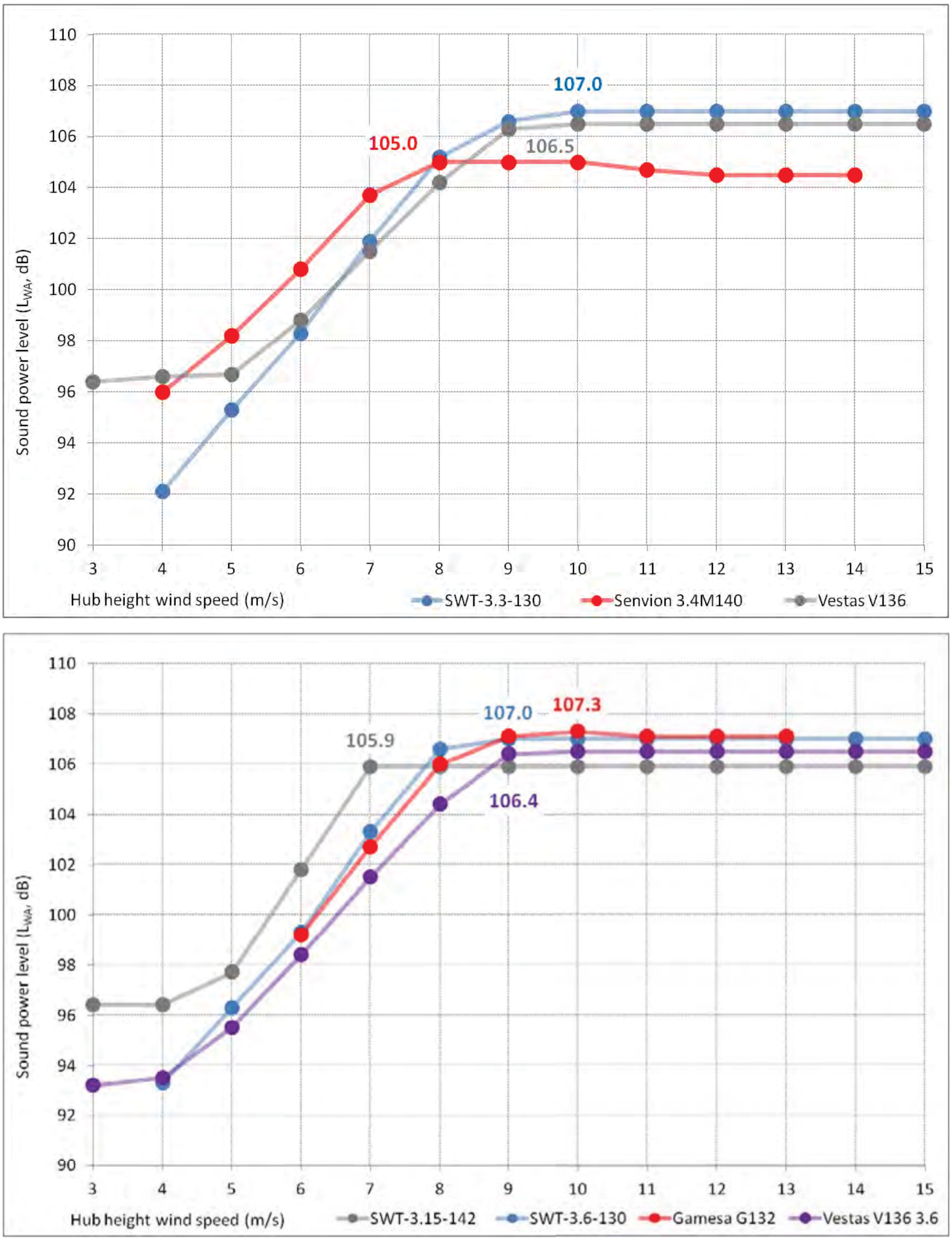
Model	Reference document
Senvion 3.4M140	Senvion document No. SD-3.20-WT.PC.01-A-B-EN *Power Curve & Sound Power Level [3.4M140/50Hz],* dated 2 June 2016 Senvion document No. GI-3.5-WT.PO.04-A-A-EN *Octave & Third Octave Band Data [3.0M122/50Hz] General Information,* dated 1 December 2015
Siemens SWT 3.3-130	Siemens document No. WP TE-40-0000-D104-01 *Standard Acoustic Emission SWT-3.3-130, Rev 0*, dated 8 May 2015
Vestas V136-3.45	Vestas document No. 0053-3713 V01 *Performance Specification V136-3.45 MW 50/60 Hz*, dated 24 November 2015 Vestas document No. 0055-9919 V00 *V136-mk3 -3.45 MW Third octave noise emission*, dated 23 November 2015
Siemens SWT-3.15-142	*Standard Acoustic Emission, SWT-3.15-142, Rev. 0* Document ID: WP ON PLM&EN EN GS-40-0000-G669-00, dated 12 May 2016
Siemens SWT-3.6-130	*Standard Acoustic Emission, SWT-3.6-130, Rev. 1* Document ID: WP ON PLM&EN EN GS-40-0000-G955-00, dated 12 May 2016
Gamesa G132-3.465	*G132-3.465MW POWER CURVE AND NOISE*. dated 26 February 2017; and MCG G132-3.465MW NOISE SPECTRUM, dated 26 February 2017
Vestas V136-3.6	*Performance Specification V136-3.60 MW 50/60 Hz* Document no.: 0056-6306 V02 2017-04-21; and *V136-3.6 MW Third octave noise emission* Document no. 0064-2970_01 2017-02-16

For each of the candidate turbines, the sound power level values used for this assessment have been derived from the above documents with the inclusion of a 1 dB margin to account for uncertainties.

The profile of A-weighted sound power levels as a function of hub height wind speed[1], detailed the documents listed in Table 1, are presented in Figure 1 for each of the candidate turbine models.

1 For the Siemens SWT 3.3-130, sound power level data referenced to hub height wind speeds have been derived from sound power level data referenced to 10 m AGL

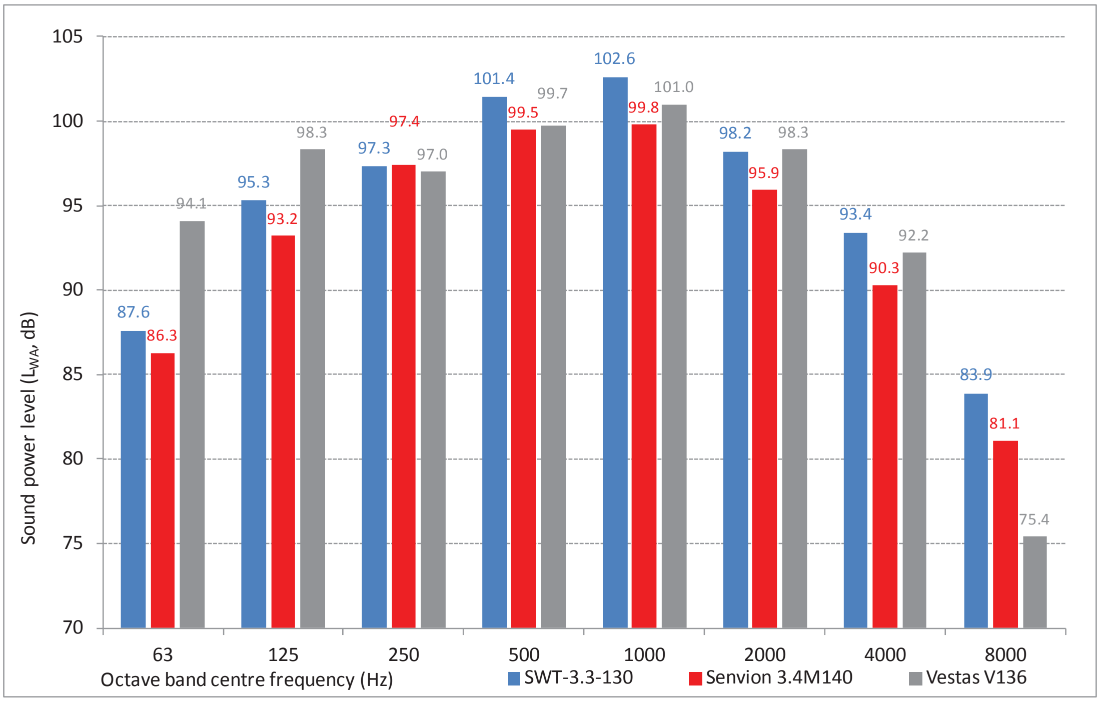
Figure 1: Guaranteed sound power level vs. hub height wind speed

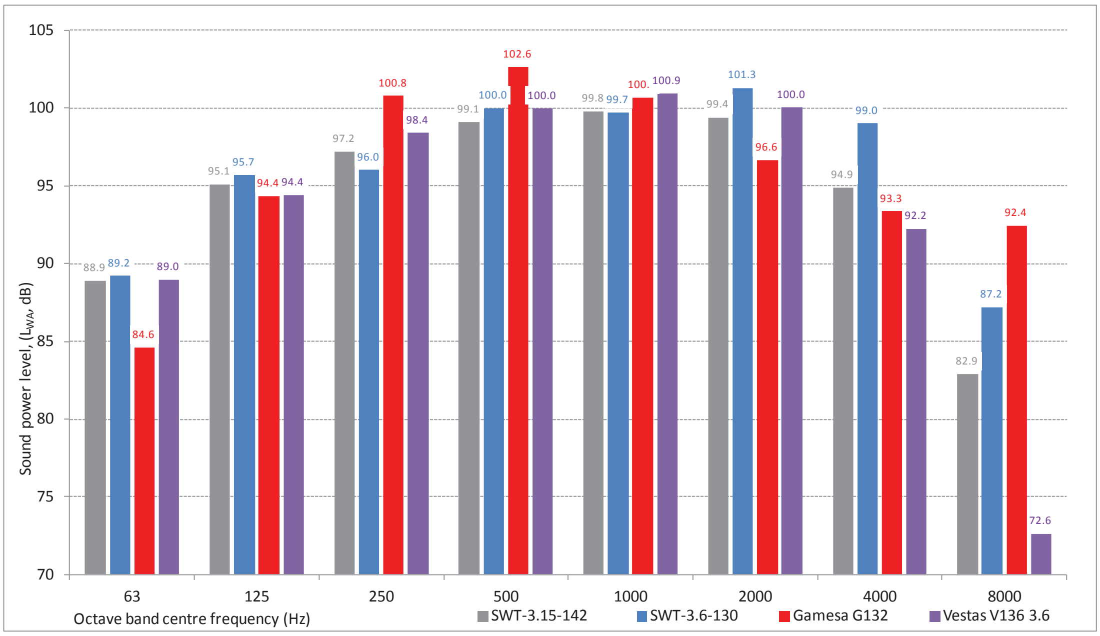


The octave band data provided in the reference documents have been adjusted to the highest sound power level detailed in Table 1 and are presented in Figure 2 for each of the candidate turbine models.

