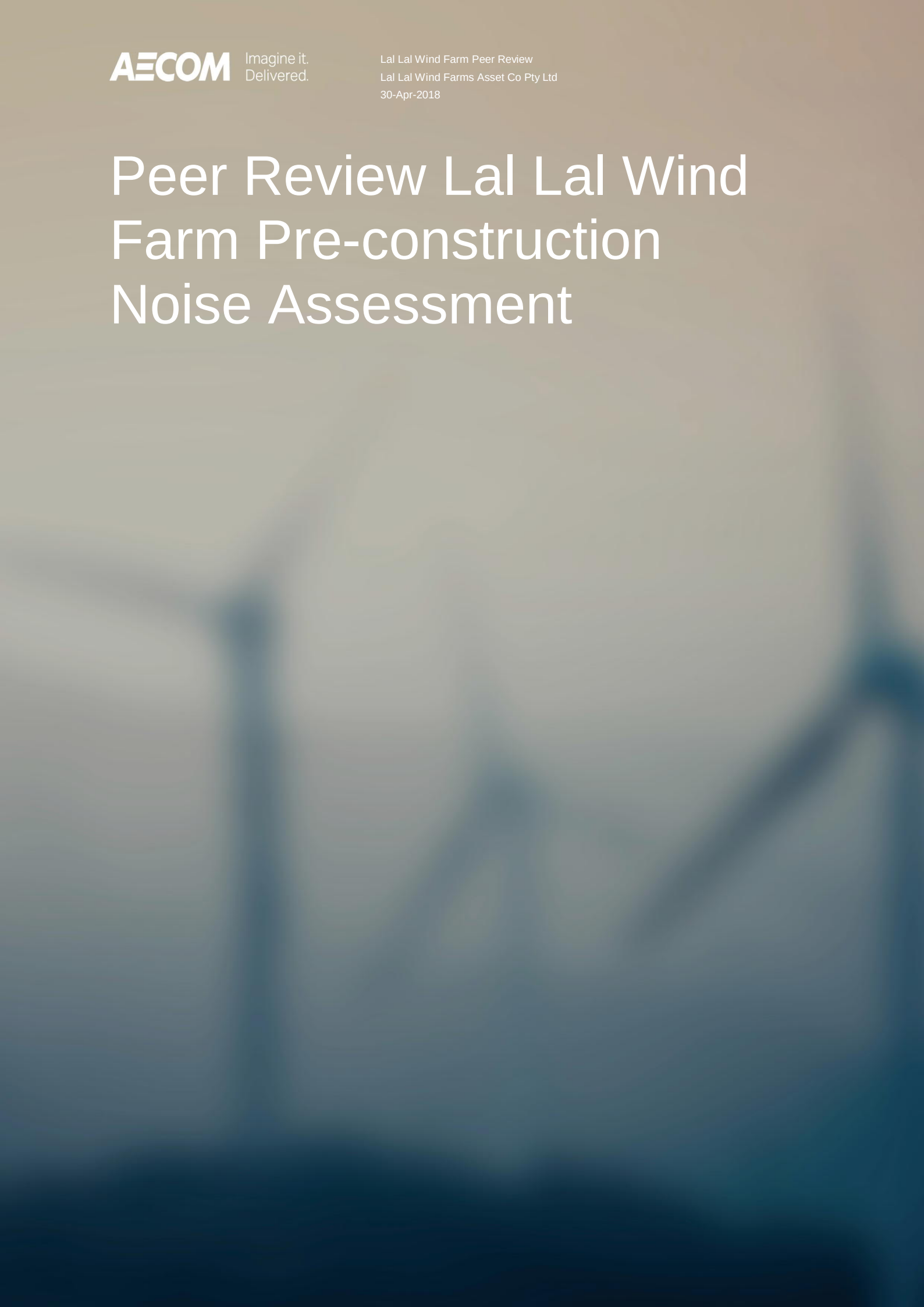
Peer Review Lal Lal Wind Farm Pre-construction Noise Assessment



