MARSHALL DAY Acoustics

6 Gipps Street
Collingwood VIC 3066
Australia
T: +613 9416 1855
ABN: 53 470 077 191
www.marshallday.com

21 April 2017

Ryan Corner Development Pty Ltd
Suite 403, 68 York Street
Sydney NSW 2000

Attention: Shaq Mohajerani

Dear Shaq

RYAN CORNER WIND FARM - PROJECT AMENDMENT

The Ryan Corner wind farm received planning approval in 2008.

On 21 August 2008, Planning Permit No. 20060222 was issued for the Ryan Corner Wind Farm for the 'use and development of land for a Wind Energy Facility'. Condition 3 of the permit details the specifications of the wind farm, including the number and scale of the turbines. The permit originally specified the tower height of the wind turbines at 78 metres, with an overall height of 121.5 metres above ground level (AGL).

On 12 August 2010, the Minister for Planning approved a minor amendment to the specifications of the wind turbines for the wind farm to allow a tower height of 80 metres and overall height of 126.3 metres AGL.

In 2013, Marshall Day Acoustics (MDA) was commissioned by Ryan Corner Development Pty Ltd (the Proponent) to prepare a noise impact assessment for the approved wind farm at the request of the Department of Transport, Planning and Local Infrastructure[1]. It was specifically requested that the noise impact assessment be carried out in accordance with NZS 6808:2010[2] and the results of the assessment are detailed in MDA Report No. Rp 004 2010165ML dated 11 September 2013 (MDA 2013 Report)

Approval is now sought by the Proponent to further vary the turbine specifications as detailed on the permit.

The following amendments are proposed:

- Increase of the tower height to 117 metres, the rotor diameter to 130 metres, and overall tip height to 180 metres AGL. This would result in an overall increase in height of up to 53.7 metres from natural ground level
- Micrositing of a number of turbines and realign access tracks
- Reduction in the number of turbines on the Ryan Corner wind farm site from the approved sixty-eight (68) to fifty-six (56).

The Proponent has commissioned MDA to prepare a revised noise assessment for the Ryan Corner Wind Farm , incorporating the proposed amendments, in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010), as required by the Victorian Government's *Policy and planning guidelines for development of wind energy facilities in Victoria* dated January 2016. MDA has prepared a revised noise assessment with the study being detailed in report Rp 001 R02 2014362ML *Ryan Corner Wind Farm - NZS 6808:2010 Noise Assessment* dated 21 April 2017 (MDA 2017 Report).

[1] Now the Department of Environment, Land, Water & Planning

[2] New Zealand Standard 6808:2010 *Acoustics – wind farm noise* (NZS 6808:2010)

The MDA 2013 Report and MDA 2017 Report are appended to this letter in Appendix A and Appendix B respectively.

Full details of the assessment inputs, methodology and outcomes are documented separately in each report.

A summary of the difference in outcomes between the 2013 and 2016 assessments is provided in Table 1 below. In particular, the table compares the highest predicted noise levels of:

- One (1) candidate turbine considered for the MDA 2013 Report
- Three (3) new candidate turbines considered in the MDA 2017 Report.

It is our understanding that the amendment seeks to alter the scale of the approved turbines, as well as minor alterations to the siting and number of turbines, and realigned access tracks.

In order to quantify the potential noise impact of the proposed amendments, a comparison of maximum predicted noise levels is presented herein between the previously approved candidate turbine models and the three (3) new candidate turbines considered in the MDA 2017 Report.

Table 1: Comparison of predicted noise levels, dB

Property	Maximum predicted noise levels (L_{A90}*) from MDA Report 004 2010165ML	Predicted noise levels (L_{A90}*) from MDA Report 001 R02 2014362ML			Maximum difference
		Vestas V126	Senvion 3.0M122	GE 3.2-130	
4 (S)	33.8	34.7	33.1	35.4	+1.6
5 (S)	34.2	34.9	33.3	35.6	+1.4
6	35.6	36.4	34.8	37.1	+1.5
7	37.1	37.9	36.3	38.5	+1.4
8 (S)	40.1	40.4	38.9	41.0	+0.9
9	38.5	39.2	37.7	39.8	+1.3
10	37.4	38.2	36.7	38.8	+1.4
11	38.1	39.4	37.9	40.0	+1.9
24 (S)	34.0	35.3	33.7	36.0	+2.0
25	34.4	35.8	34.2	36.5	+2.1
26	37.3	38.7	37.2	39.4	+2.1
27	37.9	39.2	37.6	39.8	+1.9
28 (S)	39.7	41.0	39.5	41.6	+1.9
29	38.4	39.4	37.9	40.1	+1.7
30 (S)	38.0	38.6	37.0	39.2	+1.2
31	37.3	38.0	36.4	38.6	+1.3
32	36.6	37.4	35.8	38.0	+1.4
33	34.0	34.9	33.3	35.6	+1.6
38	34.0	34.9	33.2	35.5	+1.5
77	36.9	36.0	34.4	36.7	-0.2
78 (S)	42.8	40.8	39.3	41.5	-1.3
79 (S)	42.3	40.1	38.6	40.7	-1.6

* 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*

It can be seen from Table 1 that the proposed amendments are predicted to increase wind farm noise levels by up to 2.1 dB based on the proposed candidate turbine models. It is additionally noted that the MDA 2017 Report concluded the following:

- Compliance with the lowest possible NZS 6808:2010 noise limit is achieved at all wind speeds at all identified noise sensitive locations for two (2) candidate turbine models (Vestas V126 and Senvion 3.0M122)
- Compliance with the lowest possible NZS 6808:2010 noise limit is marginally exceeded at one (1) noise sensitive location by 0.1 dB for the remaining candidate turbine model (GE3.2-130).

  It is our understanding that this turbine model can be operated in noise reduced mode and therefore applying such settings to selected turbines would result in predicted noise levels compliant with the lowest possible NZS 6808:2010 noise limit
- Compliance with the raised ETSU-R-97 noise limit is achieved at all wind speeds at all stakeholder properties for all candidate turbine models
- Compliance with the lowest possible NZS 6808:2010 noise limit is achieved at all wind speeds at all remaining properties in the vicinity of the wind farm for all candidate turbine models

It is understood that the Department of Environment, Land, Water & Planning has also requested for the following information to be provided:

> *Revised noise contour made to show the township of Yambuk*
>
> *Assessment as to whether the township zone falls within the 35dBA contour in the predictive noise assessment, and whether a 'high amenity area noise limit' should apply*

The noise contours showing the highest predicted wind farm noise levels, using the GE 3.2-130 turbine model, presented in Figure E3 of Appendix E of the MDA 2017 Report has been reproduced in Appendix C together with a zoning map[3] of the area surrounding the Yambuk township.

It can be seen from Appendix C that predicted noise levels from the Ryan Corner Wind Farm are below 35 dB L_{A90} within the Township Zone of Yambuk.

Section 6.1 of the MDA 2017 Report also provides the following comment regarding the applicability of the high amenity area noise limit in the vicinity of the Ryan Corner wind Farm:

> *The Moyne Planning Scheme dated 4 July 2016 does not specify the Farming Zone and Township Zone as promoting a higher degree of protection of amenity related to the sound environment.*
>
> *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 considered to be applicable for residential properties in the vicinity of the Ryan Corner Wind Farm.*

We trust this information is satisfactory. If you have any further questions please do not hesitate to contact us.

Yours faithfully

MARSHALL DAY ACOUSTICS PTY LTD

Christophe Delaire

Associate

[3] The zoning map was downloaded from the Department of Environment, Land, Water & Planning *Planning Maps Online* website on 8 August 2016.

APPENDIX A MDA REPORT No. Rp 001 R02 2014362ML

MARSHALL DAY Acoustics

RYAN CORNER WIND FARM
NZS 6808:2010 NOISE ASSESSMENT

Rp 001 R02 2014362ML | 21 April 2017

6 Gipps Street
Collingwood 3066 Victoria Australia
T: +613 9416 1855
A.C.N. 006 675 403
www.marshallday.com

Project: **RYAN CORNER WIND FARM**
NZS 6808:2010 Noise Assessment

Prepared for: **Ryan Corner Development Pty Ltd**
Suite 403, 68 York Street
Sydney NSW 2000

Attention: **Shaq Mohajerani**

Report No.: **001 R02 2014362ML**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Final			1 Dec. 2015	C. Delaire	J. Adcock
Final	R01	Includes consideration for Yambuk township	25 Aug. 2016	C. Delaire	D. Griffin
Final	R02	Added township label on noise contour maps	21 Apr. 2017	C. Delaire	-

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1.0 INTRODUCTION

This report, commissioned by Ryan Corner Development Pty Ltd (the Proponent), details the results of a noise assessment for the Ryan Corner Wind Farm in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise,* which is the guidance document for noise assessment that is referenced in the Victorian Government's *Policy and planning guidelines for development of wind energy facilities in Victoria* dated January 2016.

The assessment is being carried out to inform potential amendments to the project's planning permit regarding the number, size and location of turbines that may be included in the project.

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

2.0 PROJECT DESCRIPTION

2.1 Wind farm layout

The Ryan Corner Wind Farm has been approved for development with planning permit No. 20060222 having been issued on 21 August 2008.

The wind farm is located near the township of Port Fairy, Victoria.

A plan of the proposed fifty-six (56) turbine layout is presented in Appendix B together with coordinates for the wind turbines and nearby residential properties.

2.2 Wind turbines

2.2.1 Turbine type

Three candidate turbine models have been selected for this project as detailed in Table 1 below.

Table 1: WTG manufacturer specifications

Detail	Vestas V126	Senvion 3.0M122	GE 3.2-130
Make	Vestas	Senvion	GE Wind
Model	V126	M122	3.2-130
Rated power (MW)	3.3	3.0	3.2
Rotor Diameter (m)	126	122	130
Hub Height (m)	117	117	110
Overall Tip Height (m)	180	178	175
Orientation	Upwind	Upwind	Upwind
Serrated trailing edge	Yes	No	Yes
Rotor speed (rpm)	5.3-16.5	5.1-11.3	7.6-12.1
Cut-in Wind Speed (hub height, m/s)	3.0	3.0	3.0
Rated Wind Speed (hub height, m/s)	12.0	11.50	12.0
Cut-out Wind Speed (hub height, m/s)	22.5	22.0	25.0
Sound Power L_{WA} at 10 m/s (hub height, dB)	106.5*	105.5**	107.0**
Tonal audibility ($\Delta L_{a,k}$>0 dB)	Up to 0.96 dB	No[+]	No [+]

* Measured sound power level, including a margin to account for the combined uncertainty (See Section 2.2.2)

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

[+] See Section 2.2.3

2.2.2 Sound power levels

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

Table 2: Reference documents

Model	Reference document
Vestas V126	DNV-GL Test Report No. GLGH-4286 14 12099 293-A-0005-A Vestas V126-3.3MW IEC3A, mode 0, V201503 Results of acoustic noise measurements according to IEC 612400-11 Edition 3 dated 5 November 2014 (Vestas Test Report)
Senvion 3.0M122	Senvion document No. SD-3.5-WT.PC.00-A-D-EN Power Curve & Sound Power Level 3.0M122 [50Hz] dated 20 January 2014 (Senvion Document)
GE 3.2-130	GE Power & Water Product Acoustic Specifications - Normal Operation according to IEC Incl. Octave Band Spectra and 1/3rd Octave Band Spectra (GE Specification)

For each of the candidate turbines, the sound power level values used for this assessment have been derived from the above documents as follows:

- Vestas V126: Measured sound power levels including a margin to account for the combined uncertainty, as detailed in the Vestas Test Report
- Senvion 3.0M122: Guaranteed sound power level, including a 1 dB margin to account for uncertainties
- GE 3.2-130: Guaranteed sound power level, including a 1 dB margin to account for uncertainties

The profile of A-weighted sound power levels as a function of hub height wind speed is presented in Figure 1, for each of the candidate turbine models.

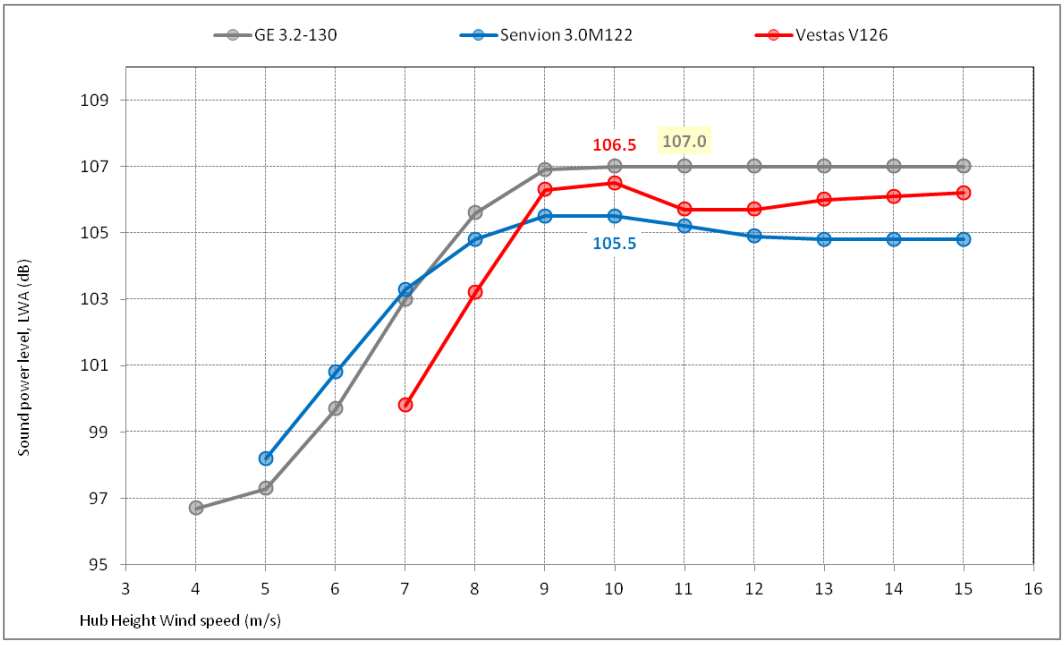


Figure 1: Guaranteed sound power level vs. hub height wind speed

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

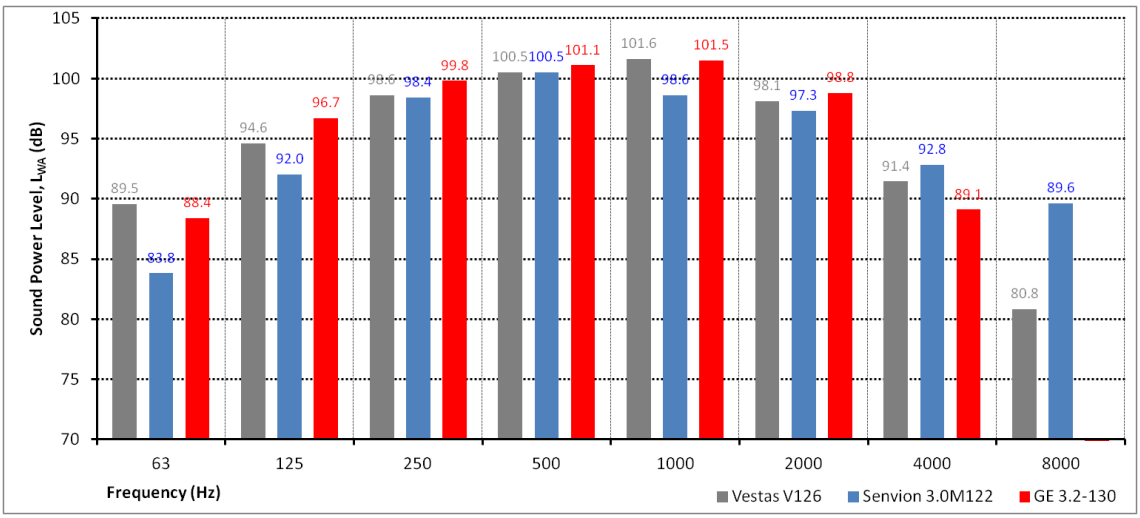


Figure 2: A-weighted octave band sound power level spectra

Tabular values are also presented in Appendix F.