A-weighted octave band sound power spectra for the Senvion 3.4M140 candidate turbine is based on information provided by Senvion for the 3.0M122 turbine. It is understood that there is sufficient similarity between these two variants, that the 3.0M122 octave band data can be considered as representative of the spectral content for the 3.4M122.

Figure 2: A-weighted octave band sound power level spectra





2.2.3 Tonality

In accordance with New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010), a risk assessment for the potential of tonality should be undertaken using tonality values determined in accordance with *International Standard IEC 61400-11 Wind turbine generator systems – Part 11: Acoustic noise measurement techniques* (IEC 61400-11).

The data for wind turbine tonality that is provided in an IEC 61400-11 emission test report relates to a complex parameter referred to as the tonal audibility, $\Delta L_{a,k}$. However, this data is not applicable for assessing tonality at receiver locations, nor does IEC 61400-11 provide a rating scheme for defining the subjective significance of reported $\Delta L_{a,k}$ values.

For the separate purpose of assessing the potential for tonality to attract a Special Audible Characteristic penalty at receiver locations, NZS 6808:2010 specifies the use of Annex C to ISO 1996-2:2007[2] or an equivalent method. Given that ISO 1996-2:2007 was superseded, the narrow band tonality procedures documented in the updated version ISO 1996-2:2017 are referenced as the appropriate "equivalent method" in accordance with NZS 6808:2010. Specifically, as per Annex J of ISO 1996-2:2017, tonal audibility levels are to be determined in accordance with ISO/PAS 20065:2016[3]. The value of the adjustments to be applied to the noise level of the wind farm, where applicable, are to be determined on the basis of Table J.1 in Annex J of ISO 1996-2:2017, using the tonal audibility level determined in accordance with ISO/PAS 20065:2017.

While the tonal audibility concepts of IEC 61400-11 and ISO 1996-2:2017 are based on similar principles, the $\Delta L_{a,k}$ of IEC 61400-11 and the ΔL_{ta} of ISO 1996-2:2017 are defined in slightly different ways and, as a result, there is not a direct relationship between the two. However, to provide some context, it is noted that IEC 61400-11 states that any tones identified with a tonal audibility of $\Delta L_{a,k}$ greater than -3 dB shall be reported. This does not infer that a tone that is greater than -3 dB is problematic or audible, but it is a technical reporting requirement for documenting the characteristics of the turbine.

When available, tonal audibility values ($\Delta L_{a,k}$) are specified in the reference documents for each of the candidate turbines, as follows:

- Senvion 3.4M140: Senvion SE typically warrants tonal audibility $\Delta L_{a,k} < 2$ dB (for wind speed at 10 m AGL above 6 m/s)
- Siemens SWT 3.3-130: Tonal audibility information was not available for this turbine model at the time of preparing this document
- Vestas V136-3.45: Tonal audibility information was not available for this turbine model at the time of preparing this document.
- Siemens SWT 3.15-142: Tonal audibility information was not available for this turbine model at the time of preparing this document
- Siemens SWT 3.6-130: Tonal audibility information was not available for this turbine model at the time of preparing this document
- Gamesa G132-3.465: Tonal audibility information was not available for this turbine model at the time of preparing this document
- Vestas V136-3.6: Tonal audibility information was not available for this turbine model at the time of preparing this document.

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2 ISO 1996-2:2007 *Acoustics — Description, measurement and assessment of environmental noise - Determination of environmental noise levels* (ISO 1996-2:2007)

3 ISO/PAS 20065:2016 *Acoustics - Objective method for assessing the audibility of tones in noise – Engineering Method* (ISO/PAS 20065:2016)

We have been advised by Senvion that there is currently no installed prototype of the 3.4M140 turbine model and therefore measured data regarding tonality is not yet available.

In the absence of test data, Senvion states, in document No. SD-3.20-WT.PC.01-A-B-EN, the following performance specification for the 3.4M140 turbine for contractual purposes:

> *There is no tonal audibility $\Delta L_{a.k} > 2$ dB (for $V_{10} \geq 6$ m/s).*

Considering that the application of a penalty in accordance with ISO 1996 -2 (as required during post-construction assessment in accordance NZS 6808:2010) apply from a tonal audibility value ΔL_{ta} equal to or greater than +4 dB, it is unlikely that a tonal audibility $\Delta L_{a.k}$ less than +2 dB measured in close proximity of a turbine would attract a penalty for Special Audible Characteristics at a receiver location.

Therefore, for the current works, no penalty for special audible characteristics for tonality has been applied to wind farm noise levels predicted using the Senvion 3.4M140.

Notwithstanding the above, we envisage that the procurement contract for the site would stipulate that the final selected turbine model must not produce emissions which would attract a penalty when assessed in accordance with the relevant noise criteria and any associated conditions of consent.

2.3 Residential receivers

A total of one hundred and two (102) residential receivers have been included in the assessment, including seventeen (17) stakeholders and eighty-five (85) non-stakeholders.

These receiver locations were based on an updated dataset provided by Synergy Wind in June 2017.

The receiver locations considered in this assessment are detailed in Appendix B.

3.0 NOISE CRITERIA

New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) is used to assess wind farm noise as prescribed by the Victorian Government's *Policy and planning guidelines for development of wind energy facilities in Victoria* dated January 2016 (Victorian Guidelines).

3.1 Objective

Section C1.1 of NZS 6808:2010 discusses 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.*

Furthermore, the *Outcome Statement* of NZS 6808:2010 reads as follows:

> *This Standard provides suitable methods for the prediction, measurement, and assessment of sound from wind turbines. In the context of the Resource Management Act, application of this Standard will provide reasonable protection of health and amenity at noise sensitive locations.*

To deliver on this objective the standard specifies noise criteria which are used to assess wind farm noise.

3.2 Noise limit

Section 5.2 *Noise limit* of NZS 6808:2010 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 noise limits requires the noise associated with wind farms to be restricted to a permissible level 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 values are below the range of 30-35 dB.

Compliance with the criteria may result in wind turbine noise being audible at some locations for some of the time. The foreword of NZS 6808:2010 notes that:

> *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.*

3.3 High amenity areas

Section 5.3.1 of NZS 6808:2010 states that the base noise limit of 40 dB L_{A90} (as detailed in Section 3.2) is *appropriate for protection of sleep, health, and amenity of residents at most noise sensitive locations*. It goes on to note that high amenity areas 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.*

Section 5.3 of NZS 6808:2010 provides details of high amenity noise limits that apply to residential receivers that are deemed to be located within a high amenity area as defined in Sections 5.3.1 and 5.3.2 of the standard. The high amenity limit specifies that wind farm noise levels (L_{A90}) during evening and night-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, for wind speeds below 6 m/s at hub height. High amenity noise limits are not applicable during the daytime period.

In Section 5.1.2.a, the Victorian Guidelines states the following:

> *Under section 5.3 of the Standard, a 'high amenity noise limit' of 35 decibels applies in special circumstances. All wind farm 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 clause C5.3.1 of the Standard. Guidance can be found on this issue in the VCAT determination for the Cherry Tree Wind Farm.*

The definition of a high amenity area provided in NZS 6808:2010 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 recommended in the Victorian Guidelines, it is therefore appropriate to follow the guidance detailed in the Cherry Tree Wind Farm Pty Ltd v Mitchell Shire Council decisions[4].

Paragraph 53 of the Cherry Tree Wind Farm Decision states the following:

> *The Tribunal does not accept that the permit conditions need to refer to the High Amenity Area provisions of the New Zealand standard because it has not been established that any such area could reasonably be identified within the environs of this wind energy facility.* […]

[4] Mitchell Shire Council interim decision dated 4 April 2013 (the Cherry Tree Wind Farm Interim Decision) and Mitchell Shire Council decision dated 27 November 2013 (the Cherry Tree Wind Farm Decision)

Further justification for the above statement was provided in Paragraphs 107 to 109 of the Cherry Tree Wind Farm Interim Decision:

> 107. *We were invited by the respondents to treat the subject land and the locality as a high amenity area. This invitation meets with the immediate conundrum that the language of the standard is not translatable to the Victorian planning framework. The "plan" referred to in section 5.3 is a plan as defined by the Resources Management Act of New Zealand. Section 43AA of that Act defines "plan" to mean "a regional plan or a district plan". No such animals exist under the Victorian legislation.*
>
> 108. *Applying the standard mutatis mutandis to the Victorian experience we treat the plan referred to in the standard as a planning scheme approved under the Planning and Environment Act 1987. The Mitchell Planning Scheme does not anywhere expressly or by implication "promote a higher degree of protection of amenity related to the sound environment of a particular area". Approaching the matter by a process of elimination it can be seen with certainty that the controls contained within the Farming zone, which includes most of the locality, do not answer this description. The purpose of the Farming zone is to encourage agricultural use, which is not an inherently quiet land use. In fact reference to the zone purposes confirms that agricultural use is to be preferred to residential use if there is potential conflict between the two.*
>
> 109. *Accordingly the Tribunal concludes that the subject land and its locality is not capable of designation as a high amenity area because it does not possess the necessary characteristics of such an area as specified in the NZ standard.*

As detailed in Paragraph 108, for the land surrounding the proposed wind farm to be considered a high amenity area, the zoning of the land must be identified in the relevant planning scheme as *promoting a higher degree of protection of amenity related to the sound environment*.

The application of the high amenity area for this site is discussed in Section 6.1.

3.4 Special audible characteristics

Section 5.4.2 of NZS 6808:2010 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 receivers 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.*

While the standard emphasises assessment of special audible characteristics during the post-construction measurement phase of a project, an assessment of tonality is possible pre-construction, using tonality assessments carried out according to IEC 61400-11.

4.0 NOISE ASSESSMENT METHODOLOGY

There are several key stages involved in a noise assessment undertaken in accordance with NZS 6808:2010.

Firstly, preliminary wind farm noise predictions[5] are carried out for all identified residential receivers around the wind farm. The results of the preliminary analysis are used for the following:

- Identification of *noise sensitive locations,* where predicted wind farm noise levels exceed 35 dB L_{A90}
- Identification of selected *noise sensitive locations* where background noise monitoring should be undertaken, if required

Section 7.1.4 of NZS 6808:2010 notes the following:

> *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.*

Having identified noise sensitive locations and carrying out any background noise monitoring that may be required, applicable limits for the wind farm noise are determined.

Once noise limits have been established, further wind farm predictions are carried out.

Compliance is assessed by comparing the predicted wind farm noise levels with the noise limits over a range of wind speeds.

5 See Section 5.1

5.0 NOISE SENSITIVE LOCATIONS

NZS 6808:2010 requires that the noise assessment be undertaken at all noise sensitive locations 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.*

Noise sensitive locations therefore include residential dwellings, schools and hotels located outside the wind farm site.

As stakeholder receivers are located within the wind farm site, they are not considered as noise sensitive locations as part of an assessment in accordance with NZS 6808:2010. However, they have been considered as part of this assessment for informative purpose.