Peer Review Lal Lal Wind Farm Pre-construction Noise Assessment

Client: Lal Lal Wind Farms Asset Co Pty Ltd

ABN: 617886567

Prepared by

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Quality Information

Document	Peer Review Lal Lal Wind Farm Pre-construction Noise Assessment
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Date	30-Apr-2018
Prepared by	Alex Dundon
Reviewed by	Harry Grynberg

Revision History

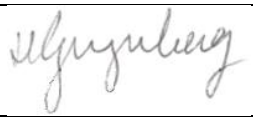
Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
1	30-Apr-2018	issue	Harry Grynberg Technical Director	

Table of Contents

Declaration

I, Dr Harry Grynberg of AECOM Australia Pty Ltd, an environmental auditor (appointed pursuant to the Environment Protection Act 1970; 'the Act'), having:

1. been requested by Lal Wind Farms Asset Co. Pty Ltd to assess that the Pre-construction Noise Assessment prepared for the site located at Yendon and Elaine ('the site') for the purposes of construction of a proposed wind farm ('the works');

2. having had regard to, among other things:

Victorian government Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria dated January 2016 and the following relevant documents: Standards New Zealand 2010; NZ6808:2010 Acoustics-Wind Farm Noise; Institute of Acoustics May 2013 A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and rating of Windfarm noise; IEC 2012 Wind Turbines- Part 11: Acoustic Noise Measurement Techniques Ed 3 61400-11;

3. considered the following documents: (i) Lal Lal Pre-construction Noise Assessment Sonus February 2018 (ii) Lal Lal Windfarm Background Noise Monitoring Report No.001 20170649 November 2017 Noise Assessment; (iii) Vestas Turbine information (iv) site layout plans

4. with the support of Alex Dundon Principal Acoustics Engineer, Acoustic team Lead AECOM South Australia, Member of Australia Acoustical Society

HEREBY DECLARE that I am of the opinion that the Preconstruction Noise Assessment contains adequate information of suitable quality to meet the requirements (i.e. that the Pre-construction Noise Assessment for the proposed works would not be contrary to, or inconsistent with, any applicable noise policy, the works are not likely to cause or contribute to noise pollution, or likely to cause an environmental hazard due to noise and that the noise requirements would be complied with should the works proceed).

DATED: 30 April 2018

Signed:

ENVIRONMENTAL AUDITOR (APPOINTED PURSUANT TO THE ENVIRONMENT PROTECTION ACT 1970)

1.0 Introduction

Dr Harry Grynberg an Environmental Auditor (Industrial Facilities) appointed pursuant to the Environment Protection Act 2007 as amended was appointed by Lal Lal Win Farms Asset Co Pty Ltd to undertake a peer review of the Pre-construction Noise Assessment of the proposed Lal Lal Wind Farm.

1.1 Regulatory Requirements

The Victorian government has issues Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria dated January 2016 in which the requirements of the Environmental Auditor Review are described as follows:

An assessment of compliance consists of two documents, being a declaration and a report supporting the declaration (an example of a similar declaration can be found in the EPA publication Landfill Licensing Guidelines, Publication 1323.2).

The declaration referred to above, issued by an EPA appointed auditor is a declaration that the noise assessment meets the requirements of:

1. *the appropriate standards*
2. *this guideline (as it relates to noise) and*
3. *the permit or other regulatory instrument.*

The declaration must be accompanied by a report, signed by the auditor, addressing the matters 1. to 3. above and detailing the considerations they have relied upon in forming their view. This report should be thorough but concise. The report must have adequate detail including an annexure listing all documents examined or relied up on to permit any reader to follow the deliberations that the auditor undertook in forming their view.

Auditor duties

An EPA appointed auditor is expected in undertaking any function to apply sound engineering and audit practices, behaving in an ethical manner upholding the reputation of the "audit system" and adhere to the wording and intent of relevant guidelines. EPA has guidelines detailing the duties and responsibilities of an EPA appointed auditor.