2.2.3 Tonality

For each of the candidate turbines, tonal audibility values (ΔLa,k) are specified in the reference documents as follows:

- Vestas V126: The Vestas Test Report presents values of tonal audibility up to 0.96 dB at the hub height wind speed of 6.5 m/s
- Senvion 3.0M122: Senvion SE warrants tonal audibility $\Delta L_{a,k} < 0$ dB (for wind speed at 10m AGL above 6 m/s)
- GE 3.2-130: Test report No. SE14009B2 prepared by Wintest Grevenbroich GmbH for GE Wind Energy GmbH and dated 10 July 2014 presents a summary of results from sound power level testing of GE 2.5-120 turbines in accordance with IEC 61400-11[1], including tonal audibility values below 0 dB at all measured wind speeds. We have been advised that the GE 3.2-130 is the latest evolution of the same turbine platform and therefore tonal audibility values for the GE 2.5-120 may be used to inform he potential for tonality for the GE 3.2-130 turbine model.

Notwithstanding the above, we envisage that the procurement contract for the site would stipulate that the turbines 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 properties

One-hundred and eleven (111) residential properties have been identified by the Proponent in the vicinity of the proposed wind farm, of which nine (9) are stakeholders. These properties are presented in presented in Appendix B.

[1] IEC 61400-11 *Wind turbines - Part 11: Acoustic noise measurement techniques*

3.0 NOISE CRITERIA

At the time of approval of the Ryan Corner Wind Farm, wind farm noise impact was assessed in accordance the New Zealand Standard 6808:1998 *Acoustics – The assessment and measurement of sound from wind turbine generators* (NZS 6808:1998). Condition 18 of the planning permit requires that compliance with the NZS 6808:1998 criteria be achieved at *any dwelling existing on land in the vicinity of the proposed wind energy facility as at 11 April 2007*.

The current noise assessment is being carried out to inform potential amendments to the project's planning permit regarding the number, size and location of turbines that may be included in the project. New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) has therefore been referenced for this assessment as it is the guidance document that is currently 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 discussed 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, generally consistent with the planning permit requirements, 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 forwarding comments of NZS 6808:2010 note 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} 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.*

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.

Section 5.3 of NZS 6808:2010 provides details of high amenity noise limits, requiring that where a residential property is deemed to be located within a high amenity area as defined in Sections 5.3.1 and 5.3.2 of NZS 6808:2010, wind farm noise levels (L_{A90}) during evening and nigh-time periods should not exceed the background noise level (L_{A90}) by more than 5 dB or 35 dB L_{A90}, whichever is the greater, for wind speeds below 6 m/s at hub height. High amenity noise limits are not applicable during the daytime period.

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 +6 dB to the measured level at the noise sensitive location.*

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

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

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 IEC61400-11.

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[2] are carried out for all identified residential properties 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

The background noise surveys allow quantification of the existing ambient noise environment around the proposed site. 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 carried out any background noise monitoring that may be required, applicable limits for 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.

5.0 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 where predicted wind farm noise levels exceed 35 dB L_{A90}.

As stakeholder properties 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.

[2] See Section 7.0

5.1 Preliminary noise predictions

Preliminary noise predictions have been undertaken at the one hundred and eleven (111) residential properties identified by the Proponenet in the vicinity of the Ryan Corner Wind Farm using the noise prediction methodology detailed in Section 7.0.

Preliminary noise predictions corresponding to the highest sound power levels for each candidate turbine model (as detailed in Section 2.2.2) are presented in Table 3. Only properties where predicted levels exceed 35 dB L_{A90} for any for the three (3) candidate turbine models are presented.

Table 3: Preliminary noise predictions, L_{A90} dB

House	Vestas V126	Senvion 3.0M122	GE 3.2-130
4 (S)	35	33	35
5 (S)	35	33	36
6	36	35	37
7	38	36	39
8 (S)	40	39	41
9	39	38	40
10	38	37	39
11	39	38	40
24 (S)	35	34	36
25	36	34	37
26	39	37	39
27	39	38	40
28 (S)	41	40	42
29	39	38	40
30 (S)	39	37	39
31	38	36	39
32	37	36	38
33	35	33	36
38	35	33	36
77	36	34	37
78 (S)	41	39	42
79 (S)	40	39	41

(S) Stakeholder property

It can be seen from Table 3 that predicted noise levels at twenty-two (22) of the identified residential properties in the vicinity of the proposed wind farm are above 35 dB L_{A90}, including eight (8) of the stakeholder properties, based on the candidate turbine model providing the highest noise levels.

Fourteen (14) properties are therefore considered as noise sensitive locations in accordance with NZS 6808:2010.

5.2 Background noise monitoring

Background noise monitoring was undertaken in March 2006 at five (5) properties. Results of this survey are presented in MDA Report No. 2005034 R2 dated 5 June 2006 together with the relevant noise limits derived in accordance with NZS 6808:1998, applicable at the time of the assessment.

6.0 NOISE LIMITS

6.1 High amenity areas

A discussion of high amenity area limits and their application to Victorian wind farms is provided in Appendix C. As detailed in the appendix, the area surrounding the proposed Ryan Corner Wind Farm is generally zoned Farming Zone with a Township Zone covering the township of Yambuk, to the south west.

The Moyne Planning Scheme dated 4 July 2016 does not specify the Farming Zone and Township Zone as promoting a higher degree of protection of amenity related to the sound environment.

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 considered to be applicable for residential properties in the vicinity of the Ryan Corner Wind Farm.

6.2 Stakeholder property

The definition given in NZS 6808:2010 of noise sensitive locations specifically excludes dwellings within the wind farm site boundary. For these properties, 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

The noise limits detailed in MDA Report No. 2005034 R2 were derived in accordance with the 1998 version of NZS 6808 using background noise levels collected in 2006.

For the purpose of this assessment, 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 properties.

7.0 NOISE PREDICTIONS

Noise from the Ryan Corner 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 2.2.2.

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 63Hz to 8kHz and each wind turbine has been modelled as a point source at hub height. All noise predictions use a receiver height of 1.5m AGL. Possible screening effects from the landscape are considered using 10m elevation contour information provided by the proponent. 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. 50% soft ground (G=0.5) has been used in the predictions.

Further details regarding the use of ISO 9613-2 for wind farm nose predictions and the use of G=0.5 is presented in Appendix D.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. In the case of wind farm layout design however, 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 below are reported to one decimal place.

Noise levels from the Ryan Corner Wind Farm predicted at all noise sensitive locations are presented in Table 4 to Table 6 for each of the candidate turbine models, based on the highest sound power level presented in Section 2.2.2.

Predicted noise levels are compared with the baseline NZS 6808:2010 noise limit of 40 dB L_{A90}.

Table 4: Predicted noise from the Ryan Corner Wind Farm – Vestas V126, dB

House	L_{A90}	Compliance with applicable noise limits?	House	L_{A90}	Compliance with applicable noise limits?
4 (S)	34.7	✓	27	39.2	✓
5 (S)	34.9	✓	28 (S)	41.0	✓
6	36.4	✓	29	39.4	✓
7	37.9	✓	30 (S)	38.6	✓
8 (S)	40.4	✓	31	38.0	✓
9	39.2	✓	32	37.4	✓
10	38.2	✓	33	34.9	✓
11	39.4	✓	38	34.9	✓
24 (S)	35.3	✓	77	36.0	✓
25	35.8	✓	78 (S)	40.8	✓
26	38.7	✓	79 (S)	40.1	✓

(S) Stakeholder

Table 5: Predicted noise from the Ryan Corner Wind Farm – Senvion 3.0M122, dB

House	L_{A90}	Compliance with applicable noise limits?	House	L_{A90}	Compliance with applicable noise limits?
4 (S)	33.1	✓	27	37.6	✓
5 (S)	33.3	✓	28 (S)	39.5	✓
6	34.8	✓	29	37.9	✓
7	36.3	✓	30 (S)	37.0	✓
8 (S)	38.9	✓	31	36.4	✓
9	37.7	✓	32	35.8	✓
10	36.7	✓	33	33.3	✓
11	37.9	✓	38	33.2	✓
24 (S)	33.7	✓	77	34.4	✓
25	34.2	✓	78 (S)	39.3	✓
26	37.2	✓	79 (S)	38.6	✓

(S) Stakeholder

Table 6: Predicted noise from the Ryan Corner Wind Farm – GE3.2-130, dB

House	L_{A90}	Compliance with applicable noise limits?	House	L_{A90}	Compliance with applicable noise limits?
4 (S)	35.4	✓	27	39.8	✓
5 (S)	35.6	✓	28 (S)	41.6	✓
6	37.1	✓	29	40.1	×
7	38.5	✓	30 (S)	39.2	✓
8 (S)	41.0	✓	31	38.6	✓
9	39.8	✓	32	38.0	✓
10	38.8	✓	33	35.6	✓
11	40.0	✓	38	35.5	✓
24 (S)	36.0	✓	77	36.7	✓
25	36.5	✓	78 (S)	41.5	✓
26	39.4	✓	79 (S)	40.7	✓

(S) Stakeholder

It can be seen from Table 4 that predicted noise levels from the Ryan Corner wind farm comply with the applicable NZS 68080:2010 limit at all noise sensitive locations for two (2) candidate turbine models (Vestas V126 and Senvion 3.0M122).

For the GE3.2-130, predicted noise levels marginally exceed the applicable NZS 68080:2010 noise limit at one (1) noise sensitive location by 0.1 dB.

It is our understanding that this turbine model can be operated in noise reduced mode and therefore applying such settings to selected turbines would result in predicted noise levels compliant with the lowest possible NZS 6808:2010 noise limit

Predicted noise levels at all stakeholder properties comply with the recommended ETSU-R-97 noise limit for all candidate turbine models.

Wind farm noise at all residential properties further from the wind farm will be lower than 35 dB L_{A90} and therefore also comply with the lowest possible NZS 6808:2010 noise limit at all wind speeds.

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

If the turbine selection and/or layout are to be changed, compliance with the relevant noise limit will need to be reassessed.

7.1 Special audible characteristics

Based on the available tonal audibility information discussed in Section 2.2.3, a penalty for tonality has not been applied for any of the assessed wind speeds.

Notwithstanding the above, it is recommended that the procurement contract for the site should stipulate that the turbines must not produce emissions which would attract a penalty when assessed in accordance with the relevant noise criteria and any associated conditions of consent.

8.0 CONCLUSION

The Ryan Corner Wind Farm is proposed to consist of up to fifty-six (56) turbines.

An assessment has been undertaken, using three (3) candidate turbine models with a hub height of up to 117m, in accordance with NZS 6808:2010 as required by the current Victorian Guidelines at one-hundred and eleven (111) residential properties identified by the Proponent in the vicinity of the project.

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 properties identified as noise sensitive locations in accordance with NZS 6808:2010. Review of land zoning surrounding the proposed site indicates that high amenity noise limits are not applicable.

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:

- Compliance with the lowest possible NZS 6808:2010 noise limit is achieved at all wind speeds at all identified noise sensitive locations for two (2) candidate turbine models (Vestas V126 and Senvion 3.0M122)
- Compliance with the lowest possible NZS 6808:2010 noise limit is marginally exceeded at one (1) noise sensitive location by 0.1 dB for the remaining candidate turbine model (GE3.2-130)

  It is our understanding that this turbine model can be operated in noise reduced mode and therefore applying such settings to selected turbines would result in predicted noise levels compliant with the lowest possible NZS 6808:2010 noise limit
- Compliance with the raised ETSU-R-97 noise limit is achieved at all wind speeds at all stakeholder properties for all candidate turbine models
- Compliance with the lowest possible NZS 6808:2010 noise limit is achieved at all wind speeds at all remaining properties in the vicinity of the wind farm for all candidate turbine models

If the turbine selection and/or layout are to be changed, compliance with the relevant noise limit will need to be reassessed.