5.1 Preliminary noise predictions

Preliminary noise predictions have been undertaken at the one hundred and two (102) residential receivers identified by Synergy Wind in the vicinity of the Alberton Wind Farm (refer Section 2.3) using the noise prediction methodology detailed in Section 6.2.

Preliminary noise predictions corresponding to the highest sound power levels for each candidate turbine model (as detailed in Section 7.2) are presented in Table 3 and Table 4.

Only receivers where predicted levels are equal or greater than 35 dB L_{A90} for any of the candidate turbine models are presented.

Table 3: Preliminary noise predictions, dB L_{A90} – Non-stakeholder receivers

Receiver	Senvion 3.4M140	Siemens SWT 3.3-130	Vestas V136-3.45	Siemens SWT-3.15-142	Siemens SWT-3.6-130	Gamesa G132-3.465	Vestas V136-3.6
D10	32	34	35	33	33	34	33
D13	36	38	38	37	37	38	37
D21	32	33	35	32	33	34	33
D22	36	37	38	36	36	38	37
D24	34	35	37	34	35	36	35
D25	32	33	35	32	33	34	33
D29	35	37	38	35	36	37	36
D30	37	39	39	37	38	39	38
D31	36	38	38	36	37	38	37
D33	36	38	38	36	37	38	37
D34	34	35	36	34	34	36	35
D35	36	38	39	37	37	38	37
D45	33	34	35	33	33	35	34
D46	36	37	38	36	36	38	37
D47	36	37	38	36	36	38	37
D48	36	38	38	36	37	38	37

Receiver	Senvion 3.4M140	Siemens SWT 3.3-130	Vestas V136-3.45	Siemens SWT-3.15-142	Siemens SWT-3.6-130	Gamesa G132-3.465	Vestas V136-3.6
D49	36	37	38	36	36	38	37
D50	33	34	35	33	33	35	34
D51	37	39	40	38	38	39	38
D52	34	36	37	35	35	36	35
D53	34	36	36	34	35	36	35
D54	35	36	37	35	35	37	36
D55	34	36	37	35	35	36	35
D56	34	36	37	35	35	36	35
D57	36	38	39	37	37	39	38
D58	35	37	37	35	35	37	36
D59	34	36	37	35	35	37	36
D60	38	39	40	38	38	40	39
D61	33	35	36	34	34	35	34
D62	37	39	40	38	38	39	38
D63	32	34	35	33	33	34	33
D64	34	35	36	34	35	36	35
D65	34	36	37	35	35	37	36
D66	35	36	37	35	35	37	36
D67	34	35	36	34	34	36	35
D68	33	34	35	33	33	35	34
D71	32	33	35	32	33	34	33
D72	34	36	37	35	35	37	36
D73	35	36	37	35	35	37	36
D74	34	36	36	34	35	36	35
D75	33	35	36	33	34	35	34
D76	32	34	35	33	33	34	33
D81	36	38	39	37	37	38	37
D82	33	35	36	34	34	35	34
D83	33	35	36	34	34	35	34
D84	34	36	37	35	35	37	36
D85	35	36	37	35	35	37	36

Table 4: Preliminary noise predictions, dB L_{A90} – Stakeholder receivers

Receiver	Senvion 3.4M140	Siemens SWT 3.3-130	Vestas V136-3.45	Siemens SWT-3.15-142	Siemens SWT-3.6-130	Gamesa G132-3.465	Vestas V136-3.6
R01	37	39	39	37	38	39	38
R02	45	47	47	46	46	47	46
R03	39	41	42	40	40	41	41
R05	39	41	41	39	40	41	40
R08	40	42	42	40	40	42	41
R09	39	41	42	40	40	41	40
R10	35	37	38	36	36	37	36
R11	35	37	38	36	36	37	36
R12	41	43	44	42	42	43	43
R13	43	44	45	43	43	45	44
R14	44	46	46	45	45	46	46
R15	41	43	43	42	42	43	42
R16	40	42	42	41	41	42	41
R17	43	45	46	44	45	45	45
R18	37	39	40	38	38	39	38
R19	36	38	39	36	37	38	37

Based on the results for the candidate turbine model providing the highest noise levels, it can be seen from Table 3 and Table 4 that predicted noise levels at sixty-three (63) of the identified residential receivers in the vicinity of the proposed wind farm are above 35 dB L_{A90}, including the sixteen (16) stakeholders.

5.2 Background noise monitoring

Section 7 of NZS 6808:2010 provides guidance on sound measurements for the development and operation of a wind farm. The standard states the following in section 7.1.1:

> *Sound level measurements are used to:*
>
> *(a) Define the noise limits (see 5.2 and 5.3);*
>
> *(b) Verify the predicted wind farm sound levels*
>
> *(c) Confirm compliance with noise limits*

Section 7 of the standard then goes on to provide guidance on a range of procedures for measuring background noise levels prior to commencement of operation of a wind farm, as well as wind farm noise levels after the development has commenced operation.

The standard notes that a wind farm operator may elect to not conduct the background and compliance measurements described in Section 7. However, planning permits for Victorian wind farm generally require compliance measurements in accordance with the standard and consideration must therefore be given to both the background and compliance measurements procedures in the standard.

In relation to the location of the measurements, Section 7.1.4 notes:

> *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 preceding section of this report identifies a total of forty-seven (47) non-stakeholder receiver locations where the predicted noise levels are higher than 35 dB L_{A90}. Accordingly, background noise measurements should be carried out prior to the wind farm being developed.

At this point in the project, the primary purpose of the noise assessment is to demonstrate the viability of the proposed wind farm by verifying that the project could be designed and operated to meet the applicable noise limits defined by NZS 6808:2010. For this purpose, the planning stage assessment has been carried out by assessing the wind farm using the lowest noise limit which could be applied to the project i.e. without consideration of any increase in noise limits which may be relevant at higher wind speeds when background noise levels are increased.

Subject to the wind farm being approved, it is proposed that background noise measurements be undertaken at a range of representative locations in order to enable post-construction compliance measurements to be carried out in accordance with Section 7 of the standard. The locations would be selected accounting for the final layout design and turbine selection for the wind farm design, as well as the final participation status of surrounding receiver locations (i.e. to prioritise the selection of non-participant receiver location). It is also proposed that the background surveys would be scheduled to occur just prior to commencement of construction of the wind farm in order to limit the time period between the background measurements and any subsequent compliance measurements. This provides the benefit of reducing the opportunity for significant environmental changes to occur in the period between the background and compliance measurements.

6.0 NOISE LIMITS

6.1 High amenity areas

The area surrounding the proposed wind farm is predominantly designated as Farming Zone in the planning map shown in Appendix C.

The *Victoria Planning Provisions Practice Note* prepared by the Department of Sustainability and Environment titled Applying the rural zones and dated March 2007 states the following:

> *The Farming Zone is designed to encourage diverse farming practices, some of which can have significant off-site impacts. For this reason, the level of amenity that can be expected in this zone will usually not be compatible with sensitive uses, particularly housing.*

Based on the above, the high amenity noise limit in NZS 6808:2010 is not considered applicable to residential receivers within a Farming Zone.

On this basis and following guidance from VCAT determination for the Cherry Tree Wind Farm, as required by the Victorian Guidelines, the high amenity noise limit detailed in NZS 6808:2010 is therefore not deemed to be applicable for residential receivers in the vicinity of the Alberton Wind Farm.

6.2 Stakeholder receivers

The definition given in NZS 6808:2010 of noise sensitive locations specifically excludes dwellings within the wind farm site boundary, identified as stakeholder receivers. For these, it is current practice to use the recommendations outlined in the final report by *The European Working Group on Noise from Wind Turbines* (ETSU-R-97) which allows for an increased base noise limit of 45 dB L_{A90} in lieu of the 40 dB L_{A90} minimum noise limit.

6.3 Applicable noise limits

For the purpose of this assessment, the NZS 6808:2010 base noise limit of 40 dB L_{A90} at all wind speeds has been used for all noise sensitive locations. This provides a conservative assessment.

The base noise limit of 45 dB L_{A90} has been used for stakeholder receivers.

7.0 NOISE PREDICTIONS

7.1 Methodology

Operational noise due to the Alberton Wind Farm has been predicted using ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation* (ISO 9613-2:1996) as implemented in version 7.4 of SoundPLAN. Predictions have been carried out using the sound power level data presented in Section 2.2.

Section C6.2.1 of NZS 6808:2010 states that, *for the purposes of this Standard, the predicted wind farm* [L_{Aeq}] *at any receiver location is deemed to be equivalent to the* [L_{A90}] *value*.

Calculations have been performed using octave band data from 63 Hz to 8 kHz and each wind turbine has been modelled as a point source at hub height. All noise predictions use a receiver height of 1.5 m above ground level (AGL). Possible screening effects from the landscape are considered using 10 m elevation contour information provided by the proponent. A copy of the site topography map is included in Appendix D. Atmospheric attenuation has been modelled using a temperature of 10 °C and 70 % humidity as recommended by NZS 6808:2010.

The hardness of the ground between the sources and the receivers needs to be defined in accordance with ISO 9613-2:1996. 100 % hard ground (G=0) is considered to be fully reflective as would occur with concrete or asphalt, while 100 % soft ground (G=1) would be considered absorptive and be appropriate for fields and grass. Our experience is that, in rural areas, it is appropriate to assume that the ground is 50 % hard/50 % soft. A ground factor of 50 % (G=0.5) has been used in the predictions.

Further details regarding the use of ISO 9613-2:1996 for wind farm noise predictions and the use of G=0.5 is presented in Appendix E.

7.2 Predicted noise levels

The predicted wind farm noise levels at the sixty-three (63) noise sensitive locations detailed in Section 5.1, where predicted levels are greater than 35 dB L_{A90} are presented in Table 5 and Table 6.

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.

The predicted levels correspond to the highest sound power level presented in Section 2.2.2 for each of the candidate turbines.

From Table 5, it can be seen that predicted noise levels from the Alberton Wind Farm comply with the NZS 6808:2010 base noise limit at all noise sensitive locations in the vicinity of the proposed site for all candidate wind turbine models.