The Victorian EPA has developed Draft Guidelines for the audit as follows:

Pre-construction predictive noise assessment audit

The audit of the predictive noise assessment is to be conducted in a manner deemed appropriate by the environmental auditor and would typically include the steps of:

- *Familiarization with the Wind Farm development proposal and planned operation.*
- *Inspection of the Wind farm project site and verification of the identified surrounding sensitive receptors (i.e. dwellings, etc.).*
- *Review of the pre-construction noise assessment considering the WEF development proposal and operations including, turbine technical specifications and power ratings, tower locations, topography, transformer stations and other relevant factors.*
- *Review of background noise assessments.*
- *Detailed review (audit) of the predictive noise assessment, including:*
  - *Methodology applied to conduct the assessment*
  - *Noise monitoring equipment and parameters used*
  - *Sound modelling programs employed*
  - *An assessment of Special Audible Characteristics (SACs) – Amplitude Modulation, Tonality and Impulsivity (described in Section 6.7 of the Standard).*
- *Risk assessments*
- *Preparation of the environmental noise audit report*

1.2 Scope of Work

The scope of work has been prepared taking these requirements into account. It is noted that the Draft EPA guidelines were an outcome of a workshop and have yet to be adopted.
On this basis the proposed scope is:

- Familiarization with the Wind Farm development proposal and planned operation.
- Discussion with Sonus regarding its approach and methodology
- Verification of the identified surrounding sensitive receptors (i.e. dwellings, etc) based on Google Maps.
- Review of the pre-construction noise assessment considering the WEF development proposal and operations including, turbine technical specifications and power ratings, tower locations, topography, transformer stations and other relevant factors.
- Review of background noise assessments.
- Detailed review (audit) of the predictive noise assessment, including:
  - Methodology applied to conduct the assessment
  - Noise monitoring equipment and parameters used
  - Sound modelling programs employed
  - An assessment of Special Audible Characteristics (SACs) – Amplitude Modulation, Tonality and Impulsivity (described in Section 6.7 of the Standard).
- Site inspection
- Preparation of the environmental noise audit report and declaration.

1.3 Planning Permit Noise Criteria

The following are the noise criteria applicable to the development.

23. Except as provided below in this condition, the operation of the wind energy facility must comply with New Zealand Standard 6808:2010, Acoustics – Wind Farm Noise (the Standard) as modified by this condition to the satisfaction of the Minister for Planning.

    In determining compliance the following requirements apply:

    a) The operator must ensure that at any wind speed, wind farm sound levels, determined in accordance with the Standard at noise sensitive locations (as defined in the Standard) do not exceed a noise limit of 40dB LA90,10min or background (LA90,10min) plus 5dB, whichever is greater.

    b) Compliance must be assessed separately for all-time and night time. For the purpose of this requirement, night time is defined as 10.00pm to 7.00am, and

    c) Where special audible characteristics, including tonality, impulsive sound or excessive amplitude modulation occur, the measured noise level with the identified special audible characteristics will be modified by applying a penalty of up to + 6 dB L90 in accordance with section 5.4 of the Standard.

    Any dwelling on the subject land may be exempt from this condition. This exemption will be given effect through an agreement with the landowner and must be registered on title, unless varied through the written consent of the Minister for Planning. Such dwellings will be known as host dwellings.

2.0 Proposed Development

2.1 Site Location and layout

It is proposed to develop two wind farm areas, one near the township of Yendon (38 wind turbines) and one near the township of Elaine (22 wind turbines) south east of Ballarat, Victoria. The proposed layouts are shown in Figures 1 and 2 included in Appendix A.

2.2 Turbines

It is proposed to install 60 turbines manufactured by Vestas, model V136, 3.8 MW. The hub height of the turbines is 93m and the diameter of the rotors is 136m. It is proposed to use serrated blades.