9.0 SUMMARY OF PARAMETERS

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

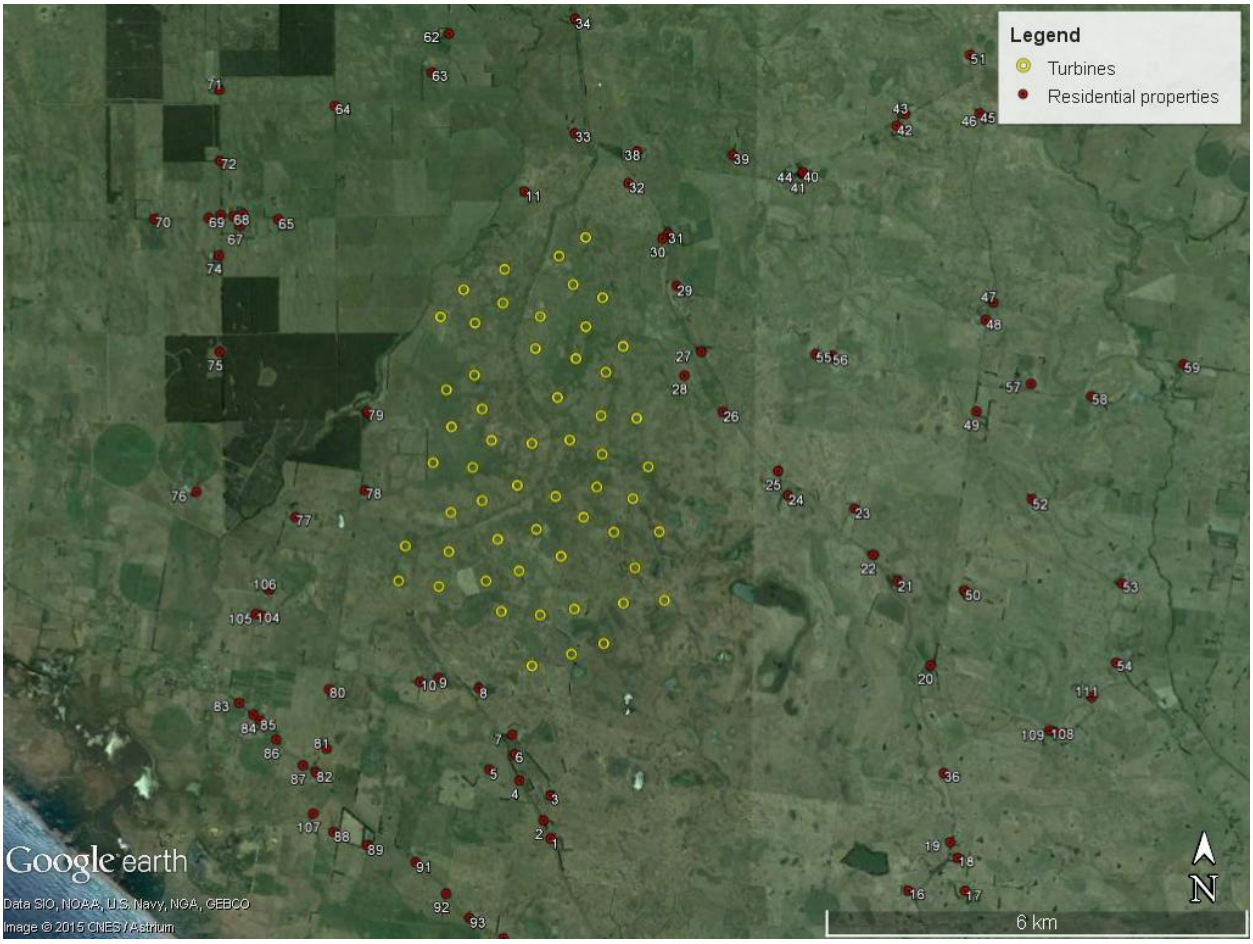
APPENDIX A GLOSSARY OF TERMINOLOGY

Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
dB	Decibel. The unit of sound level.
Frequency	Sound can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals. Sound is generally described over the frequency range from 63Hz to 8000Hz (8kHz). This is roughly equal to the range of frequencies on a piano.
Octave band	Sound, which can occur over a range of frequencies, may be divided into octave bands for analysis. The audible frequency range is generally divided into eight (8) octave bands. The octave band frequencies are 63Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, 4kHz and 8kHz.

Noise is often not steady. Traffic noise, music noise and the barking of dogs are all examples of noises that vary over time. When such noises are measured, the noise level can be expressed as an average level, or as a statistical measure, such as the level exceeded for 90% of the time.

L_{A90}	The A-weighted noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
L_{Aeq}	The A-weighted equivalent continuous sound level. This is commonly referred to as the average noise level.

APPENDIX B RYAN CORNER WIND FARM LAYOUT



B1 Turbine coordinates (AGD66 Zone 54)

Turbine	Easting	Northing	Turbine	Easting	Northing	Turbine	Easting	Northing
B6	598757	5758884	B30	598310	5761771	B52	596999	5762670
B8	599580	5759399	B31	599170	5762065	B54	596538	5762502
B9	599046	5759421	B32	598757	5762109	B55	597162	5762223
B10	597757	5758672	B33	598794	5762791	B58	596563	5762043
B13	597858	5759298	B34	598143	5762373	B59	597195	5761778
B14	597305	5759354	B35	599017	5763152	B60	597771	5761728
B15	597523	5759851	B36	598332	5762921	B62	596360	5761472
B16	597291	5760468	B37	597836	5763071	B63	596923	5761397
B17	597818	5760511	B38	598479	5763372	B64	597556	5761138
B18	598232	5760192	B39	597911	5763523	B66	596605	5760859
B20	599229	5760008	B40	598734	5763844	B67	597053	5760926
B21	599568	5760455	B41	598302	5763921	B69	595952	5760279
B22	598922	5760458	B43	598516	5764577	B70	595849	5759805
B23	598493	5760673	B44	598133	5764316	B72	596522	5760128
B24	599196	5760931	B45	597353	5764138	B73	597094	5759789

Turbine	Easting	Northing	Turbine	Easting	Northing	Turbine	Easting	Northing
B25	598687	5761099	B46	596825	5763915	B74	596421	5759720
B26	598099	5760974	B47	597384	5763720	B75	598345	5759377
B28	599422	5761378	B48	596493	5763534	B76	598296	5758739
B29	598768	5761513	B49	597048	5763375			

B2 Dwellings coordinates (AGD66 Zone 54)

Property	Easting	Northing	Distance to nearest turbine (m)	Property	Easting	Northing	Distance to nearest turbine (m)
1	597975	5756143	2541	57	604892	5762497	5584
2	597878	5756402	2276	58	605747	5762311	6394
3	597981	5756747	1941	59	607068	5762746	7768
4 (S)	597543	5756971	1718	60	597138	5768213	3890
5 (S)	597114	5757134	1671	61	596888	5768507	4255
6	597484	5757347	1357	62	596668	5767554	3486
7	597445	5757618	1105	63	596419	5767007	3019
8 (S)	596985	5758281	872	64	595034	5766551	3189
9	596409	5758436	1288	65	594208	5764955	2692
10	596143	5758383	1370	66	593706	5765039	3169
11	597717	5765306	1079	67	593665	5764869	3129
12	604630	5753104	8071	68	593571	5765006	3273
13	603817	5753670	7126	69	593218	5764987	3584
14	603420	5754084	6558	70	592447	5764982	4298
15	603370	5754550	6155	71	593393	5766801	4486
16	603058	5755340	5346	72	593391	5765794	3839
17	603865	5755329	5911	73	593389	5765028	3446
18	603766	5755796	5524	74	593355	5764456	3272
19	603660	5756021	5298	75	593354	5763088	3172
20	603411	5758532	3929	76	592993	5761115	3077
21	602957	5759722	3394	77	594399	5760739	1623
22	602613	5760102	3067	78 (S)	595399	5761105	999
23	602358	5760760	2809	79 (S)	595442	5762217	1138
24 (S)	601413	5760961	1917	80	594850	5758295	1814
25	601277	5761304	1860	81	594802	5757453	2577
26	600505	5762154	1337	82	594649	5757124	2939
27	600206	5763008	1202	83	593568	5758118	2839
28 (S)	599961	5762673	1004	84	593765	5757948	2794
29	599864	5763944	1140	85	593857	5757869	2780
30 (S)	599672	5764614	1161	86	594088	5757591	2831
31	599747	5764685	1241	87	594465	5757221	2933

Property	Easting	Northing	Distance to nearest turbine (m)	Property	Easting	Northing	Distance to nearest turbine (m)
32	599198	5765407	1080	88	594886	5756274	3662
33	598442	5766120	1548	89	595363	5756082	3529
34	598464	5767743	3168	91	596050	5755830	3317
35	598304	5768202	3633	92	596476	5755382	3532
36	603583	5756999	4669	93	596806	5755033	3763
37	598335	5768563	3992	94	597289	5754740	3961
38	599327	5765854	1517	95	597115	5753882	4834
39	600689	5765783	2488	96	598847	5754153	4620
40	601682	5765530	3308	97	599056	5754284	4520
41	601688	5765503	3306	98	599934	5753384	5601
42	603023	5766174	4783	99	600495	5753780	5393
43	603149	5766336	4957	100	600296	5753102	5982
44	601673	5765507	3293	101	600296	5753102	5982
45	604208	5766335	5958	102	600554	5752786	6358
46	604305	5766271	6033	103	600486	5752655	6466
47	604371	5763651	5378	104	593815	5759371	2083
48	604258	5763410	5247	105 (S)	593906	5759353	1998
49	604108	5762116	4745	106	594013	5759713	1841
50	603909	5759583	4334	107	594600	5756537	3500
51	604080	5767164	6137	108	605095	5757584	5807
52	604884	5760860	5333	109	605164	5757571	5877
53	606155	5759651	6581	110	605306	5757550	6018
54	606057	5758536	6535	111	605699	5758051	6267
55	601828	5762954	2805	112	605285	5751821	9486
56	602065	5762934	3025				

(S) Stakeholder property

APPENDIX C HIGH AMENITY AREA NOISE LIMITS

C1 NZS 6808:2010 requirements

The concept of a high amenity area was introduced in the 2010 version of NZS 6808. Section 5.3 of NZS 6808:2010 provides details of high amenity noise limits, requiring that where a noise sensitive location is situated within a high amenity area, as defined in Sections 5.3.1 and 5.3.2 of NZS 6808:2010, wind farm noise levels (L_{A90}) during evening and nigh-time periods should not exceed the background noise level (L_{A90}) by more than 5 dB or 35 dB L_{A90}, whichever is the greater, for wind speeds below 6 m/s at hub height. High amenity noise limits are not applicable during the daytime period.

Section 5.3 of NZS 6808:2010 states that:

> *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…*

Subsequent to this, Section C5.3.1 of the Standard provides a calculation procedure for evaluating whether relevant background noise levels for a potential high amenity area are sufficiently low to confirm the application of a high amenity noise limit.

C2 Victorian requirements

High amenity noise limits are explicitly referenced in the Victorian Guidelines, with Section 5.1.2.a stating 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 area in Victoria, specifically in order to satisfy Section 5.1.2.a of the guidelines. In particular it is unclear whether the Victorian Guidelines intend for an assessment of high amenity area to explicitly include an evaluation using Section C5.3.1 of the Standard or whether an evaluation based on planning legislation only may be appropriate in some cases. Due to this ambiguity, the means of applying the Victoria Guidelines requirements to an assessment of high amenity area for a Victorian wind farm is, to some degree, uncertain.

C3 VCAT Cherry Tree determination

The VCAT determination detailed in the Cherry Tree Wind Farm Pty Ltd v Mitchell Shire Council decision[3], as referenced by the Victorian Guidelines, does however provide some additional context to this issue. 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.* […]

Justification for this 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 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*.

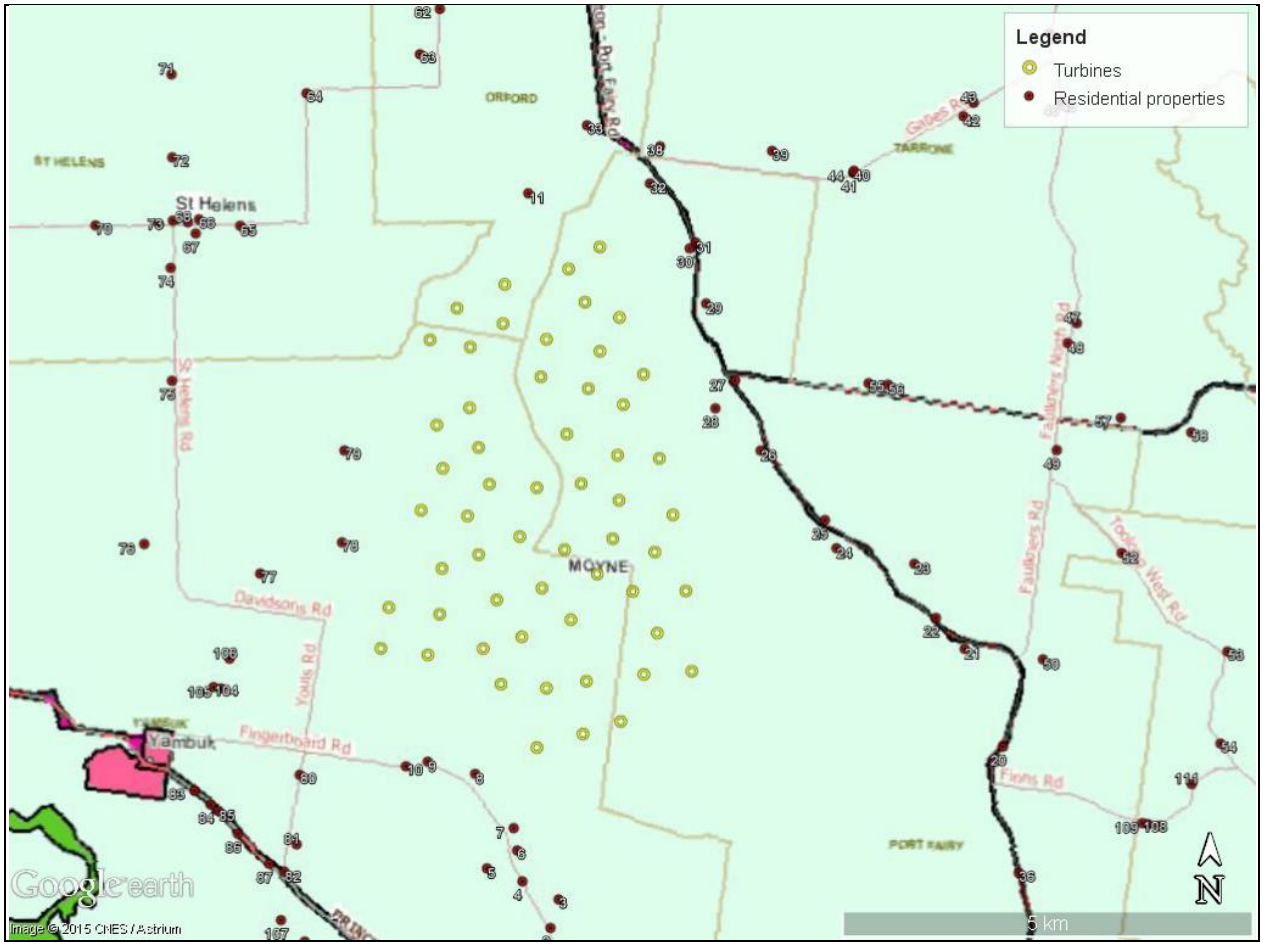
[3] Mitchell Shire Council interim decision dated 4 April 2013 (the Cherry Tree Wind Farm Interim Decision) and Mitchell Shire Council decision dated 27 November 2013 (the Cherry Tree Wind Farm Decision)

C4 Planning considerations

NZS 6808:2010 states that 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.