Table 5: Highest predicted noise levels at non-stakeholder receivers - dB L_{A90}

Receiver	Applicable base noise limit	Senvion 3.4M140	Siemens SWT 3.3-130	Vestas V136-3.45	Siemens SWT-3.15-142	Siemens SWT-3.6-130	Gamesa G132-3.465	Vestas V136-3.6
D10	40	32.1	33.9	34.8	32.7	32.9	34.3	33.3
D13	40	36.0	37.9	38.3	36.5	36.7	38.1	37.2
D21	40	31.7	33.3	34.7	32.3	32.5	33.8	32.9
D22	40	35.5	37.4	38.1	36.1	36.3	37.7	36.7
D24	40	33.7	35.4	36.5	34.3	34.5	35.9	34.9
D25	40	31.6	33.2	34.8	32.3	32.5	33.8	32.8
D29	40	34.9	36.6	37.6	35.4	35.6	37.0	36.0
D30	40	36.8	38.7	39.2	37.3	37.6	38.9	38.0
D31	40	35.7	37.5	38.3	36.2	36.5	37.9	36.9
D33	40	35.8	37.6	38.4	36.3	36.6	38.0	37.0
D34	40	33.5	35.3	36.3	34.1	34.3	35.7	34.7
D35	40	36.2	38.0	38.7	36.7	37.0	38.3	37.4
D45	40	32.5	34.2	35.5	33.1	33.3	34.6	33.7
D46	40	35.5	37.3	38.2	36.0	36.2	37.7	36.6
D47	40	35.6	37.4	38.3	36.1	36.3	37.8	36.7
D48	40	35.8	37.5	38.4	36.3	36.5	37.9	36.9
D49	40	35.7	37.4	38.3	36.2	36.4	37.8	36.8
D50	40	32.6	34.4	35.4	33.2	33.4	34.7	33.8
D51	40	37.2	39.0	39.6	37.6	37.9	39.3	38.3
D52	40	34.0	35.8	36.7	34.6	34.8	36.1	35.2
D53	40	33.8	35.5	36.5	34.3	34.6	35.9	34.9
D54	40	34.5	36.3	37.1	35.0	35.3	36.6	35.7
D55	40	34.2	36.0	36.9	34.7	35.0	36.3	35.4
D56	40	34.2	36.0	36.9	34.8	35.0	36.4	35.4
D57	40	36.4	38.2	38.9	36.9	37.1	38.5	37.6
D58	40	34.7	36.5	37.3	35.2	35.4	36.8	35.8
D59	40	34.4	36.2	37.0	34.9	35.2	36.5	35.5
D60	40	37.5	39.3	39.9	38.0	38.2	39.6	38.6
D61	40	32.9	34.6	35.7	33.5	33.7	35.0	34.1
D62	40	37.2	39.1	39.6	37.7	37.9	39.3	38.4
D63	40	32.1	33.8	35.0	32.7	32.9	34.2	33.3
D64	40	33.7	35.4	36.4	34.2	34.5	35.8	34.8
D65	40	34.4	36.2	36.9	34.9	35.1	36.5	35.5
D66	40	34.5	36.3	37.1	35.0	35.3	36.7	35.7
D67	40	33.6	35.4	36.1	34.1	34.4	35.7	34.8

Receiver	Applicable base noise limit	Senvion 3.4M140	Siemens SWT 3.3-130	Vestas V136-3.45	Siemens SWT-3.15-142	Siemens SWT-3.6-130	Gamesa G132-3.465	Vestas V136-3.6
D68	40	32.5	34.3	35.1	33.0	33.3	34.6	33.7
D71	40	31.6	33.3	34.7	32.3	32.5	33.8	32.8
D72	40	34.4	36.2	37.1	35.0	35.2	36.6	35.6
D73	40	34.6	36.4	37.2	35.1	35.4	36.7	35.7
D74	40	33.7	35.5	36.4	34.2	34.5	35.8	34.8
D75	40	32.8	34.5	35.6	33.4	33.6	34.9	33.9
D76	40	32.1	33.8	35.0	32.7	32.9	34.2	33.2
D81	40	36.2	38.1	38.6	36.7	37.0	38.3	37.4
D82	40	32.9	34.6	35.8	33.5	33.7	35.0	34.1
D83	40	33.0	34.7	35.9	33.6	33.8	35.1	34.2
D84	40	34.4	36.2	37.0	34.9	35.1	36.5	35.5
D85	40	34.5	36.2	37.3	35.1	35.3	36.7	35.7

Table 6: Highest predicted noise levels at stakeholder receivers - L_{A90}, dB

Receiver	Applicable base noise limit	Senvion 3.4M140	Siemens SWT 3.3-130	Vestas V136-3.45	Siemens SWT-3.15-142	Siemens SWT-3.6-130	Gamesa G132-3.465	Vestas V136-3.6
R01	45	36.9	38.8	39.1	37.4	37.7	38.9	38.1
R02	45	44.8	46.9	46.8	45.5	46.0	46.7	46.2
R03	45	39.2	41.2	41.4	39.8	40.1	41.2	40.5
R05	45	38.8	40.7	41.1	39.3	39.6	40.9	40.0
R08	45	39.6	41.5	41.9	40.1	40.4	41.7	40.8
R09	45	39.2	41.0	41.5	39.6	39.9	41.3	40.3
R10	45	35.0	36.8	37.5	35.5	35.8	37.1	36.2
R11	45	35.3	37.1	37.7	35.8	36.0	37.4	36.4
R12	45	41.3	43.3	43.5	41.9	42.2	43.3	42.6
R13	45	42.5	44.4	44.6	43.0	43.4	44.5	43.7
R14	45	44.2	46.3	46.3	44.9	45.3	46.2	45.6
R15	45	41.1	43.1	43.2	41.7	42.1	43.1	42.4
R16	45	40.1	42.1	42.3	40.7	41.0	42.1	41.4
R17	45	43.4	45.4	45.5	44.0	44.5	45.4	44.7
R18	45	37.3	39.1	39.6	37.8	38.1	39.3	38.4
R19	45	35.9	37.7	38.4	36.4	36.7	38.0	37.1

Note: Shaded cell(s) exceed the applicable base noise limit

The following can be seen from Table 6:

- Predicted noise levels from the Alberton Wind Farm comply with the applicable base noise limit at all stakeholder receivers using the Senvion 3.4 M140 turbine model
- Predicted noise levels from the Alberton Wind Farm exceed the applicable base noise limit at three (3) stakeholder receivers R02, R14 and R17 by 1.9 dB, 1.3 dB and 0.4 dB respectively using the Siemens SWT-3.3-130 turbine model
- Predicted noise levels from the Alberton Wind Farm exceed the base limit at three (3) stakeholder receivers R02, R14 and R17 by 1.8 dB, 1.3 dB and 0.5 dB respectively, using the Vestas V136-3.45 turbine model
- Predicted noise levels from the Alberton Wind Farm exceed the base limit at one (1) stakeholder receiver, R02 by 0.5 dB, using the Siemens SWT-3.15-142 turbine model
- Predicted noise levels from the Alberton Wind Farm exceed the base limit at two (2) stakeholder receivers, R02 and R14 by 1.0 dB and 0.3 dB respectively, using the Siemens SWT-3.6-130 turbine
- Predicted noise levels from the Alberton Wind Farm exceed the base limit at three (3) stakeholder receivers, R02, R14 and R17 by 1.7 dB, 1.2 dB and 0.4 dB respectively, using the Gamesa G132 turbine model
- Predicted noise levels from the Alberton Wind Farm exceed the base limit at two (2) stakeholder receivers, R02 and R14 by 1.2 dB and 0.6 dB respectively, using the Vestas V136-3.6 turbine model.

Wind farm noise at other stakeholder receivers further from the wind farm will be lower than 35 dB L_{A90} and therefore also comply with the lowest applicable NZS 6808:2010 noise limit of 40 dB L_{A90} at all wind speeds by at least 5 dB.

Noise contour maps are presented in Appendix F for the highest sound power levels corresponding to each of the candidate turbine models.

Given the margin of compliance at a number of receiver locations (for certain wind turbine models) and subject to the wind farm being approved, it is likely a permit requirement will require that once the final turbine selection and layout (allowing for micro-siting) are confirmed, that compliance with the relevant noise limit will also need to be reassessed.

7.3 Special audible characteristics

Based on the information provided in Section 2.2.3, it is considered that a penalty for tonality is not applicable for any of the assessed wind speeds.

This is based on the assumption that the turbine procurement contract for the site would stipulate that the turbines must not produce emissions which would attract a penalty for tonality when assessed in accordance with the relevant noise criteria and any associated conditions of consent.

8.0 CONCLUSION

The Alberton Wind Farm is proposed to consist of thirty-four (34) turbines, west Yarram in Victoria.

An assessment has been undertaken in accordance with NZS 6808:2010 as required by the current Victorian Guidelines at one hundred and two (102) residential receivers identified by Synergy Wind in the vicinity of the project.

The assessment has considered a number of candidate wind turbine models for the site, as follows:

- Senvion 3.4M140
- Siemens SWT 3.3-130
- Vestas V136-3.45
- Siemens SWT 3.15-142
- Siemens SWT 3.6-130
- Gamesa G132-3.465
- Vestas V136-3.6

Wind farm noise levels predicted using ISO 9613-2:1996, for each candidate turbine model, have been assessed against a base noise limit of 40 dB L_{A90} for non-stakeholder receivers identified as noise sensitive locations in accordance with NZS 6808:2010. A review of land zoning surrounding the proposed site indicates that high amenity noise limits are not applicable.

Compliance with the NZS 6808:2010 noise limit is achieved at all wind speeds at all identified non-stakeholder receivers identified in the vicinity of the proposed Alberton wind Farm for each of the assessed candidate wind turbine models.

For stakeholders, a base noise limit of 45 dB L_{A90} was used as recommended by supplementary guidance commonly referenced in Victoria (ETSU-R-97). Results of the NZS 6808:2010 noise assessment are as follows:

- Using the Senvion 3.4 M140 turbine model

  Compliance with the NZS 6808:2010 noise limit is achieved at all wind speeds at all identified receivers identified in the vicinity of the proposed Alberton wind Farm

- Using the Siemens SWT 3.3-130 turbine model

  Predicted noise levels exceed the applicable base noise limit at three (3) stakeholder receivers, R02, R14 and R17 by 1.9 dB, 1.3 dB and 0.4 dB respectively

- Using the Vestas V136-3.45 turbine model

  Predicted noise levels exceed the applicable base noise limit at three (3) stakeholder receivers, R02, R14 and R17 by 1.8 dB, 1.3 dB and 0.5 dB respectively

- Using the Siemens SWT-3.15-142 turbine model

  Predicted noise levels exceed the NZS 6808:2010 noise limit at one (1) stakeholder receiver, R02 by 0.5 dB

- Using the Siemens SWT-3.6-130 turbine model

  Predicted noise levels exceed the NZS 6808:2010 noise limit at two (2) stakeholder receivers, R02 and R14 by 1.0 dB and 0.3 dB respectively

- Using the Gamesa G132 turbine model

  Predicted noise levels exceed the NZS 6808:2010 noise limit at three (3) stakeholder receivers, R02, R14 and R17 by 1.7 dB, 1.2 dB and 0.4 dB respectively

- Using the Vestas V136-3.6 turbine model

  Predicted noise levels exceed the NZS 6808:2010 noise limit at two (2) stakeholder receivers, R02 and R14 by 1.2 dB and 0.6 dB respectively

- Compliance with the lowest possible NZS 6808:2010 noise limit is achieved at all wind speeds at all remaining receivers in the vicinity of the wind farm for all candidate turbine models

Given the margin of compliance at a number of receiver locations (for certain wind turbine models) and subject to the wind farm being approved, it is likely a permit requirement will require that once the final turbine selection and layout (allowing for micro-siting) are confirmed, that compliance with the relevant noise limit will also need to be reassessed.