3.0 Review of the Pre-construction Noise Assessment

Sonus Pty Ltd undertook the pre-construction noise assessment and prepared a report Lal Lal Wind Farm Pre-construction Noise Assessment (S5464C5) dated April 2018 (Appendix B). The following is the findings of the peer review of the assessment and report.

3.1 Review of Input data

As part of our peer review, we have reviewed the input data used in the noise assessment. This information includes:

- Location of proposed turbines
- Technical data for proposed turbines, including sound power levels
- Location of sensitive receptors
- Background noise assessment (completed by Marshall Day in 2017)

In reviewing the information, we have the following findings:

- The locations used by Sonus for noise modelling are consistent with the locations shown in the Sonus report.
- Sound power levels have not been adjusted to account for uncertainty. While there are no statements within the Vestas specification that the values are a warranted or guaranteed maximum noise level, we understand from the 1/3rd octave band data that the overall sound power levels represent an upper 95th percentile confidence limit for the proposed wind turbines. The Sonus report states that this is a warranted sound power level (in accordance with the IOA Guidelines) Institute of Acoustics May 2013.
- There are no details on Special Audible Characteristics (SACs) that may be present from the particular model of wind turbines. We acknowledge that the 1/3rd octave band data does not indicate the presence of tones; however, as these levels are not guarantees of the values, we note that SACs may require assessment after construction of the project.
- The locations used for noise modelling of the most affected sensitive receptors (at which monitoring was also conducted) are considered appropriate.

3.2 Review of Modelling Methodology

As part of our review of methodology, we have reviewed Sonus' assumptions, as well as the noise model used for prediction of noise levels. The review makes the following findings:

- The noise model was completed through the use of SoundPLAN 8.0 implementing the ISO 9613-2 prediction algorithm. We agree that this software and algorithm is appropriate for modelling of noise from wind turbines.
- The correct hub height of 93 metres was used for the noise modelling.
- The IOA methodology as used by Sonus in their assessment provides appropriate assumptions for modelling of wind turbine noise.
- Turbine locations and source levels provided in the Sonus report were input into the noise model, as were receptor locations. Heights for sources and receptors were consistent with requirements.
- We concur with Sonus' statement in regards to wake turbulence on a downwind turbine.
- We note that the use of CONCAWE and the ISO 9613-2 standard with a ground absorption factor of G = 0.0 are provided for information purposes only. In our opinion, ISO 9613-2 with a ground absorption factor of G = 0.5 is the appropriate methodology for the Lal Lal Wind Farm. The approach is considered conservative.

3.3 Review of Output data

The output data provided by Sonus was reviewed as part of the audit process. Based on our experience and the site topography, we feel that the most appropriate algorithm for prediction of noise from the wind turbines is ISO 9613-2, using a ground factor of G = 0.5. This value is considered appropriate for flat or evenly sloping terrain.

All outputs from this modelling methodology complied with the requirements of NZ6808:2010 (i.e. complied with 40 dB(A) or background plus 5 dB(A)). At all non-associated locations, predicted noise levels were equal to or below 40 dB(A) for all wind speeds.

While we note that Sonus have provided data for a ground factor of G = 0.0, and using the CONCAWE prediction methodology which indicate compliance with the requirements of NZ6808:2010; we feel that these methodologies are overly conservative when compared with the methodology as recommended by IOA .

3.4 Compliance with NZ6808:2010 Acoustics-Wind Farm Noise

The planning permit conditions require that the wind farm is operated in accordance with the NZ6808:2010 Acoustics-Wind Farm Noise (the standard). The assessment against the requirements of the standard relevant to the pre-construction noise assessment is presented in Table 1.

3.5 Compliance with Pre Construction Noise Assessment Aspects of the Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria.

The Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria require that this assessment address compliance with the guidelines. The assessment against this guideline is presented in Table 2.