The area surrounding the proposed Ryan Corner Wind Farm is generally zoned Farming Zone as shown in the planning map in Figure C1, with Yambuk zoned as Township Zone (see Figure C2).

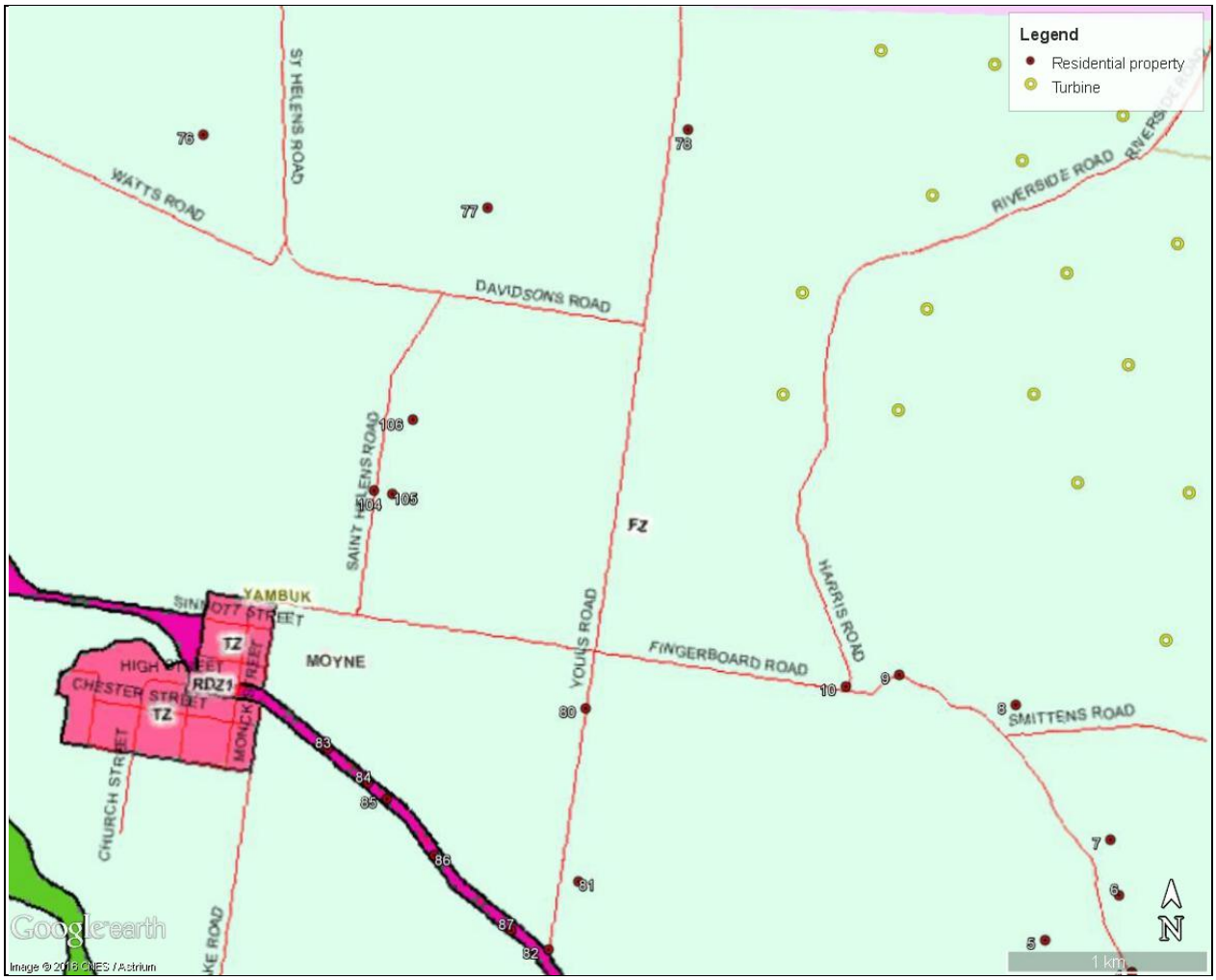
Figure C1: Planning map[4]



Legend: Light green – Farming Zone
Pink – Township Zone

[4] The zoning map was downloaded from the Department of Environment, Land, Water & Planning *Planning Maps Online* website on 21 August 2015.

Figure C2: Planning map (Yambuk township)[5]



Legend: Light green – Farming Zone
Pink – Township Zone

The Moyne Planning Scheme dated 4 July 2016 does not specify the Farming Zone and Township Zone as promoting a higher degree of protection of amenity related to the sound environment.

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 considered to be applicable for residential properties in the vicinity of the Ryan Corner Wind Farm.

[5] The zoning map was downloaded from the Department of Environment, Land, Water & Planning *Planning Maps Online* website on 8 August 2016.

APPENDIX D 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 3m to 11m 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 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 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 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 1.5m 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.

---

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.

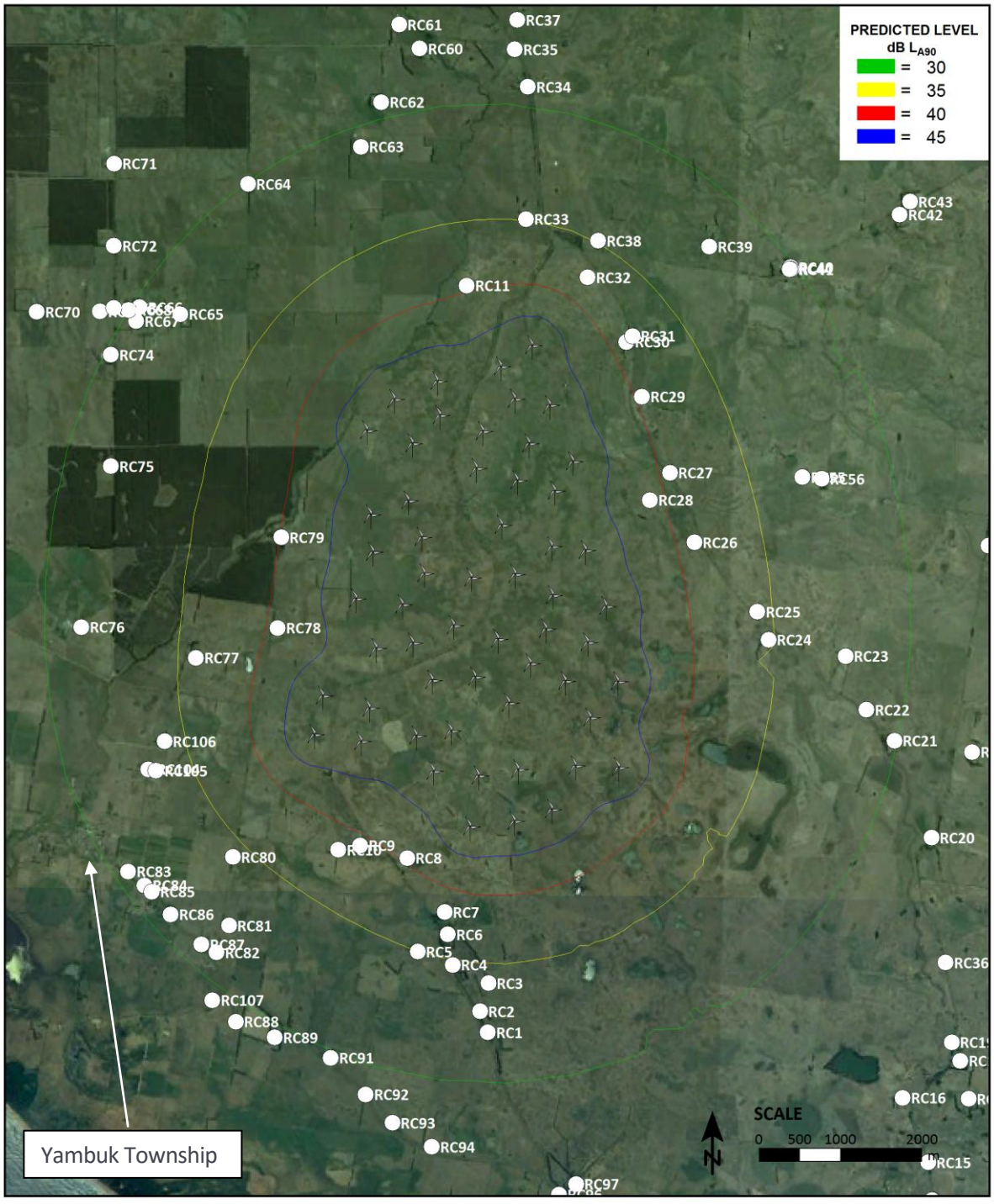
The key findings of these studies demonstrated the suitability of the ISO 9613-2:1996 method to predict the propagation of wind turbine noise for:

- the types of noise source heights associated with a modern wind farm, extending the scope of application of the method beyond the 30m 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 E NOISE CONTOUR MAPS

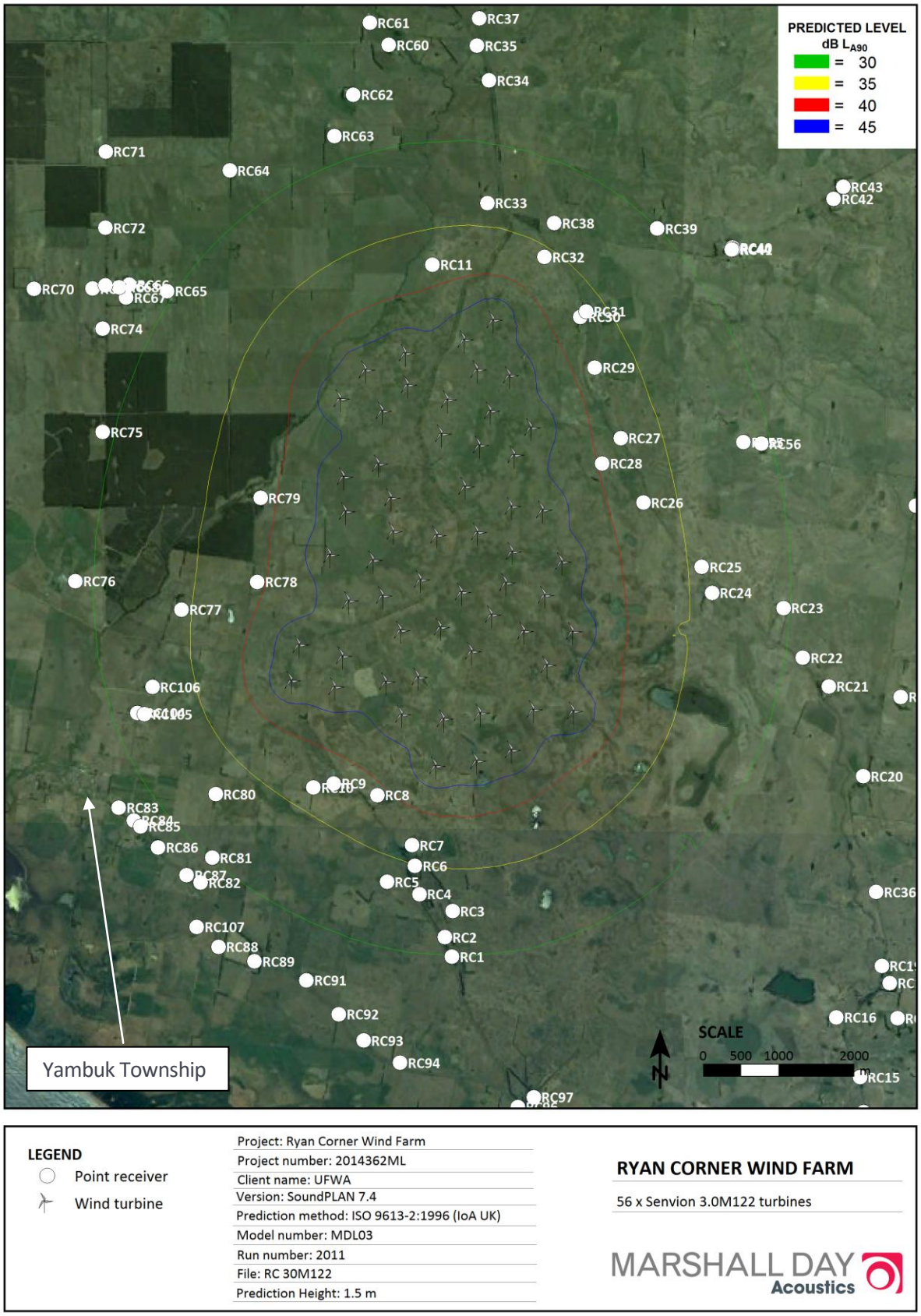
E1 Vestas V126



LEGEND	
○ Point receiver	
Wind turbine	
Project: Ryan Corner Wind Farm	
Project number: 2014362ML	
Client name: UFWA	
Version: SoundPLAN 7.4	
Prediction method: ISO 9613-2:1996 (IoA UK)	
Model number: MDL03	
Run number: 2012	
File: RC V126	
Prediction Height: 1.5 m	
RYAN CORNER WIND FARM	
56 x Vestas V126 turbines	