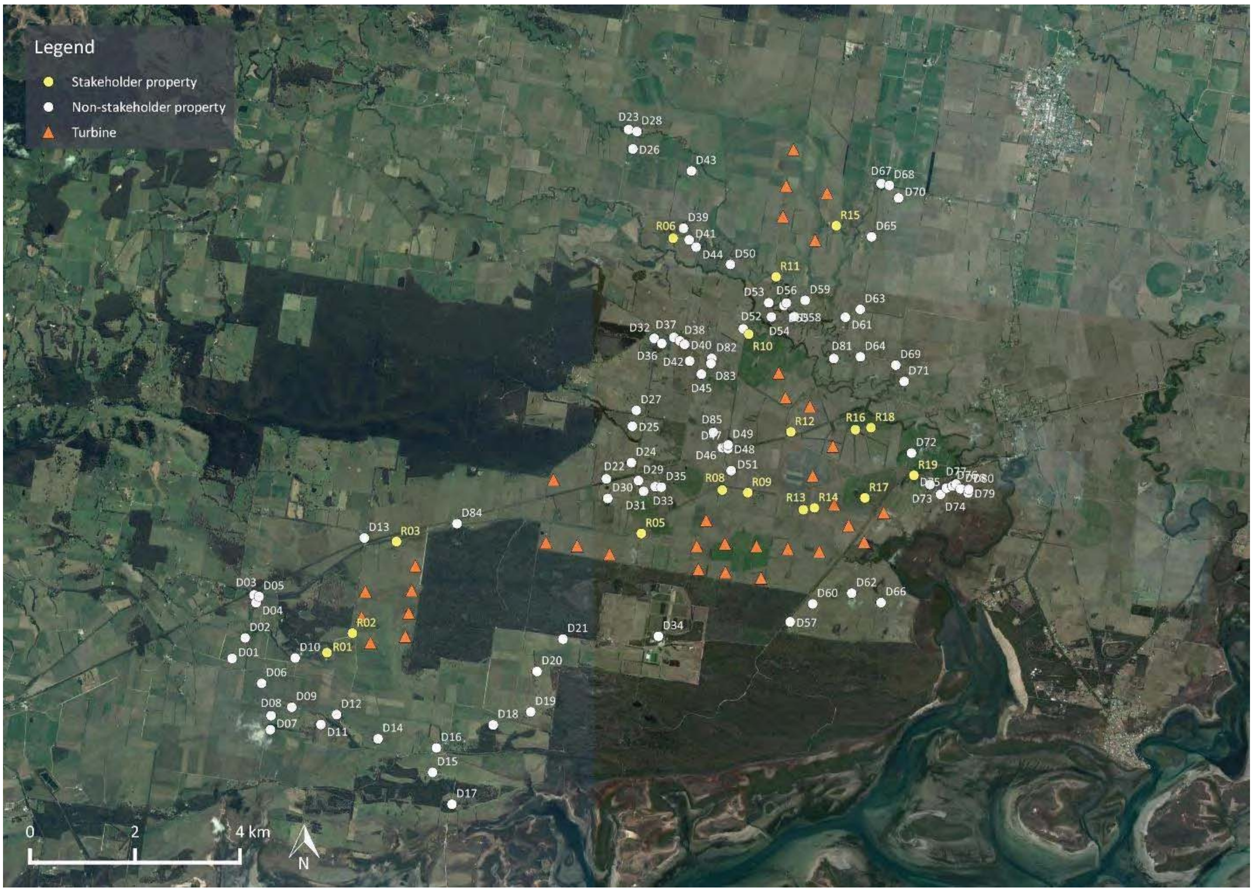
9.0 SUMMARY OF PARAMETERS

Documentation of relevant parameters as required by NZS 6808:2010 is contained in Appendix G.

APPENDIX A GLOSSARY OF TERMINOLOGY

A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
dB	Decibel. The unit of sound level.
Frequency	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
L_{A90}	The noise level exceeded for 90 % of the measurement period, measured in A-weighted decibels. This is commonly referred to as the background noise level.
L_W	The sound power level. The level of total sound power radiated by a sound source.
L_{WA}	The “A” weighted sound power level.
Octave Band	A range of frequencies where the highest frequency included is twice the lowest frequency. 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.

APPENDIX B ALBERTON WIND FARM LAYOUT



B1 Turbine coordinates (WGS84 Zone 55)

Turbine	Easting	Northing	Turbine	Easting	Northing
T01	458853	5721594	T18	466207	5723430
T02	458685	5722082	T19	466293	5722824
T03	458756	5722567	T20	466711	5729705
T04	459518	5721714	T21	466771	5730287
T05	459584	5722157	T22	466804	5723380
T06	459637	5722587	T23	466912	5730979
T07	459708	5723054	T24	466630	5726724
T08	462198	5723499	T25	467223	5726089
T09	462340	5724695	T26	467278	5724773
T10	462791	5723439	T27	467403	5723331
T11	463408	5723282	T28	467323	5729252
T12	465069	5723430	T29	467662	5725331
T13	465102	5722990	T30	467551	5730153
T14	465248	5723919	T31	467683	5724225
T15	465606	5723479	T32	467964	5723825
T16	465616	5722934	T33	468258	5723514
T17	466758	5726258	T34	468632	5724068

B2 Dwelling coordinates (WGS84 Zone 55) – Stakeholder receivers

Receiver	Easting	Northing	Distance to nearest turbine (m)	Receiver	Easting	Northing	Distance to nearest turbine (m)
R01	458025	5721403	850	R11	466580	5728555	1,019
R02	458511	5721773	355	R12	466861	5725604	605
R03	459349	5723517	586	R13	467098	5724123	594
R05	464013	5723672	720	R14	467310	5724158	379
R06	464619	5729290	2,133	R15	467727	5729528	489
R08	465556	5724498	656	R16	468091	5725646	533
R09	466041	5724449	954	R17	468272	5724349	457
R10	466058	5727464	935	R18	468387	5725686	808
R01	458025	5721403	850	R19	469205	5724777	912

B3 Dwelling coordinates (WGS84 Zone 55) – Non-stakeholder receivers

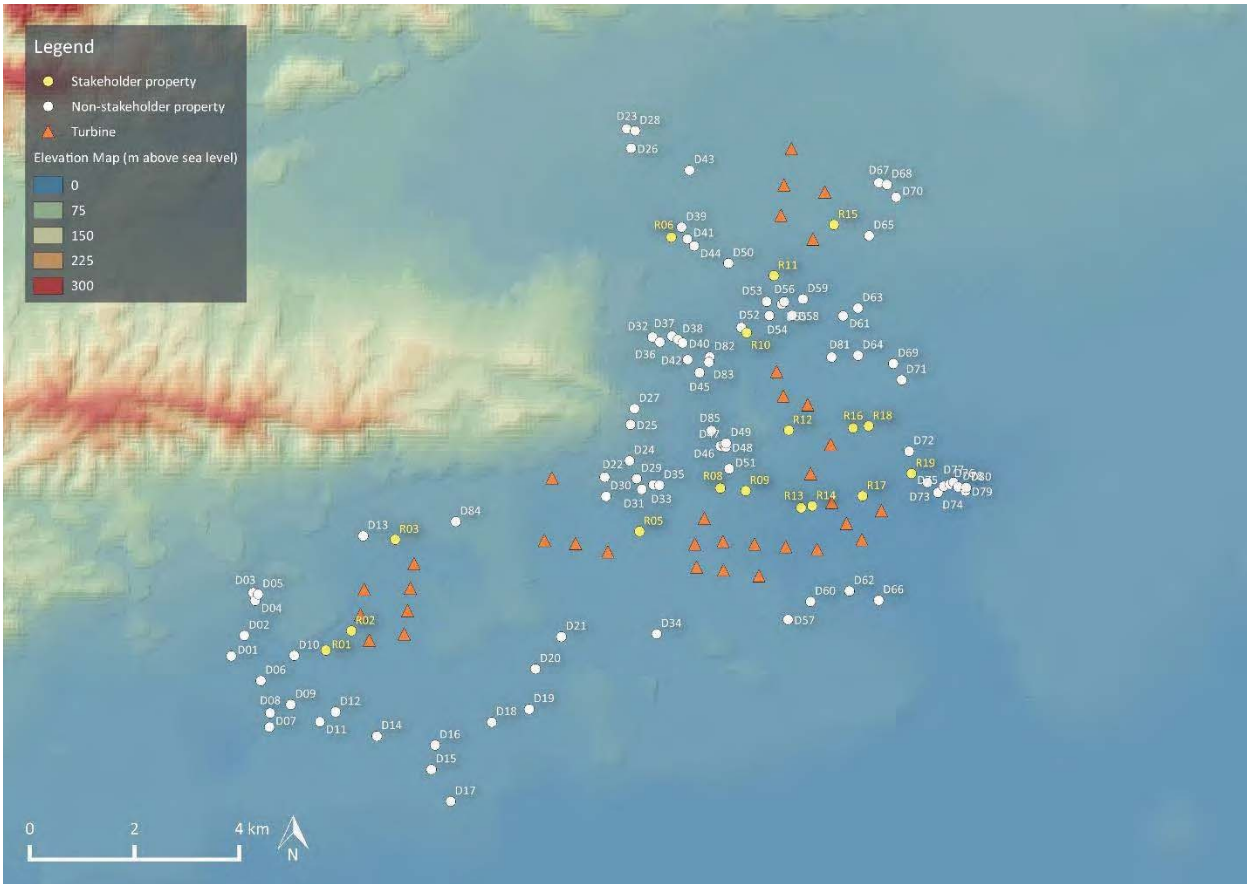
Receiver	Easting	Northing	Distance to nearest turbine (m)	Receiver	Easting	Northing	Distance to nearest turbine (m)
D01	456219	5721293	2,589	D44	465058	5729122	1,753
D02	456468	5721683	2,253	D45	465158	5726702	1,472
D03	456636	5722500	2,091	D46	465557	5725302	1,417
D04	456675	5722351	2,028	D47	465624	5725326	1,456
D05	456731	5722471	1,992	D48	465662	5725284	1,426
D06	456782	5720820	2,211	D49	465666	5725357	1,416
D07	456947	5719936	2,526	D50	465711	5728791	1,355
D08	456961	5720204	2,348	D51	465724	5724867	1,061
D09	457354	5720365	1,938	D52	465957	5727564	1,076
D10	457420	5721301	1,463	D53	466440	5728061	1,350
D11	457910	5720036	1,821	D54	466491	5727792	1,077
D12	458209	5720224	1,514	D55	466729	5728009	1,289
D13	458737	5723585	1,018	D56	466778	5728057	1,313
D14	458998	5719763	1,837	D57	466848	5721988	1,003
D15	460039	5719125	2,641	D58	466928	5727796	1,113
D16	460111	5719590	2,205	D59	467134	5728108	1,160
D17	460407	5718517	3,318	D60	467278	5722331	1,008
D18	461192	5720028	2,376	D61	467900	5727786	1,575
D19	461907	5720276	2,788	D62	468021	5722533	1,009
D20	462027	5721045	2,460	D63	468183	5727934	1,574
D21	462521	5721661	1,798	D64	468186	5727032	1,348
D22	463348	5724709	1,008	D65	468397	5729317	1,076
D23	463770	5731358	3,165	D66	468579	5722356	1,202
D24	463822	5725019	1,517	D67	468582	5730329	1,046
D25	463843	5725711	1,814	D68	468737	5730295	1,194
D26	463853	5730988	3,001	D69	468860	5726875	1,816
D27	463917	5726014	2,056	D70	468913	5730054	1,366
D28	463929	5731320	3,002	D71	469019	5726564	1,834
D29	463958	5724677	1,496	D72	469159	5725201	1,250
D30	463373	5724339	1,058	D73	469510	5724603	1,028
D31	464056	5724474	1,315	D74	469711	5724415	1,133
D32	464260	5727382	2,460	D75	469822	5724534	1,278
D33	464278	5724560	1,163	D76	469938	5724573	1,400