Table 1 Assessment of Preconstruction Noise assessment against NZ 6808:2010 Requirements

Relevant NZ 6808:2010 Requirement	Information	Commentary	Compliance
Section 3.1.2 A frequency weighted L_{90} to be used	Sonus Report	A frequency weighted L_{90} is used in the report.	Comply
Section 5.2 Noise limits	Planning Permit, Sonus Report	The planning permit is consistent with the requirements of the standard and the Sonus report assesses against the Planning permit requirements.	Comply
Section 5.3 High Amenity Areas requiring more stringent noise controls	Planning Permit, Sonus Report	Given the planning permit requirements, this is not considered a high amenity area and therefore complies with the requirements.	Comply
Section 5.4 Special Audible Characteristics	Planning Permit Sonus Report, one third octave data provided by Lal Lal Wind farms.	No details have been provided on Special Audible Characteristics within the Sonus Report. We note that 1/3rd octave band data indicates that tones may not be present, but recommend follow-up investigations after construction.	Comply – for planning. Follow up after construction.
Section 5.5 other factors (ultrasound and infrasound and building vibration)	The standard indicates that ultrasound and infrasound from wind farms are not considered to adversely impact. The standard recommends that vibration be assessed if the issue arise but that vibration impacts beyond the windfarm area are imperceptible.	No compliance issues identified.	Comply
Section 5.6 Cumulative effects	Sonus Report	No cumulative effects were identified from nearby wind turbines. The assessment was for the whole wind farm.	Comply
Section 5.7 Uncertainty	Sonus report	The Sonus report makes no adjustment for addressing uncertainty. However, the Sonus report identifies the sound power level as a warranted sound power level. Warranted sound power levels already include a correction for uncertainty, and no further adjustment is necessary under IOA guidelines.	Comply
Section 6.1.1 Methods	Vestas Performance specification(Doc 0067-3747 V03)- 95% rated power	The higher wind speeds at which the noise is greatest will be at maximum power.	Comply

Relevant NZ 6808:2010 Requirement	Information	Commentary	Compliance
6.1.2 variables to be included	Sonus report	The conditions have been addressed.	Comply
6.1.3 modelling	Sonus report	The use of SoundPlan with ISO 9613.2 and CONCAWE are acceptable for modelling	Comply
6.1.4 octave bands to be addressed (63Hzto 4kHz)	Sonus report	Bands are addressed (20 Hz to 10 kHz)	comply
6.1.5 wind speed range (6-10 m/s)	Sonus report	3 m/s to 13 m/s has been assessed	comply
6.1.6 use of 95% rated power	Vestas Performance specification(Doc 0067-3747 V03)	The higher wind speeds at which the noise is greatest will be at maximum power.	comply
6.2.1 Use of Wind Turbine Sound Power Levels (SPL)	Sonus Report	The Vestas Specification indicates that it has been prepared in accordance with IEC 61400-11. The standard also specifies that the L_{EQ} should be used as the L_{90}. The Sonus report uses a 2 dB (A) reduction based on recommendations in the IOA guidance for use of the modelling approach using ETSU-R-97. This is accepted industry practice.	Comply
6.2.2 use of SPL against wind speed	Vestas Performance specification(Doc 0067-3747 V03)	The SPLs were produced in accordance with IEC 61400-11 ed.3	Comply
7.1 Background Noise Measurement Locations	Marshall Day Background Noise reports	Locations selected for noise monitoring represented those locations with the highest predicted noise levels. As all locations were at or below 40 dB(A), it is noted that background noise measurements are immaterial to the results of the noise assessment.	Comply
7.2 Background Sound data	Marshall Day Background Noise reports	No issues.	Comply
7.3Wind Data	Marshall Day Background Noise reports	It was noted that wind measurements were not conducted at wind height, but adjusted from meteorological masts to match wind height using	Comply