MARSHALL DAY Acoustics

E2 Senvion 3.0M122



LEGEND

- Point receiver
- Wind turbine

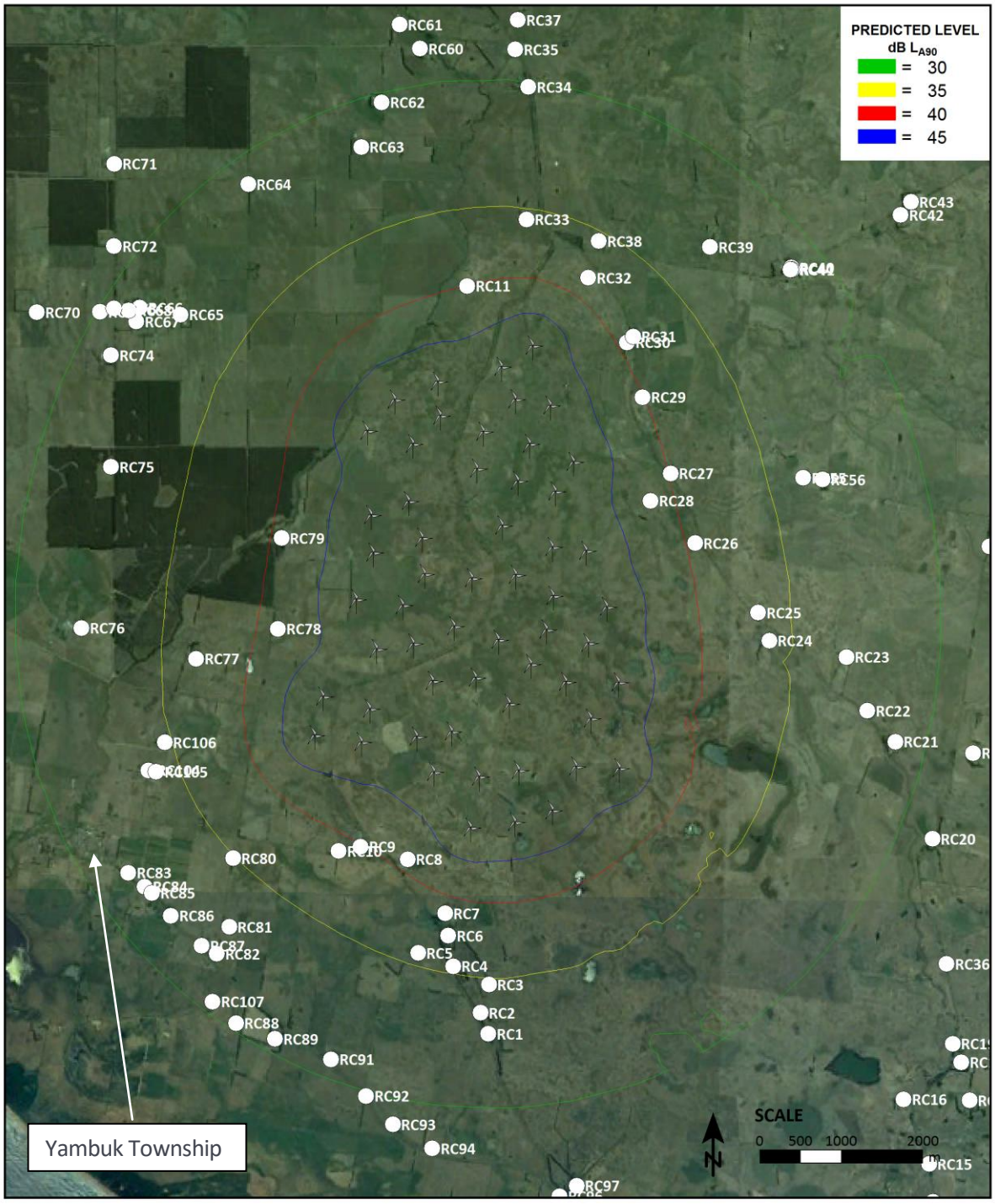
Project: Ryan Corner Wind Farm
Project number: 2014362ML
Client name: UFWA
Version: SoundPLAN 7.4
Prediction method: ISO 9613-2:1996 (IoA UK)
Model number: MDL03
Run number: 2011
File: RC 30M122
Prediction Height: 1.5 m

RYAN CORNER WIND FARM

56 x Senvion 3.0M122 turbines

MARSHALL DAY Acoustics

E3 GE 3.2-130


PREDICTED LEVEL
dB L_{A90}
= 30
= 35
= 40
= 45
RC61
RC37
RC60
RC35
RC34
RC62
RC63
RC71
RC64
RC43
RC42
RC33
RC72
RC38
RC39
RC40
RC11
RC32
RC70
RC65
RC67
RC31
RC74
RC29
RC75
RC27
RC28
RC79
RC26
RC76
RC78
RC25
RC24
RC77
RC23
RC22
RC106
RC21
RC20
RC80
RC8
RC83
RC85
RC86
RC81
RC7
RC6
RC82
RC5
RC4
RC36
RC3
RC107
RC2
RC88
RC1
RC89
RC91
RC92
RC16
RC93
RC94
RC15
RC97
Yambuk Township
SCALE
0 500 1000 2000
N
LEGEND
Point receiver
Wind turbine
Project: Ryan Corner Wind Farm
Project number: 2014362ML
Client name: UFWA
Version: SoundPLAN 7.4
Prediction method: ISO 9613-2:1996 (IoA UK)
Model number: MDL03
Run number: 2010
File: RC GE130
Prediction Height: 1.5 m
RYAN CORNER WIND FARM
56 x GE 3.2-130 turbines
MARSHALL DAY Acoustics

APPENDIX F DOCUMENTATION

F1 Predictions

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

(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 (including a margin for uncertainty)

	Hub height wind speed (m/s)											
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
GE 3.2-130	96.7	97.3	99.7	103.0	105.6	106.9	107.0	107.0	107.0	107.0	107	107
Senvion 3.0M122	-	98.2	100.8	103.3	104.8	105.5	105.5	105.2	104.9	104.8	104.8	104.8
Vestas V126	-	-	-	99.8	103.2	106.3	106.5	105.7	105.7	106.0	106.1	106.2

Reference octave band spectrum

	Octave Band Centre Frequency (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
GE 3.2-130	88.4	96.7	99.8	101.1	101.5	98.8	89.1	66.4
Senvion 3.0M122	83.8	92.0	98.4	100.5	98.6	97.3	92.8	89.6
Vestas V126	89.5	94.6	98.6	100.5	101.6	98.1	91.4	80.8

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

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

(f) Distance of noise sensitive locations from the wind turbines: See Appendix Table B2 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 D)

(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: 10m elevation contours, screening effects in accordance with ISO9613-2:1996 prediction algorithm as detailed in Appendix D

(k) Predicted far-field wind farm sound levels: See Table 4 of Section 7.0

APPENDIX B MDA REPORT No. Rp 004 2010165ML

MARSHALL DAY Acoustics

RYAN CORNER WIND FARM

NZS6808:2010 Noise Impact Assessment

004 2010165ML

11 September 2013

6 Gipps Street
Collingwood 3066 Victoria Australia
T: +613 9416 1855 F: +613 9416 1231
A.C.N. 006 675 403
www.marshallday.com

Project: **RYAN CORNER WIND FARM**
Noise Impact Assessment

Prepared for: **Union Fenosa Wind Australia Pty Ltd**
Suite 4.03, 68 York Street
Sydney NSW 2000

Attention: **Shaq Mohajerani**

Report No.: **004 2010165ML**

Document control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Final	-		11/09/2013	C. Delaire	D. Griffin

TABLE OF CONTENTS

1.0 INTRODUCTION

A planning permit, No. 2006222 (the Planning permit), for the development of the Ryan corner Wind Farm was issued on 21 August 2008. The project proponent, Union Fenosa Wind Australia Pty Ltd (UFWA), was granted Secondary Consent Approval on 12 August 2010 to vary the turbine dimensions in Condition 3 of the Planning permit. This allows the proponent to propose alternative wind turbine models for the project.

To assist with assessment of variation in turbine dimensions, a Consolidated Report (002 R01 2010165ML, titled *Ryan corner Wind Farm - Consolidated Pre-Construction and Noise Impact Assessment Report*) was prepared for the Department of Transport, Planning and Local Infrastructure[1] (DTPLI), and issued 24 January 2012. The Consolidated Report is a standalone summary of noise assessment material presented in reports prepared in 2006 [2] and 2011[3].

The methodologies and assessment presented in the Consolidated Report are consistent with the Planning permit requirements, specifically, prepared in accordance with the New Zealand Standard 6808:1998 – *Acoustics – The assessment and measurement of sound from wind turbine generators* (NZS6808:1998).

Although the Planning permit requires the wind farm to comply with NZS6808:1998, we understand that the DTPLI has requested an informative revised noise impact assessment to be undertaken in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS6808:2010) as required by the current Victorian Government's *Policy and planning guidelines for development of wind energy facilities in Victoria* dated August 2012.

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

1 Known as the Department for Planning and Community Development (DPCD) at the time the report was issued.

2 Report No. 2005034 R3 titled *Ryan Corner Wind Farm - Noise Impact Assessment*, dated 8 June 2006

3 Report No. 002 R03 2009051 titled Ryan Corner *Wind Farm – Revised Wind Turbines Selection*, dated 1 April 2011

2.0 WIND FARM LAYOUT

2.1 Turbine arrangements

The Ryan corner Wind Farm is to be located near the township of Port Fairy, Victoria. The wind farm was originally approved for sixty-eight (68) wind turbines, however the final design will only consist of sixty-seven (67) wind turbines.

A plan of the proposed wind farm is presented in Appendix B together with GPS coordinates for the wind turbines.

UFWA has selected two (2) candidate wind turbine models for the project, as presented in Table 1.

Table 1: Selected wind turbine models

Model	Power output	Hub height	Rotor Diameter
Vestas V90	2.0MW	80m	90m
REpower MM92	2.0MW	80m	92.5m

2.2 Sound power levels

Manufacturer's sound power data specification derived from measurement in accordance with IEC61400-11[4], used for this assessment have been sourced from the documents detailed in Table 2.

Table 2: Reference documents

Model	Sound Power Level	Reference spectrum
Vestas V90	Document No. 0004-6207 V05 *General Specification V90–1.8/2.0 MW 50 Hz VCS* dated 19 November 2010	AECOM report titled *Vestas V90 1.8/2.0 MW – Wind Turbine Sound Power Level* dated 20 August 2013
REpower MM92	REpower document titled *Power Curve & Sound Power Level – REpower MM92 [2050kW] Guaranteed* dated 11 May 2009	WindTest report D-2.9-VM-SM-16-B Rev A-EN dated 18 March 2009

Sound power level data for the Vestas V90 and REpower MM92 turbines are presented in Figure 1.

[4] IEC61400-11 *Wind turbine generator systems – Part 11: Acoustic noise measurement techniques*

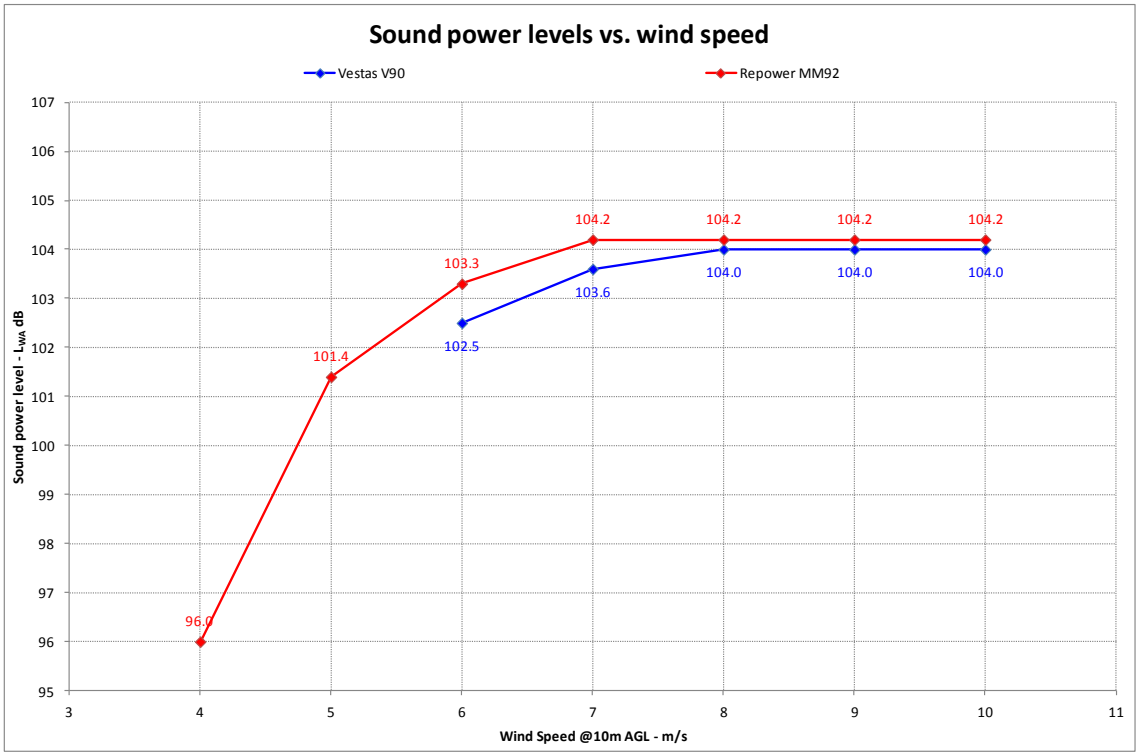


Figure 1: Sound power level data

2.2.1 Reference sound power spectrum

Reference sound power spectrum data adjusted to the highest sound power level presented in Figure 1 Vestas V90 and REpower MM92 turbines are presented in Figure 2.