Receiver	Easting	Northing	Distance to nearest turbine (m)	Receiver	Easting	Northing	Distance to nearest turbine (m)
D34	464339	5721714	1,487	D77	470008	5724610	1,479
D35	464393	5724553	1,064	D78	470094	5724521	1,531
D36	464402	5727287	2,298	D79	470239	5724441	1,650
D37	464632	5727402	2,110	D80	470251	5724509	1,678
D38	464746	5727334	1,980	D81	467680	5726999	1,018
D39	464816	5729479	1,908	D82	465354	5727002	1,306
D40	464838	5727269	1,873	D83	465338	5726904	1,304
D41	464925	5729257	1,841	D84	460504	5723858	1,131
D42	464933	5726951	1,712	D85	465384	5725596	1,525
D43	464967	5730568	1,826				

APPENDIX C ZONING MAP

The zoning maps used in the following map were downloaded from the Department of Environment, Land, Water & Planning *Planning Maps Online* website on June 2017.

APPENDIX D SITE TOPOGRAPHY MAP



APPENDIX E NOISE PREDICTION MODEL

Operational wind farm noise levels are predicted at all residential dwellings considered within this assessment using a three-dimensional noise model generated in SoundPLAN® version 7.4 software. Specifically, predictions have been carried out using the SoundPLAN implementation of ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation* (ISO 9613-2:1996) to calculate noise propagation from the wind farm to each receiver location.

The use of this method 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* (NZS 6808:2010).

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 levels 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 9613-2:1996, the noise levels 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 sound power level data to determine the corresponding octave band and total calculated noise level at relevant receiver locations.

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.

A number of Australian and international studies support 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. This ground absorption factor of G=0.5 is adopted in combination with several cautious 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 degrees and relative humidity of 70 % (conditions which give rise to low atmospheric absorption). The studies demonstrate that applying the ISO 9613-2:1996 prediction methodology in this way provides a reliable representation of the upper noise levels expected in practice.

The following specific adjustments have been made:

- In instances where the ground terrain provides marginal or partial acoustic screening, the barrier effect should be limited to not more than 2 dB
- Screening attenuation calculated based on the screening expected for the source located at the tip height of the wind turbine (in contrast to hub height in non-adjusted ISO 9613 predictions)
- In instances where the ground falls away significantly between the source and receiver, such as valleys, an adjustment of 3 dB should be added to the calculated sound pressure level. A terrain profile in which the ground falls away significantly is defined as one where the mean sound propagation height is at least 50 % greater than would occur over flat ground.

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 6808:2010 refers to ISO 9613-2:1996 as an appropriate prediction methodology 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, part funded by the European Commission, Development of a Wind Farm Noise Propagation Prediction Model[6] 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 standards 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, 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. It is noted that this publication specifically refers to predictions made to receiver heights of 4m in the interest of representing 2-storey dwellings which are more common in the UK. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation factors, 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 comparative measurement and prediction studies[7, 8, 9] 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.

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6 Bass, Bullmore and Sloth - *Development of a wind farm noise propagation prediction model*; Contract JOR3-CT95-0051, Final Report, January 1996 to May 1998.

7 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.

8 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.

9 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.

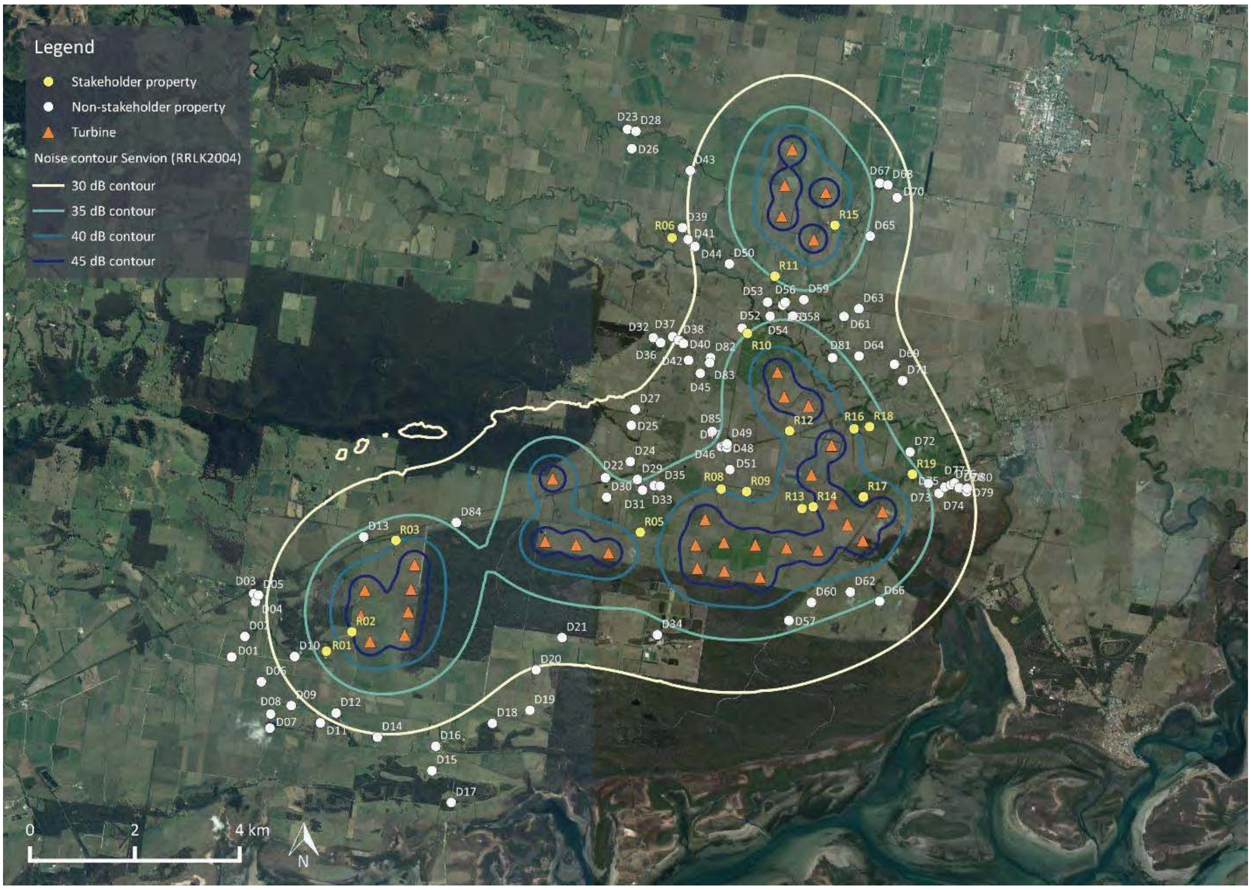
The key findings of these studies demonstrated the suitability of the ISO 9613-2:1996 method to predict the propagation of wind turbine noise for:

- 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 the original ISO 9613
- 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.

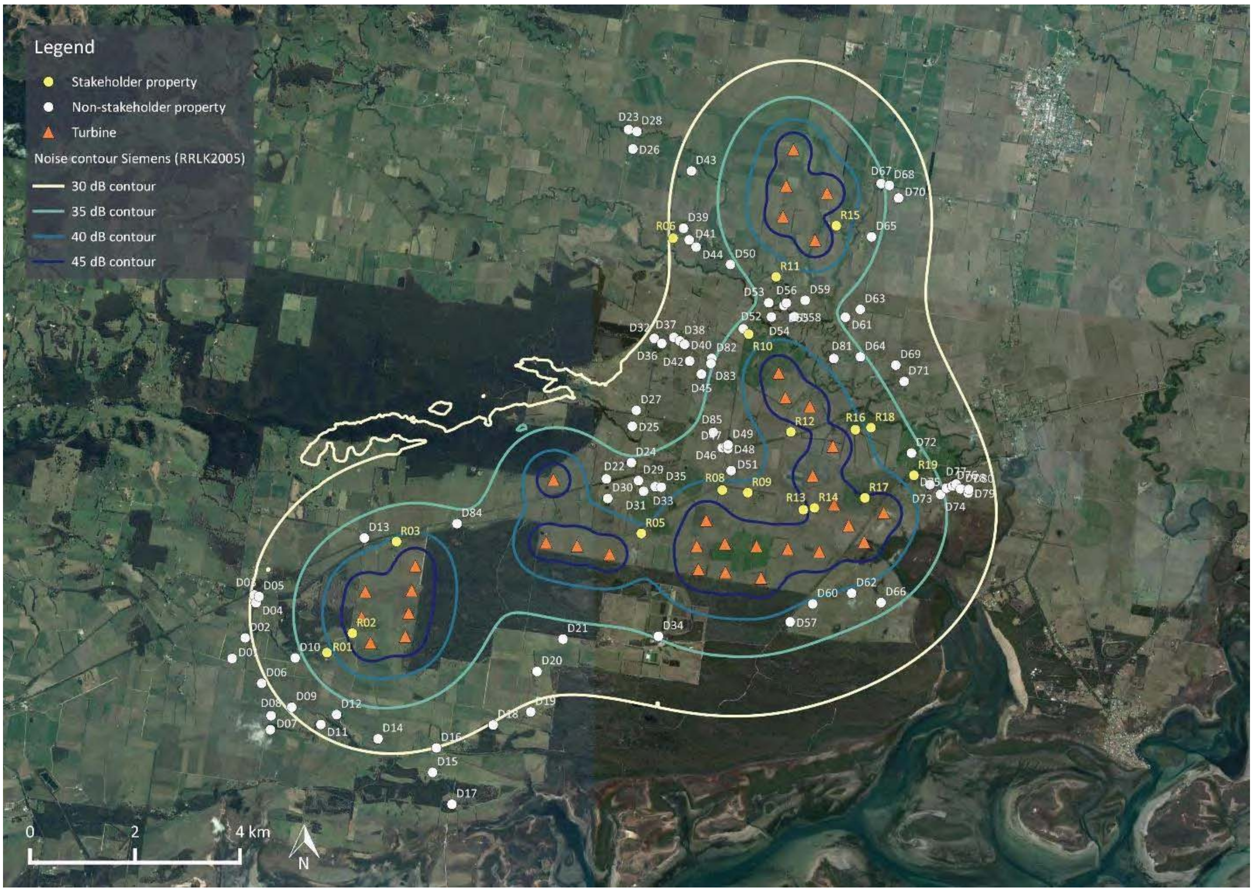
ISO 9613-2:1996 is primarily intended for the prediction of total A-weighted noise levels.