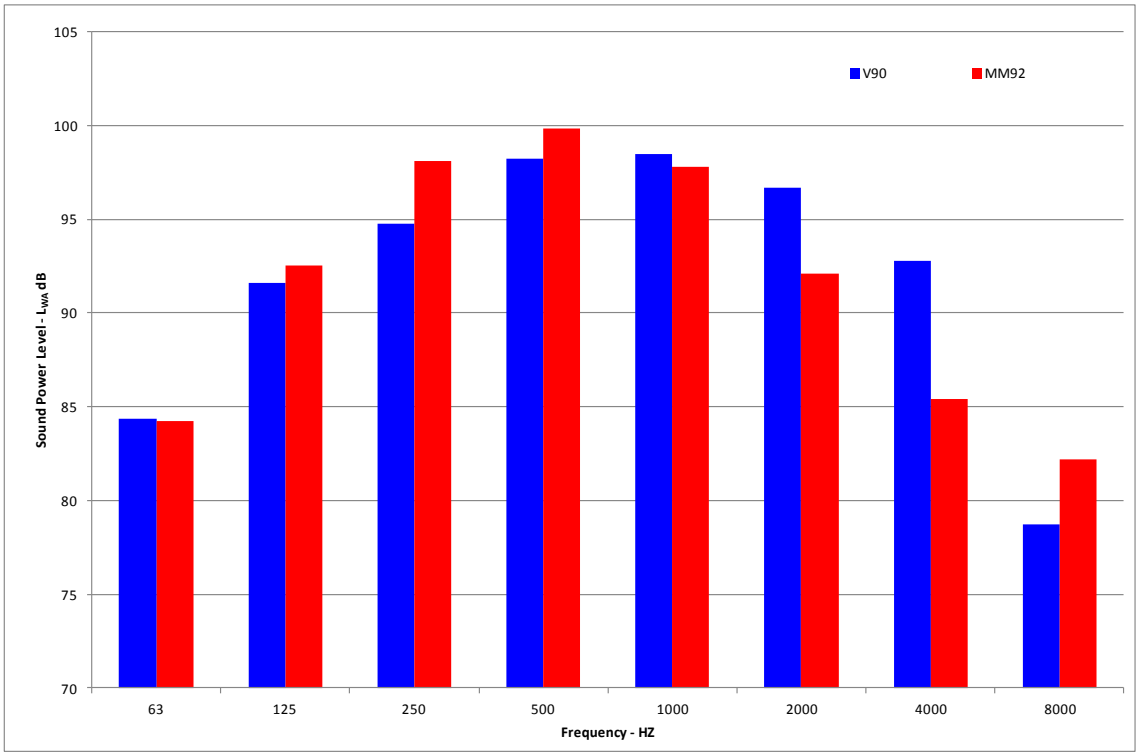


Figure 2: Reference octave band sound power spectrum

2.2.2 Tone audibility

The documents referenced in Table 2 include tonality test results for wind speeds in the range of 6-10m/s referenced at 10m above ground level (AGL)[5]. These results are summarised in Table 3.

Table 3: Summary of test report tonality results

	REpower MM92		Vestas V90	
Wind Speed* m/s	**Tone audibility ($\Delta L_{a,k}$) dB**	**Frequency Hz**	**Tone audibility ($\Delta L_{a,k}$) dB**	**Frequency Hz**
6	<-3	-	-0.6	158
			0.1	592
7	<-3	-	-2.1	166
8	<-3	-	-**	-
9	-2.96	160	-**	-
10	-**	-	-**	-

* at 10m AGL
** no reported value

IEC61400-11:2006 requires the reporting of identified tones where the tonal audibility, $\Delta L_{a,k}$ is higher than or equal to -3.0dB. It is important to note that the reporting requirements of IEC61400-11:2006 do not necessarily reflect the expected levels of audibility or annoyance from the assessed tones. Work by Zwicker and Fastl[6] indicates that:

- $\Delta L_{a,k}$ = -2dB is approximately the audibility threshold for a tone
- $\Delta L_{a,k}$ < 0dB the tone, while perhaps audible, is generally unlikely to cause significant issues

On the basis of the above we consider that, where $\Delta L_{a,k}$ < 0dB, identified tones are unlikely to be problematic at the IEC61400-11:2006 assessment location. Where $\Delta L_{a,k}$ > 0dB, identified tones are potentially audible at the IEC61400-11:2006 sound power test location near the turbine[7].

Audible tones identified during a sound power level testing in close proximity of a wind turbine are not necessarily audible at a neighbouring residential property. If a tone is not deemed audible in close proximity of a turbine (IEC61400-11:2006 assessment location), it is generally unlikely that it would be audible at a neighbouring residential property.

[5] It should be noted that the IEC61400-11:2006 mandatory reporting requirements for the sound power level testing, including tonality assessment, correspond to wind speeds between 6 and 10m/s at 10m AGL
This wind speed range is approximately equivalent to a wind speed range of 8.4-13.9m/s at hub height using the standard IEC61400-11:2006 roughness length of 0.05m.

[6] Fastl, H, Zwicker, E, (2007) Psycho-acoustics, Berlin, Springer

[7] This is consistent with comments from the recently released 3rd version of the IEC61400-11 standard, which states in Section 9.5.8 that a "*tone is audible if the tonal audibility is above 0 dB.*"

The available data for the candidate turbine models indicates the following:

- REpower MM92: the highest reported tone audibility is -2.96dB at 9m/s and therefore it is unlikely that tones would be audible at a receptor location
- Vestas V90: the highest reported tone audibility is 0.1dB at 6m/s in close proximity of the turbine. Although it is marginally over 0dB, it is considered unlikely that tones would be audible at a receptor location.

2.3 Residential properties

Twenty-four (24) residential properties were identified for assessment in the Consolidated Report including seven (7) stakeholder properties that are involved with the project development. These properties are presented in Table 4.

Table 4: Assessable residential properties (AGD66 Z54)

House	Easting	Northing	Distance to nearest turbine (m)
H04 (S)	597543	5756971	1623
H05	597114	5757134	1576
H06	597484	5757347	1261
H07	597445	5757618	1008
H08 (S)	596985	5758281	714
H09	596409	5758436	1059
H10	596143	5758383	1324
H11	597717	5765306	1048
H24 (S)	601413	5760961	1444
H25	601277	5761304	1327
H26	600505	5762154	1216
H27	600206	5763008	1126
H28 (S)	599961	5762673	927
H29	599864	5763944	1078
H30 (S)	599672	5764614	965
H31	599747	5764685	1063
H32	599198	5765407	998
H33	598442	5766120	1494
H38	599327	5765854	1437
H77	594399	5760739	1179
H78 (S)	595399	5761105	556
H79 (S)	595442	5762217	633
H80	594850	5758295	1680
H106	594013	5759713	1356

(S) Stakeholder property

3.0 NOISE LIMIT CRITERIA

Section C1.1 of NZS6808:2010 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.*

The *Outcome Statement* of NZS6808:2010 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 intention, the standard specifies noise criteria which are used to assess wind farm noise.

3.1.1 Noise limit

Section 5.2 *Noise limit* of NZS6808:2010 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 5dB, or a level of 40dB $L_{A90(10\ min)}$, 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 30-35dB.

Compliance with the criteria may result in wind turbine noise being audible at some locations for some of the time. The forwarding comments of NZS 6808:2010 note 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.*

3.1.2 High amenity areas

Section 5.3.1 of NZS6808:2010 states that the baseline noise limit of 40dB L_{A90} detailed above in Section 3.1.1 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.*

The definition of a high amenity area provided in NZS6808:2010 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.

Section 5.3 of NZS6808:2010 provides details of high amenity noise limits, requiring that where a residential property is deemed to be located within a high amenity area as defined in Sections 5.3.1 and 5.3.2 of NZS6808:2010, wind farm noise levels (L_{A90}) during evening and nigh-time periods should not exceed the background noise level (L_{A90}) by more than 5dB or 35dB L_{A90}, whichever is the greater, for wind speeds below 6m/s at hub height. High amenity noise limits are not applicable during the daytime period.

3.1.3 Special audible characteristics

Section 5.4.2 of NZS6808:2010 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 properties while concurrently noting in Section 5.4.1 that:

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

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 IEC61400-11.

4.0 NOISE ASSESSMENT METHODOLOGY

There are several key stages involved in a noise assessment undertaken in accordance with NZS6808:2010.

Firstly, preliminary wind farm noise predictions are carried out for all identified residential properties 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 35dB L_{A90}
- Identification of selected *noise sensitive locations* where background noise monitoring should be undertaken

The background noise surveys allow quantification of the existing ambient noise environment around the proposed site. Section 7.1.4 of NZS6808:2010 notes the following:

> *If there are no noise sensitive locations within the 35dB $L_{A90(10\ min)}$ predicted wind farm sound level contour then background sound level measurements are not required.*

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

Where required, alteration of the turbine layout or a noise management plan can be considered to achieve compliance with noise limits.

5.0 NOISE SENSITIVE LOCATIONS

NZS6808:2010 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 include residential dwellings, schools and hotels located outside the wind farm site where predicted wind farm noise levels exceed 35dB L_{A90}.

As stakeholder properties are located within the wind farm site, they are not considered as noise sensitive locations as part of an assessment in accordance with NZS6808:2010. However, they have been considered as part of this assessment for informative purpose.

The eleven (11) identified noise sensitive locations are detailed in Table 5 of Section 7.0. All of these locations were considered in the Consolidated Report.

6.0 NOISE LIMITS

6.1 High amenity areas

The area surrounding the proposed wind farm is zoned Farming Zone (FZ) as 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 regarding farming zones:

> *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, it is our understanding that the high amenity noise limit is not generally applicable for residential properties located within a Farming Zone. On this basis, the high amenity noise limit has not been applied in this assessment.

6.2 Assessment noise limits

Noise limits applicable for this project have previously been determined in accordance with NZS6808:1998, as required by the Planning permit. Background noise monitoring results and noise limit derivation are detailed in the Consolidated Report. A summary of noise limits is presented in tabular format in Appendix D.

Derivation of noise limits differ between NZS6808:1998 and NZS6808:2010, owing to differences in the methodology for background noise monitoring. The key differences are as follows:

- Use of L_{A90} parameter in accordance with NZS6808:2010 in comparison to the use of L_{A95} parameter in accordance with NZS6808:1998[8].
- Use of hub height reference for wind speeds in accordance with NZS6808:2010 in comparison to the use of 10m above ground level (AGL) in the Consolidated Report, in accordance with NZS6808:1998.

For simplicity, in this informative assessment, compliance with NZS6808:2010 is assessed against the baseline noise limit at all wind speeds. This approach is not dependant on the two key differences noted above and is considered conservative.

For consistency and ease of comparison with the findings presented in the Consolidated Report, all wind speeds are referenced to 10m AGL within this report.

6.3 Stakeholders

As stated in Section 5.0, stakeholder properties are not considered as part of an assessment in accordance with NZS6808:2010.

Notwithstanding this, as detailed in our Consolidated Report, a noise limit based on an increased baseline noise limit of 45dB has been recommended for stakeholder properties with an agreement with the proponent.

7.0 NOISE PREDICTIONS

Noise from the Ryan corner Wind Farm has been predicted using ISO9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation* (ISO9613-2:1996) as implemented in version 7.2 of SoundPLAN. Predictions have been carried out using the sound power level data presented in Section 2.2.

Calculations have been performed using octave band source data from 63Hz to 8kHz and each wind turbine has been modelled as a point source at hub height. All noise predictions use a receiver height of 1.5m AGL. For consistency with the Consolidated Report, possible screening effects from the landscape have not been considered in this assessment. Atmospheric attenuation has been modelled using a temperature of 10°C and 70% humidity as recommended by NZS6808:2010.

[8] NZS6808:2010 notes in Section C2.5: *The 1998 version of this Standard used the L95 descriptor. Since 1999 this has been updated in New Zealand Standards to the L90 descriptor. There is no significant difference between the L90 and L95 values of typical environmental sound so this change does not affect the recommended noise limits in this Standard*

The hardness of the ground between the sources and the receivers needs to be defined in accordance with ISO9613-2:1996. 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 to be absorptive, appropriate for fields and grass. Our experience is that, in rural areas, generally with similar topography as the subject site, it is appropriate to assume that the ground is 50% hard/50% soft. 50% soft ground (G=0.5) has been used in the predictions.

Further details regarding the use of ISO9613-2 for wind farm nose predictions and the use of G=0.5 is presented in Appendix E.

Predicted noise levels at the assessable residences detailed in Table 4 are shown in Table 5 for the two (2) proposed turbine models, Vestas V90 and REpower MM92.

Table 5: Maximum predicted noise levels[9], L_{Aeq} dB

House	Noise sensitive location*	REpower MM92+	Vestas V90+
H04 (S)	No	33.8	32.4
H05	No	34.2	32.8
H06	Yes	35.6	34.3
H07	Yes	37.1	35.9
H08 (S)	No	40.1	39.2
H09	Yes	38.5	37.3
H10	Yes	37.4	36.2
H11	Yes	38.1	37.0
H24 (S)	No	34.0	32.6
H25	No	34.4	33.0
H26	Yes	37.3	36.0
H27	Yes	37.9	36.7
H28 (S)	No	39.7	38.6
H29	Yes	38.4	37.3
H30 (S)	No	38.0	36.9
H31	Yes	37.3	36.1
H32	Yes	36.6	35.5
H33	No	34.0	32.6
H38	No	34.0	32.7
H77	Yes	36.9	35.6

[9] Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. In the case of wind farm layout design however, 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 presented levels are reported to one decimal place.

House	Noise sensitive location*	REpower MM92+	Vestas V90+
H78 (S)	No	42.8	41.9
H79 (S)	No	42.3	41.5
H80	No	33.8	32.5
H106	No	34.5	33.1

(S) Stakeholder property
* As defined in Section 4.0
+ based on sound power level at 8m/s at 10m AGL

It can be seen from Table 5 that predicted noise levels at all noise sensitive locations comply with the NZS6808:2010 baseline noise limit of 40dB at all wind speeds with a tolerance of at least 2dB.

Predicted noise levels at stakeholder properties comply with the raised baseline noise limit of 45dB at all wind speeds with a tolerance of at least 3dB.

Wind farm noise at all residential properties further from the wind farm will be lower than 33dB L_{Aeq} and therefore comply with the NZS6808:2010 baseline noise limit at all wind speeds.

7.1 Special audible characteristics

Based on the information provided in Section 2.2.2, it is considered that a penalty for tonality would not be applicable for either of the candidate turbines at any of the assessed wind speeds.

8.0 CONCLUSION

Following the issuing of the Consolidated Report (002 R01 2010165ML) on 24 January 2012, we understand that the Department of Transport, Planning and Local Infrastructure (DTPLI) requested an informative noise impact assessment for the Ryan corner Wind Farm in accordance with NZS6808:2010.

Predicted noise levels have been calculated at all assessable properties identified in the Consolidated Report using the ISO9613-2:1996 algorithm.

It has been found that predicted wind farm noise complies with the relevant baseline noise limit at all wind speeds at all assessed properties for both candidate turbines.

9.0 SUMMARY OF PARAMETERS

Documentation of relevant parameters as required by NZS6808:2010 is contained in Appendix G.