APPENDIX F NOISE CONTOUR MAPS

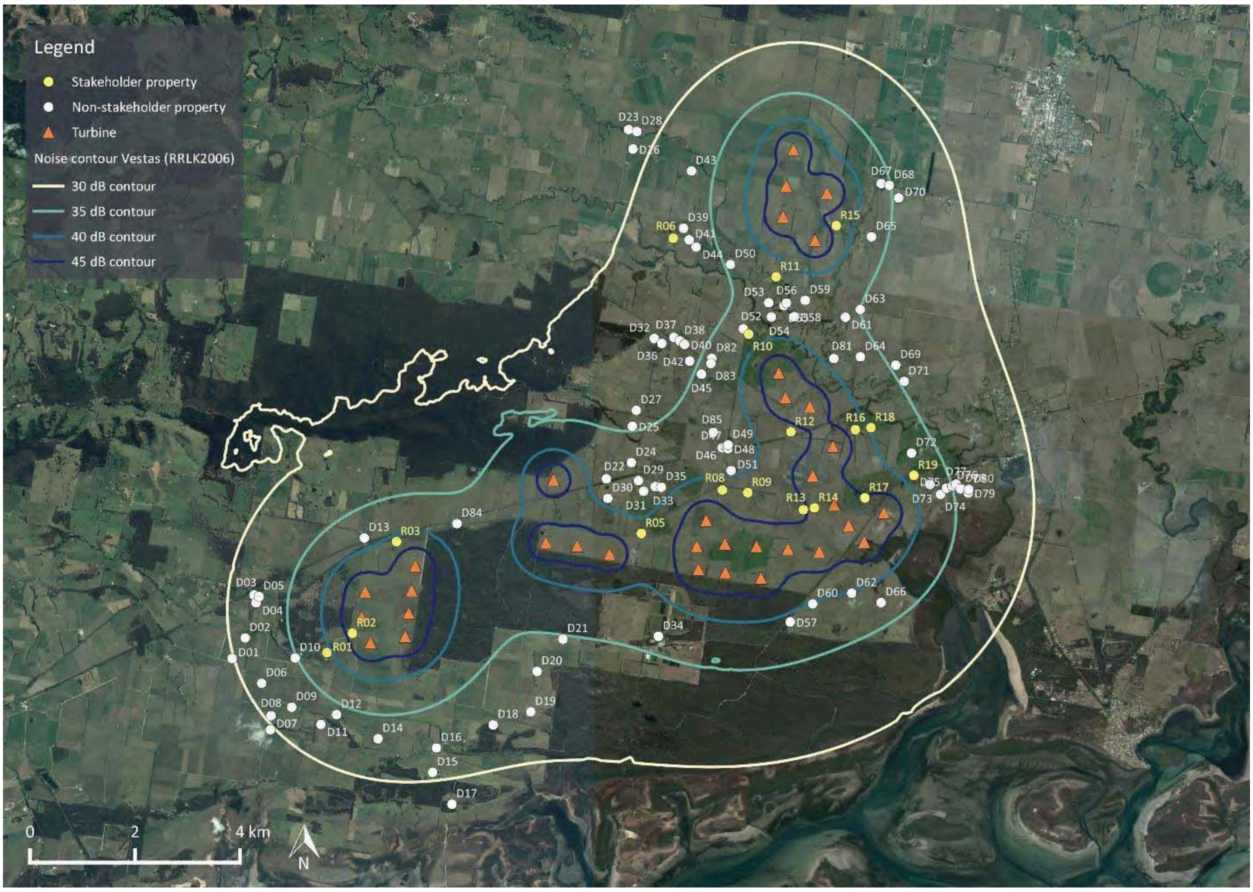
F1 Senvion 3.4M140



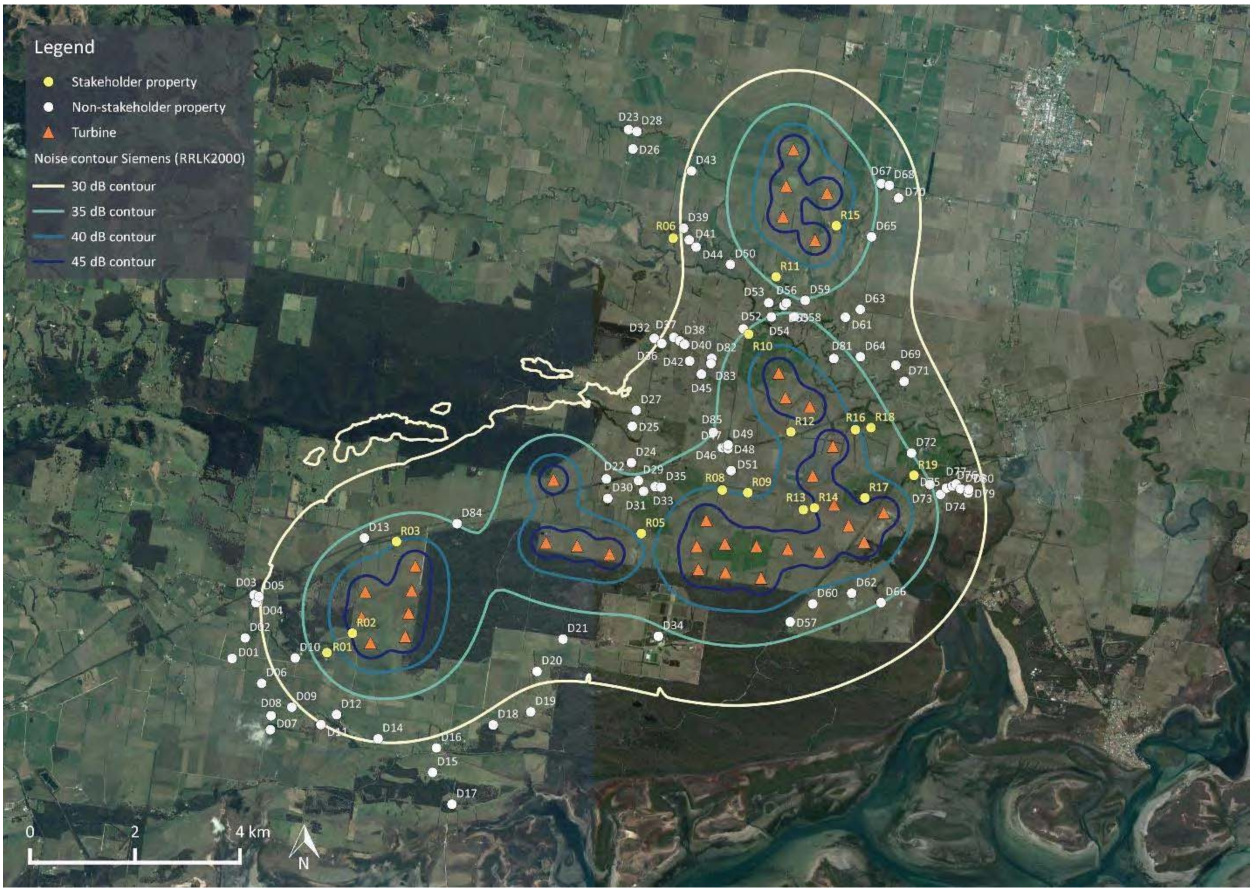
F2 Siemens SWT 3.3-130



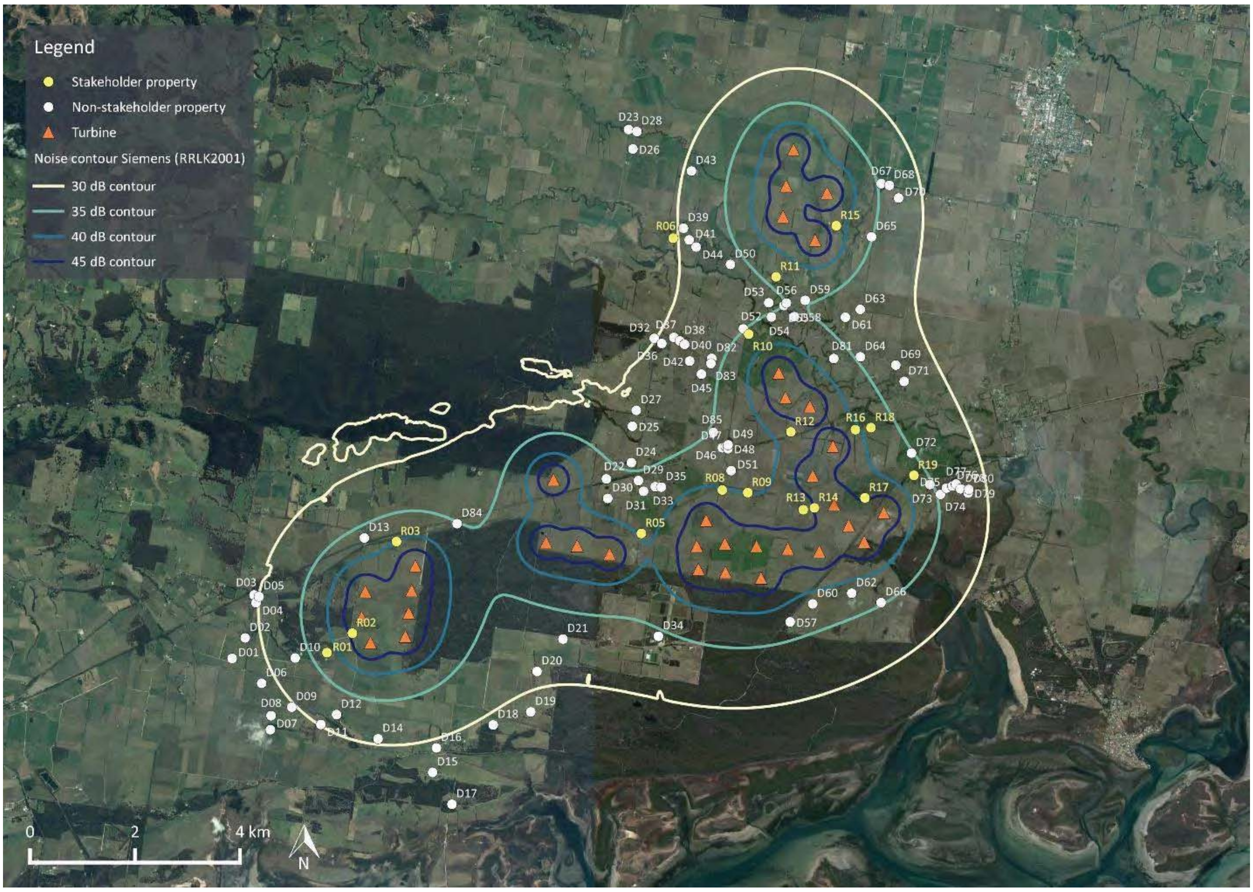
F3 Vestas V136-3.45



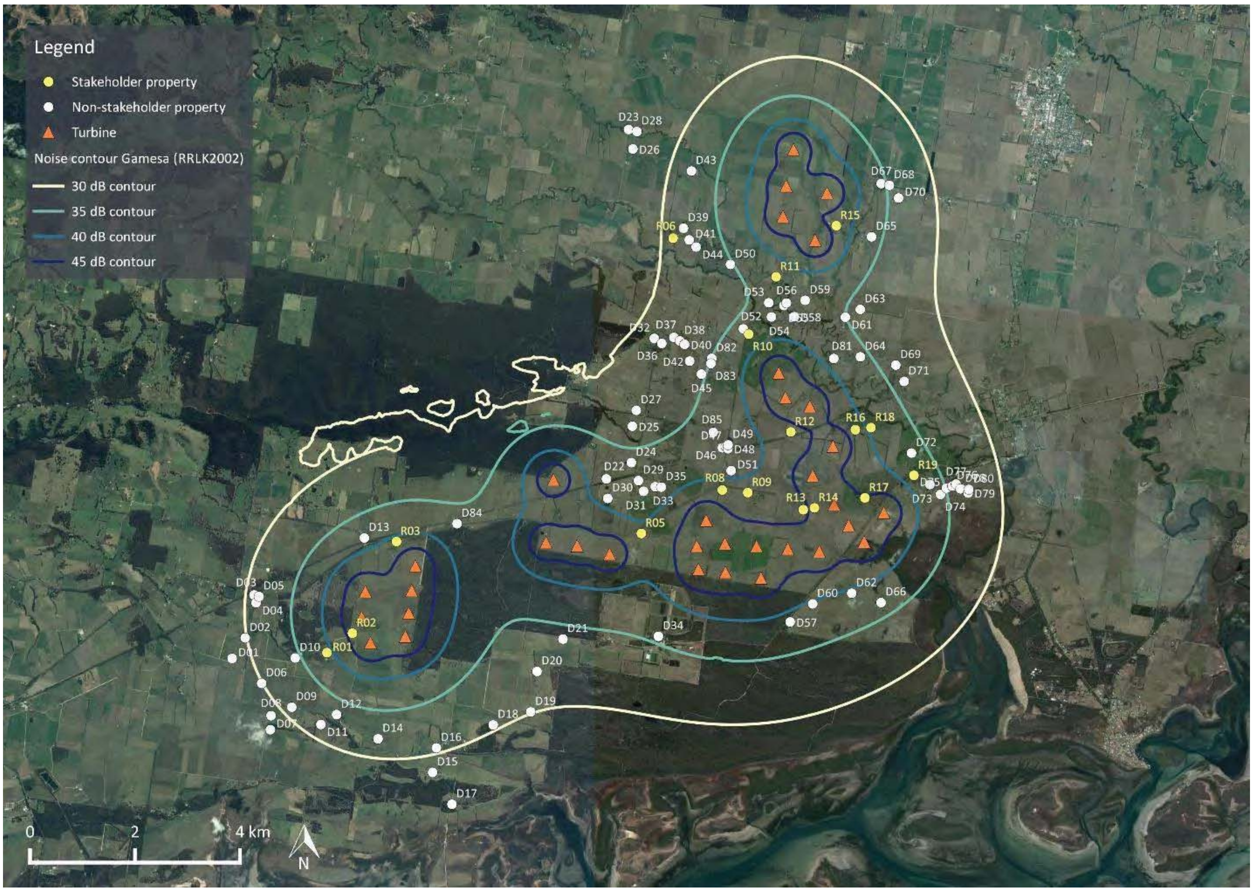
F4 Siemens SWT 3.15-142



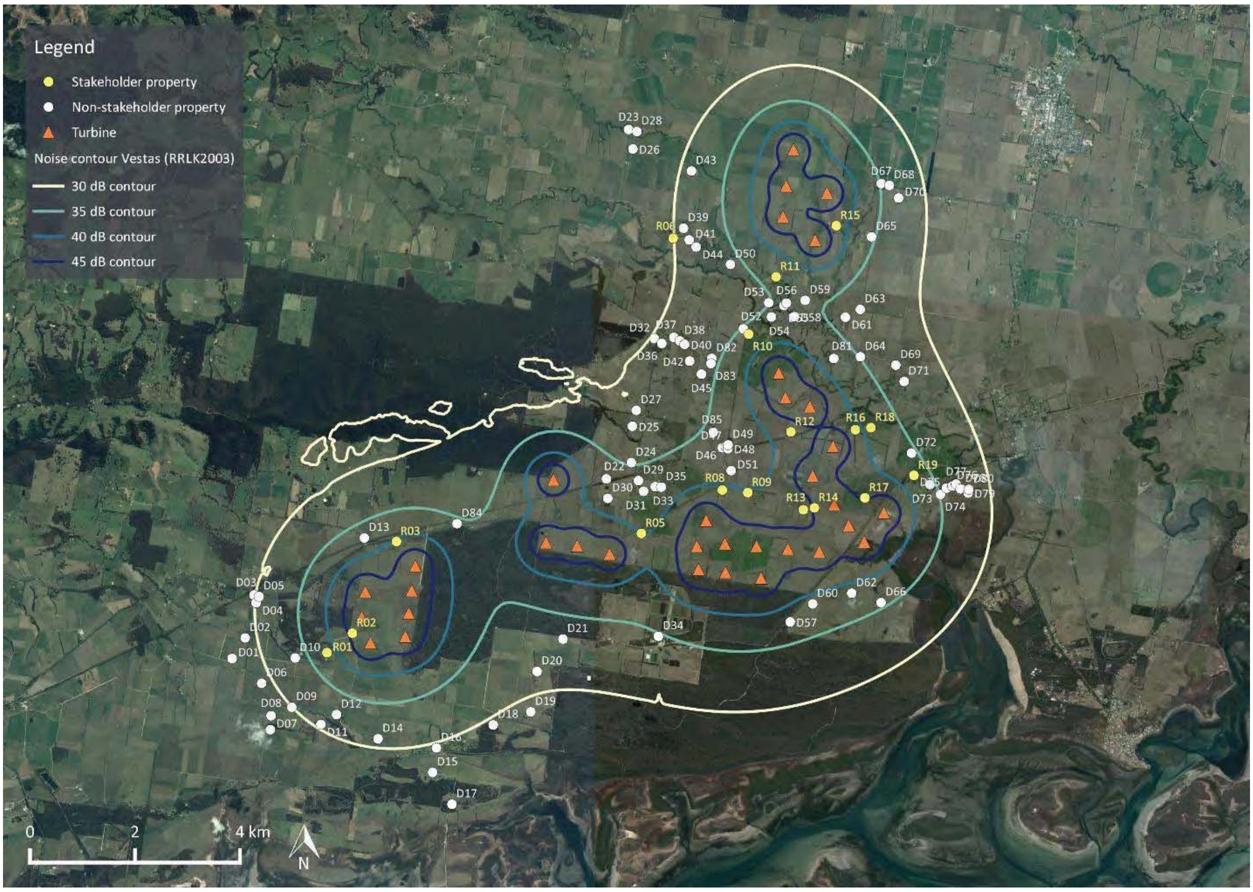
F5 Siemens SWT 3.6-130



F6 Gamesa G132-3.465



F7 Vestas V136-3.6



APPENDIX G DOCUMENTATION

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

(b) Noise sensitive locations: See Section 5.0 and Appendix B

(c) Wind turbine sound power levels, L_{WA} dB (also refer to Section 2.2.2)

Sound power levels (Guaranteed levels + 1dB margin for uncertainty)

Turbine model	Hub height wind speed (m/s)											
	4	5	6	7	8	9	10	11	12	13	14	15
Senvion 3.4M140	96.0	98.2	100.8	103.7	105.0	105.0	104.9	104.7	104.5	104.3	104.2	-
Siemens SWT 3.3-130	92.1	95.3	98.3	101.9	105.2	106.6	107.0	107.0	107.0	107.0	107.0	107.0
Vestas V136-3.45	96.6	96.7	98.8	101.5	104.2	106.3	106.5	106.5	106.5	106.5	106.5	106.5
Siemens SWT-3.15-142	96.4	97.7	101.8	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9
Siemens SWT-3.6-130	93.3	96.3	99.3	103.3	106.6	107.0	107.0	107.0	107.0	107.0	107.0	107.0
Gamesa G132-3.465	-	-	99.2	102.7	106	107.1	107.3	107.1	107.1	107.1	-	-
Vestas V136-3.6	93.5	95.5	98.4	101.5	104.4	106.4	106.5	106.5	106.5	106.5	106.5	106.5