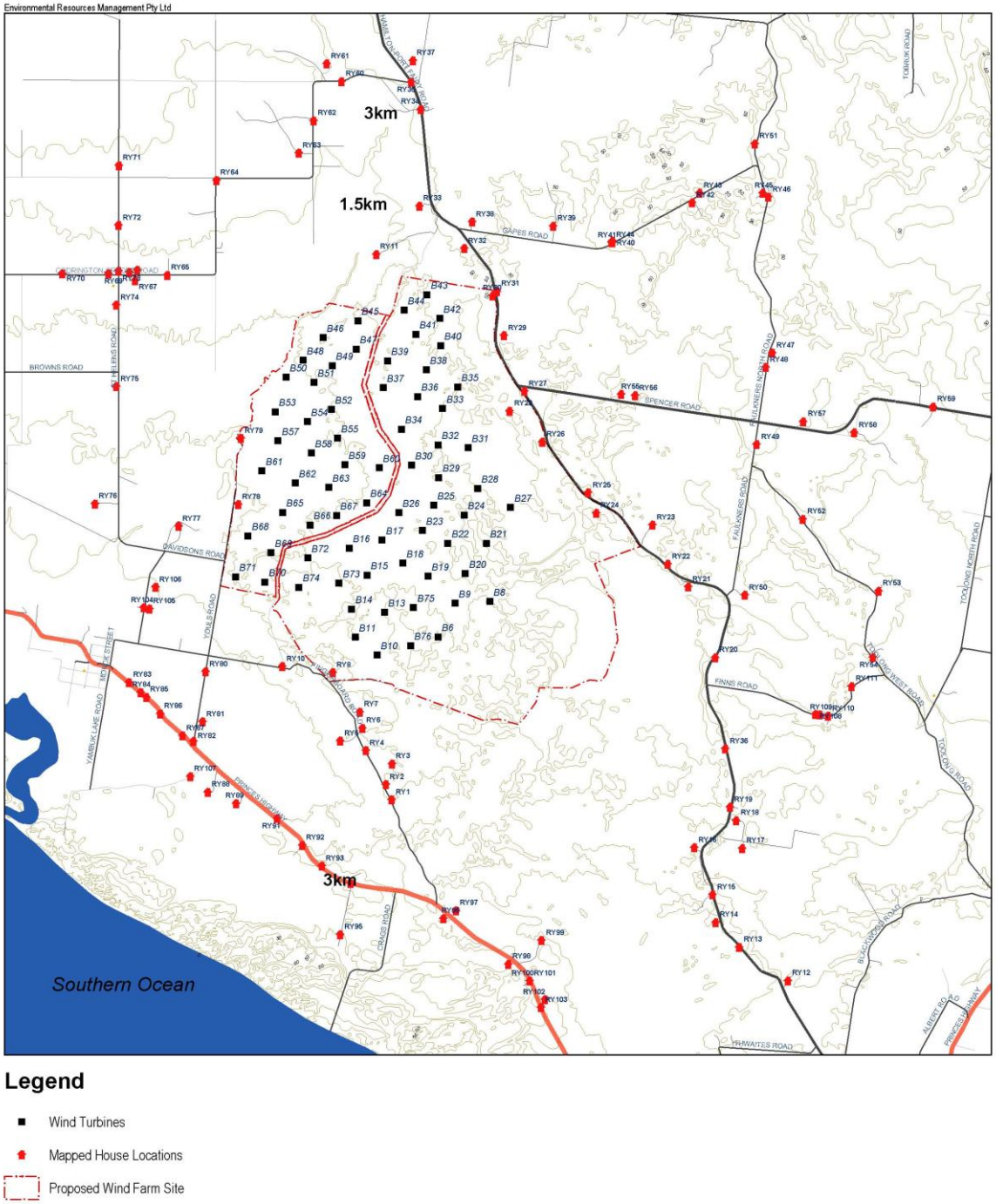
APPENDIX A **ACOUSTIC TERMINOLOGY**

Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
dB	Decibel. The unit of sound level.
Frequency	Sound can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals. Sound is generally described over the frequency range from 63Hz to 8000Hz (8kHz). This is roughly equal to the range of frequencies on a piano.
Octave band	Sound, which can occur over a range of frequencies, may be divided into octave bands for analysis. The audible frequency range is generally divided into eight (8) octave bands. The octave band frequencies are 63Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, 4kHz and 8kHz.

Noise is often not steady. Traffic noise, music noise and the barking of dogs are all examples of noises that vary over time. When such noises are measured, the noise level can be expressed as an average level, or as a statistical measure, such as the level exceeded for 90% of the time.

L_{A90}	The A-weighted noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
L_{A95}	The A-weighted noise level exceeded for 95% of the measurement period. This is commonly referred to as the background noise level.
L_{Aeq}	The A-weighted equivalent continuous sound level. This is commonly referred to as the average noise level.

APPENDIX B **RYAN CORNER WIND FARM LAYOUT**



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Source:	M:\0028511...\0028511GIS\		

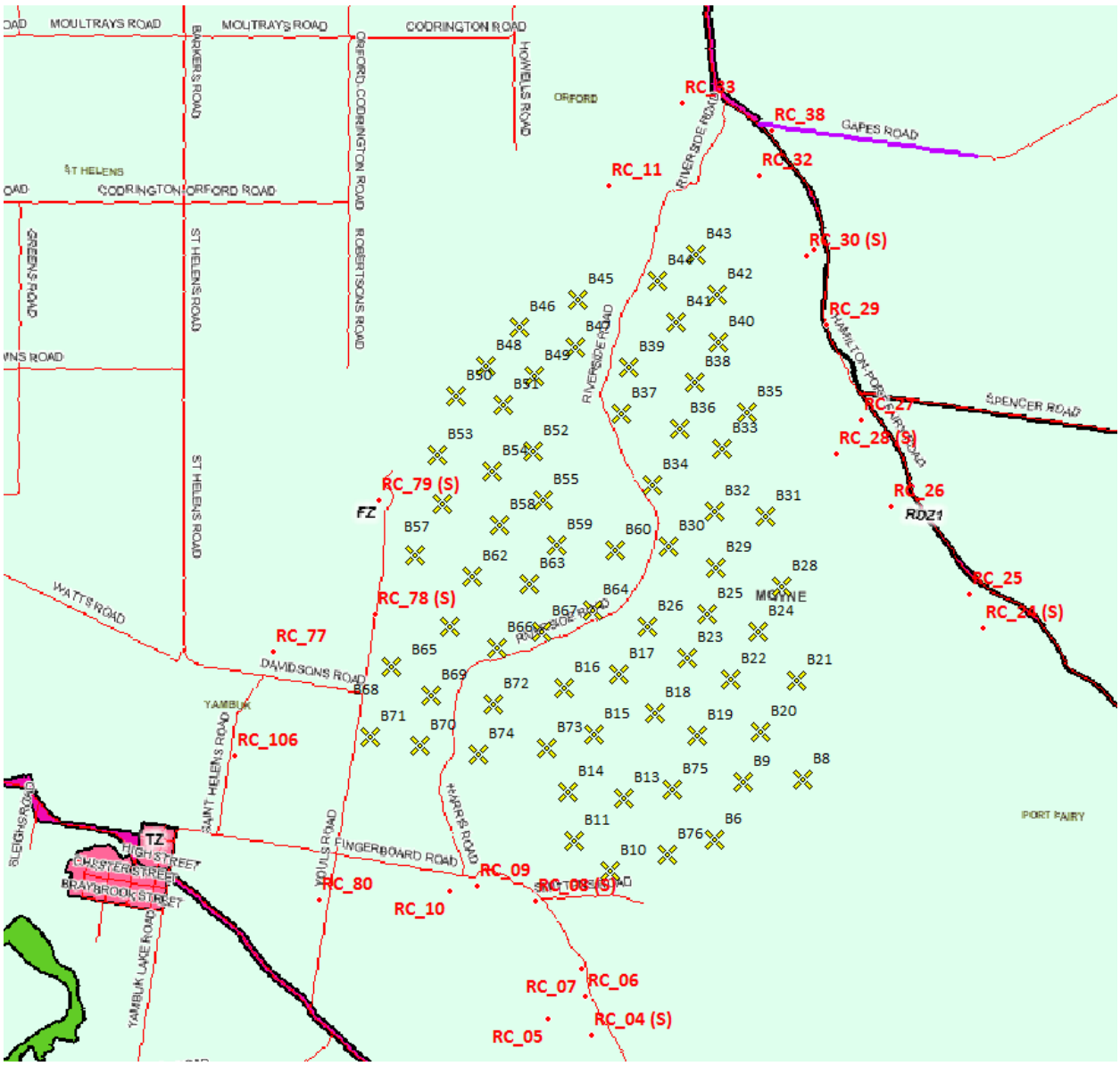
1 0 1 Kilometers

ERM | Windfarm Site with Mapped House Locations
Ryan Corner Wind Farm

B1 Turbine coordinates (AGD66 Z54)

Turbine	Eastings	Northings	Turbine	Eastings	Northings
B6	598757	5758884	B44	598189	5764373
B8	599628	5759481	B45	597410	5764195
B9	599046	5759451	B46	596825	5763915
B10	597733	5758581	B47	597384	5763720
B11	597368	5758879	B48	596493	5763534
B13	597858	5759298	B49	596982	5763442
B14	597305	5759354	B50	596205	5763246
B15	597565	5759924	B51	596673	5763159
B16	597266	5760376	B52	596964	5762705
B17	597818	5760511	B53	596023	5762666
B18	598165	5760125	B54	596564	5762503
B19	598587	5759905	B55	597067	5762224
B20	599214	5759950	B57	596069	5762181
B21	599568	5760455	B58	596630	5761976
B22	598922	5760458	B59	597195	5761778
B23	598493	5760673	B60	597771	5761728
B24	599196	5760931	B61	595799	5761677
B25	598687	5761099	B62	596360	5761472
B26	598099	5760974	B63	596923	5761397
B28	599422	5761378	B64	597556	5761138
B29	598768	5761563	B65	596145	5760977
B30	598310	5761771	B66	596605	5760764
B31	599265	5762065	B67	597053	5760926
B32	598757	5762109	B68	595565	5760580
B33	598834	5762722	B69	595953	5760299
B34	598143	5762373	B70	595849	5759805
B35	599085	5763085	B71	595355	5759895
B36	598412	5762921	B72	596570	5760211
B37	597836	5763071	B73	597094	5759789
B38	598559	5763372	B74	596421	5759720
B39	597911	5763523	B75	598345	5759377
B40	598802	5763777	B76	598296	5758739
B41	598384	5763969			
B42	598787	5764236			
B43	598572	5764634			

APPENDIX C **ZONING MAP**



As downloaded from land.vic.gov.au on 29 July 2013.

APPENDIX D **SUMMARY OF NOISE LIMITS**

D1 **24 hour noise limits, L_{A95} dB**

	Wind speed @ 10m AGL (m/s)							
House	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
H04 (S)	45.0	45.0	45.0	46.4	48.9	51.5	53.9	56.2
H05	40.0	41.6	43.9	46.4	48.9	51.5	53.9	56.2
H06	40.0	41.6	43.9	46.4	48.9	51.5	53.9	56.2
H07	40.0	41.6	43.9	46.4	48.9	51.5	53.9	56.2
H08 (S)	45.0	45.0	45.0	46.6	48.9	50.9	52.7	54.0
H09	40.0	42.0	44.3	46.6	48.9	50.9	52.7	54.0
H10	40.0	42.0	44.3	46.6	48.9	50.9	52.7	54.0
H11	42.3	44.1	45.9	47.6	49.1	50.3	51.0	51.2
H24 (S)	45.7	47.3	49.0	50.6	52.3	54.0	-	-
H25	45.7	47.3	49.0	50.6	52.3	54.0	-	-
H26	45.7	47.3	49.0	50.6	52.3	54.0	-	-
H27	45.7	47.3	49.0	50.6	52.3	54.0	-	-
H28 (S)	45.7	47.3	49.0	50.6	52.3	54.0	-	-
H29	42.3	44.1	45.9	47.6	49.1	50.3	51.0	51.2
H30 (S)	45.0	45.0	45.9	47.6	49.1	50.3	51.0	51.2
H31	42.3	44.1	45.9	47.6	49.1	50.3	51.0	51.2
H32	42.3	44.1	45.9	47.6	49.1	50.3	51.0	51.2
H33	42.3	44.1	45.9	47.6	49.1	50.3	51.0	51.2
H38	42.3	44.1	45.9	47.6	49.1	50.3	51.0	51.2
H77	44.4	46.5	48.5	50.3	51.9	53.1	53.7	53.6
H78 (S)	45.0	46.5	48.5	50.3	51.9	53.1	53.7	53.6
H79 (S)	45.0	46.5	48.5	50.3	51.9	53.1	53.7	53.6
H80	40.0	42.0	44.3	46.6	48.9	50.9	52.7	54.0
H106	44.4	46.5	48.5	50.3	51.9	53.1	53.7	53.6

(S) stakeholder in the project

D2 Night-time noise limits, L_{A95} dB

	Wind speed @ 10m AGL (m/s)							
House	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
H04 (S)	45.0	45.0	45.0	49.0	-	-	-	-
H05	40.0	40.2	43.9	49.0	-	-	-	-
H06	40.0	40.2	43.9	49.0	-	-	-	-
H07	40.0	40.2	43.9	49.0	-	-	-	-
H08 (S)	45.0	45.0	45.0	47.2	-	-	-	-
H09	40.0	40.5	43.5	47.2	-	-	-	-
H10	40.0	40.5	43.5	47.2	-	-	-	-
H11	45.9	49.6	52.2	52.8	52.8	52.8	-	-
H24 (S)	46.0	46.3	46.3	46.3	46.3	46.3	-	-
H25	46.0	46.3	46.3	46.3	46.3	46.3	-	-
H26	46.0	46.3	46.3	46.3	46.3	46.3	-	-
H27	46.0	46.3	46.3	46.3	46.3	46.3	-	-
H28 (S)	46.0	46.3	46.3	46.3	46.3	46.3	-	-
H29	45.9	49.6	52.2	52.8	52.8	52.8	-	-
H30 (S)	45.9	49.6	52.2	52.8	52.8	52.8	-	-
H31	45.9	49.6	52.2	52.8	52.8	52.8	-	-
H32	45.9	49.6	52.2	52.8	52.8	52.8	-	-
H33	45.9	49.6	52.2	52.8	52.8	52.8	-	-
H38	45.9	49.6	52.2	52.8	52.8	52.8	-	-
H77	45.3	46.4	46.4	46.4	-	-	-	-
H78 (S)	45.3	46.4	46.4	46.4	-	-	-	-
H79 (S)	45.3	46.4	46.4	46.4	-	-	-	-
H80	40.0	40.5	43.5	47.2	-	-	-	-
H106	45.3	46.4	46.4	46.4	-	-	-	-

(S) stakeholder in the project

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 7.2 software. Specifically, predictions have been carried out using the SoundPLAN implementation of ISO9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation* (ISO9613-2:1996) 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 NZS6808:2010 *Acoustics – Wind farm noise* (NZS6808:2010).