Octave band spectrum adjusted, L_{WA}

Turbine model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	Overall
Senvion 3.4M140*	86.3	93.2	97.4	99.5	99.8	95.9	90.3	81.1	105.0
Siemens SWT 3.3-130	87.6	95.3	97.3	101.4	102.6	98.2	93.4	83.9	107.0
Vestas V136-3.45	94.1	98.3	97.0	99.7	101.0	98.3	92.2	75.4	106.5
Siemens SWT-3.15-142	88.9	95.1	97.2	99.1	99.8	99.4	94.9	82.9	105.9
Siemens SWT-3.6-130	89.2	95.7	96.0	100.0	99.7	101.3	99.0	87.2	107.0
Gamesa G132-3.465	84.6	94.4	100.8	102.6	100.7	96.6	93.3	92.4	107.3
Vestas V136-3.6	89.0	94.4	98.4	100.0	100.9	100.0	92.2	72.6	106.5

* Based on octave band spectral information for the Senvion 3.0M122 turbine

(d) Wind turbine model: See Table 1 of Section 2.2.1

(e) Turbine hub height: See Table 1 of Section 2.2.1

(f) Distance of noise sensitive locations from the wind turbines: See Appendix Tables B2 and B3 of Appendix B

(g) Calculation procedure used: ISO 9613-2:1996 prediction algorithm as implemented in SoundPLAN v7.4 (See Section 7.0 and Appendix E)

(h) Meteorological conditions assumed:

Temperature: 10 °C

Relative humidity: 70 %

Atmospheric pressure: 101.325 kPa

(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 elevation contours provided by the Proponent

(k) Predicted far-field wind farm sound levels: See Table 5 and Table 6 of Section 7.0 and Appendix F.