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 1m/s and 5m/s, measured at a height of 3m to 11m 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 ISO9613-2:1996, the noise levels of each 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 ISO9613-2:1996 for the prediction of total A-weighted noise levels 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 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 ISO9613-2:1996 prediction methodology in this way provides a reliable representation of the upper noise levels expected in practice.

In support of the use of ISO9613-2:1996 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
- NZS6808:2010 refers to ISO9613-2:1996 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[10] found that the ISO9613-2:1996 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 ISO9613-2:1996 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 ISO9613-2:1996 method as the appropriate standard and specifically designated G=0.5 as the appropriate ground characterisation. It is noted that this publication specifically referred 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 1.5m which tends to result in higher ground attenuation factors for a given ground absorption factor, however conversely, predictions in Australia do not generally incorporate a -2dB 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.

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

- The IoA document *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (IOA GPG) published in May 2013 provides detailed descriptive advice to assist with the use of ETSU-R-97 for noise assessment of UK wind farm developments. The good practice guide recommends a ground factor of G = 0.5 when used in conjunction with the inputs described in the UK (IoA) journal article noted above.
- A range of comparative measurement and prediction studies[11, 12, 13] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO9613-2:1996 and G=0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

The key findings of these studies demonstrated the suitability of the ISO9613-2:1996 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 30m maximum source heights considered in the original ISO9613
- 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 5m/s.

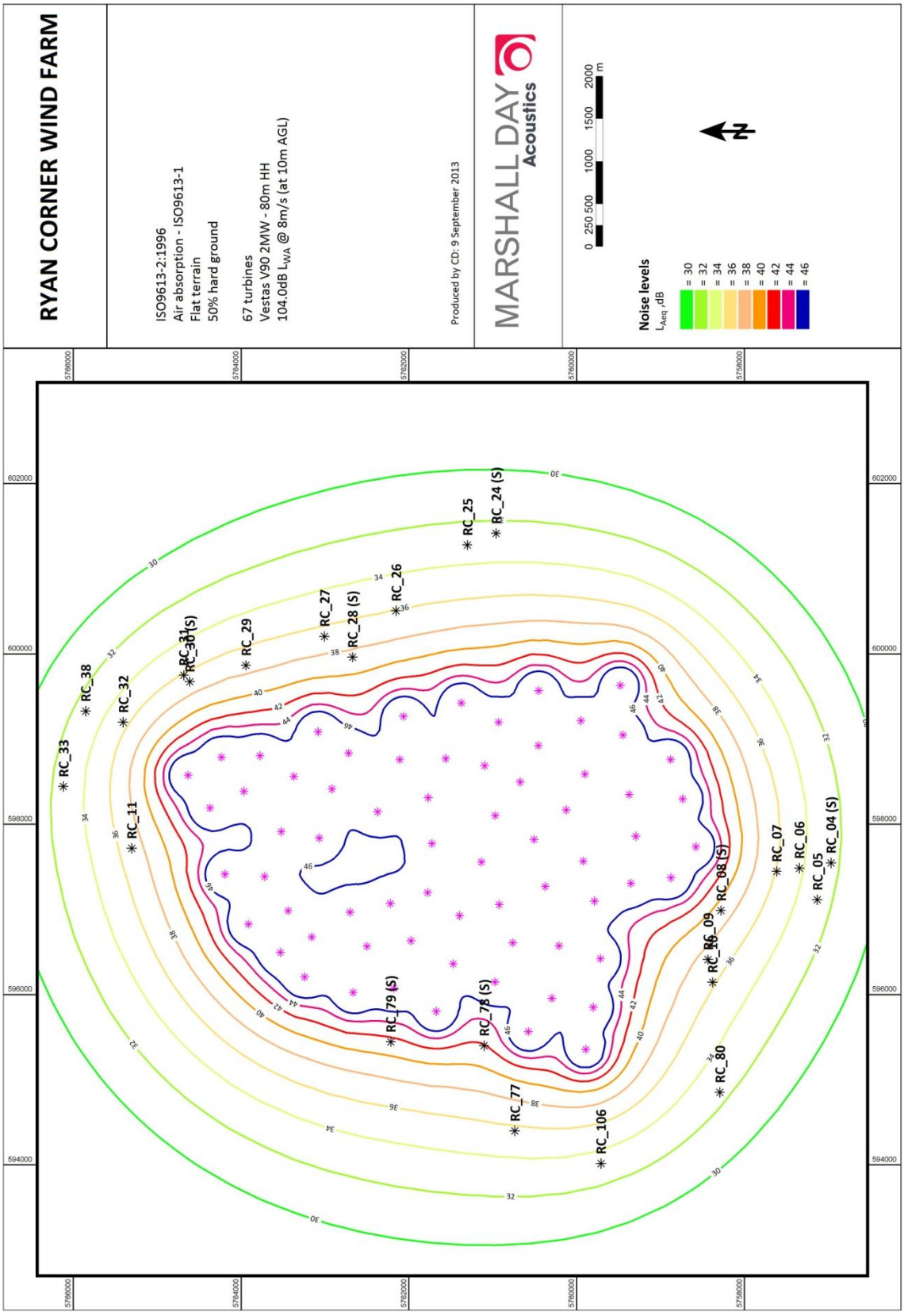
[11] Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

[12] 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.

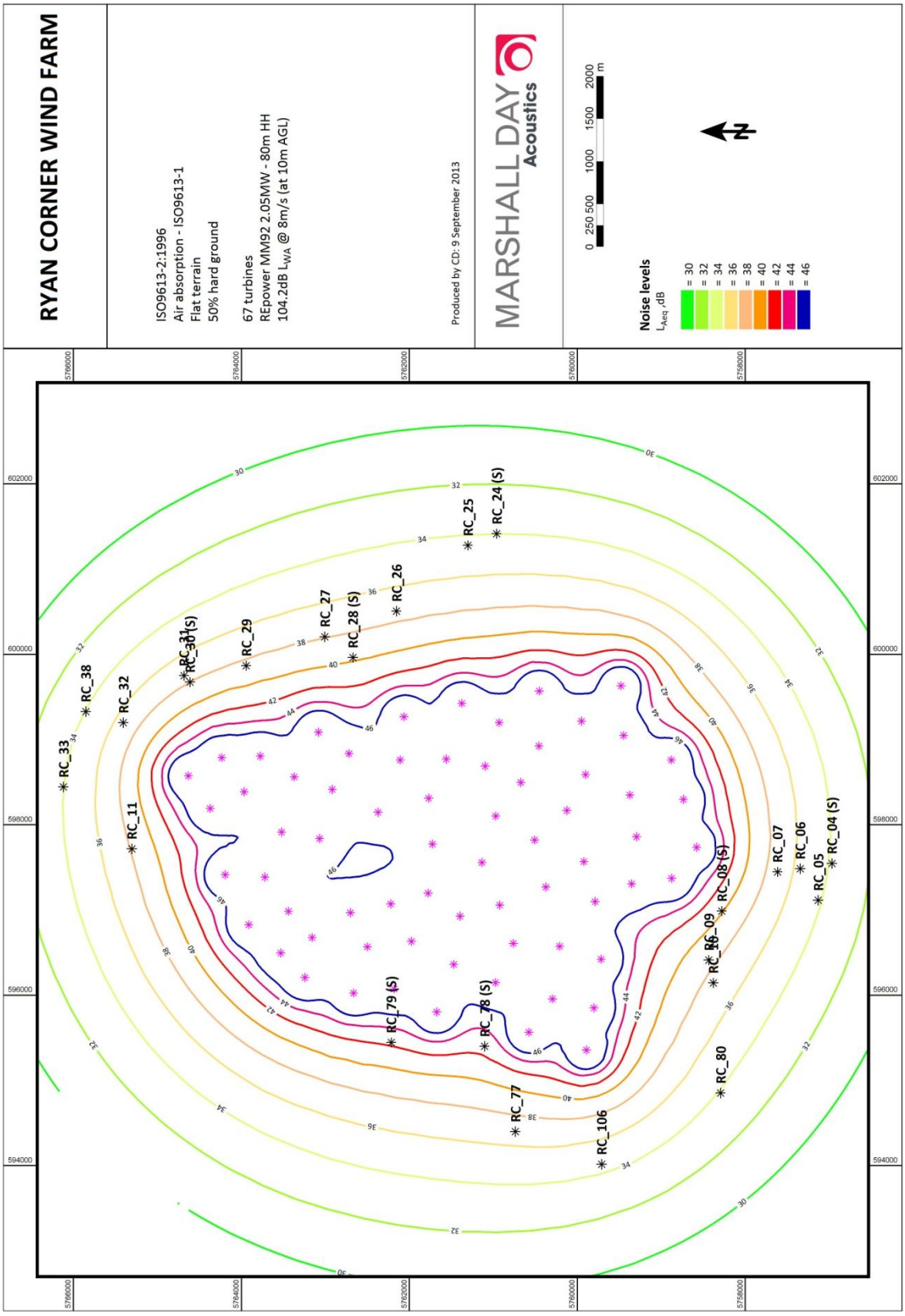
[13] Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

APPENDIX F **NOISE CONTOUR MAP**

F1 Vestas V90



F2 **REpower MM92**



APPENDIX G **DOCUMENTATION**

Predictions

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

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

(c) Maximum sound power levels, L_{WA} dB (also refer to Section 2.2)

Turbine model	Octave Band Centre Frequency (Hz)								
	Overall	63	125	250	500	1000	2000	4000	8000
Vestas V90	104.0	84.3	91.6	94.8	98.2	98.5	96.7	92.8	78.7
REpower MM92	104.2	84.3	92.5	98.1	99.8	97.8	92.1	85.4	82.2

(d) Wind turbine models: Vestas V90 and REpower MM92 (see Section 2.1)

(e) Turbine hub height: 80m

(f) Distance of noise sensitive locations from the wind turbines: Table 4 of Section 2.3

(g) Calculation procedure used: ISO9613-2:1996 prediction algorithm as implemented in SoundPLAN v7.2 (See Section 7.0 and Appendix E)

(h) Meteorological conditions assumed:

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

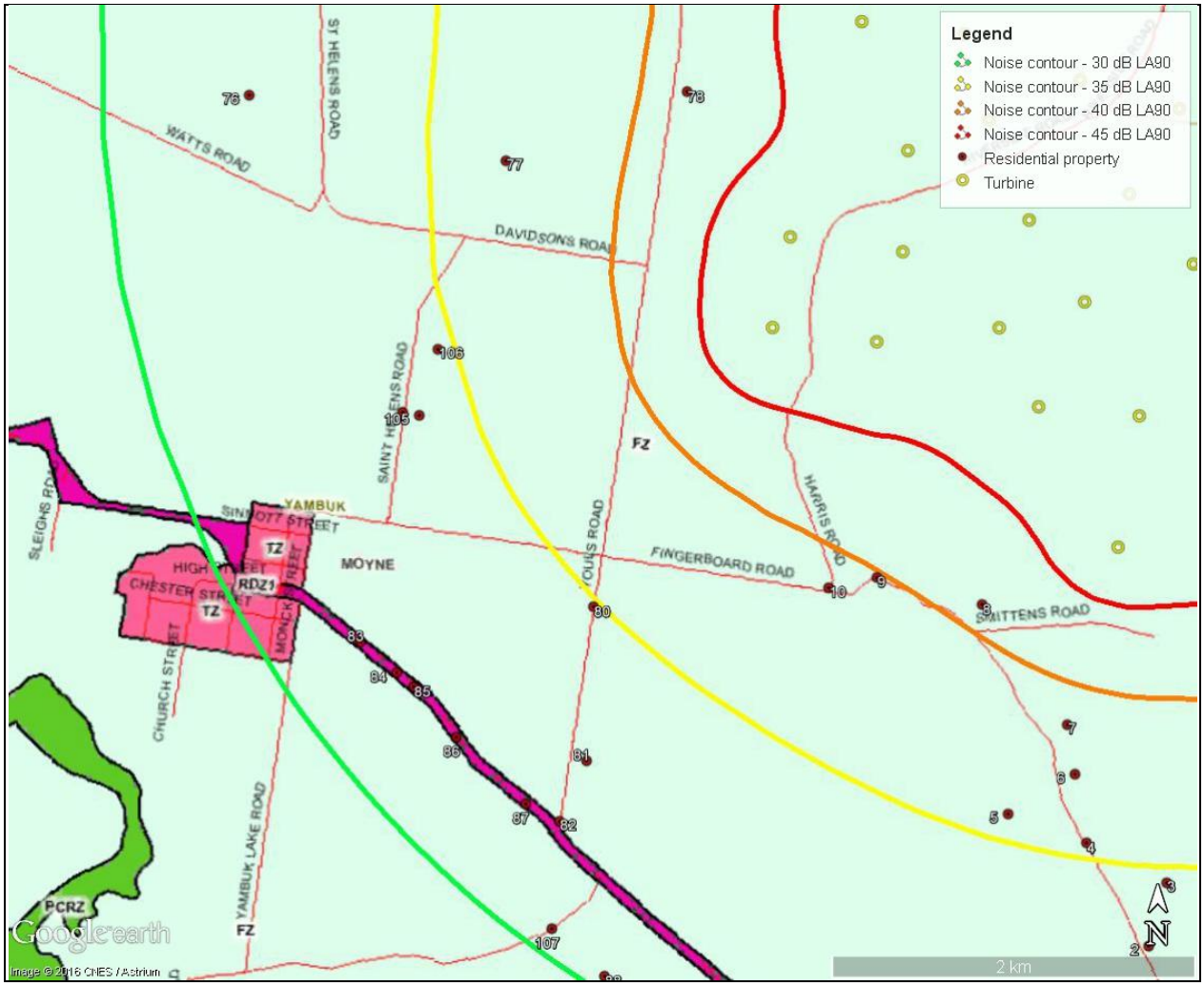
(i) Air absorption parameters:

	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: No screening effects

(k) Predicted far-field wind farm sound levels: See Table 5 of Section 7.0

APPENDIX C NOISE CONTOUR MAP AROUND THE YAMBUK TOWNSHIP



Legend: Light green – Farming Zone
Pink – Township Zone
Yellow line – 35 dB L_{A90} noise contour