Relevant NZ 6808:2010 Requirement	Information	Commentary	Compliance
		shear estimations. This is an acceptable practice.	
7.4 Background Measurement	Marshall Day Background Noise reports	No concerns regarding background measurements.	Comply
8.2 Background sound Levels	Marshall Day Background Noise reports	Information provided per NZ 6808:2010 in reports	Comply
Appendix B-3 Amplitude Modulation		No information on Special Audible Characteristics was provided. However, we note that Amplitude Modulation is not generally able to be tested prior to construction of wind turbines.	To be assessed post construction
Appendix C Uncertainty	Vestas Warrantied SPLs	As above, the Sonus report has not included any corrections for uncertainty; however, they have stated that sound power levels are warranted, which would include a value of uncertainty already. Beyond uncertainty, we note that Sonus conducted a sensitivity analysis to look at the impact of changing ground absorption of calculation methodology, and also found compliance.	Comply

Table 2 Assessment of Compliance with Pre Construction Noise Assessment Aspects of the Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria

Requirement of the planning Policy as it relates to Noise and the Preconstruction Noise Assessment	Document	Comments	Compliance
A wind energy facility should comply with the noise limits recommended for dwellings and other noise sensitive locations in the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (the Standard	Sonus Report	As discussed in section 3 , the report complies with the requirements of the standard	Comply
The Standard specifies a general 40 decibel limit for wind farm sound levels, or the sound should not exceed the background sound level by more than five decibels, whichever is the greater. 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.	Planning Permit	The planning permit specifies the noise compliance requirements. No high amenity noise limit was included as part of the planning permits conditions.	Comply
Certification of whether a wind energy facility complies with the Standard and other applicable noise requirements must be undertaken by an acoustic engineer. The wind energy facility operator must provide the responsible authority with appropriate documentation signed by an independent, appropriately qualified and experienced person. The certifier must be able to demonstrate to the responsible authority appropriate independence, qualifications and experience to carry out the task.	Sonus Report	The Sonus Report addresses this requirement	Comply
Wind farm noise compliance must be established by testing and reporting by specialist noise and acoustic consultants familiar with the application of the applicable standards and requirements. In seeking to achieve compliance, parties may seek to engage an environmental auditor, appointed under the Environment Protection Act 1970, to conduct an assessment and verification of wind farm noise compliance. This assessment would verify noise compliance, with regard to the relevant standards and planning permit conditions, and this guideline.	This report	An assessment has been conducted.	Comply

4.0 Conclusions

4.1 Compliance with the Appropriate Standards

The appropriate noise standards are defined in the planning permit and refers to standards derived from the **NZ 6808:2010.** The Pre-construction Noise Assessment was assessed and the results are presented in section 3 of this report. Based on that assessment it was concluded that the Sonus report demonstrates compliance with the Appropriate Standards. We have relied on the Noise data provided by Vestas. Special Audible Characteristics will need to be assessed post construction.

4.2 Compliance with the Pre Construction Noise Assessment Aspects of the Policy and Planning Guidelines for the Development of Wind Energy facilities in Victoria.

Based on the assessment provided in Section 3, this assessment concludes with respect to the Pre-construction noise assessment, the guidelines have been complied with.

4.3 Compliance with the planning permit

Based on the assessment provided in section 3, the preconstruction noise assessment demonstrates compliance with the permit requirements (clause 23) for the noise assessment.

5.0 References

- Institute of Acoustics May 2013 A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and rating of Windfarm noise
- IEC 2012 Wind Turbines- Part 11: Acoustic Noise Measurement Techniques Ed 3 61400-11
- Government of Victoria, January 2016; Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria
- Marshall Day Acoustics November 2017: Lal Lal Windfarm Background Noise Monitoring Report No. 001 20170649
- Marshall Day Acoustics March 2018; Lal Lal Wind Farm - Background Noise Monitoring Report Rp 001 R01 20170649
- Minister for Planning March 2017 Planning Permit PL-SP/05/0461/A
- Sonus, April 2018; Lal Lal Wind Farm Pre-construction Noise Assessment (S5464C5).
- Standards New Zealand 2010; NZ6808:2010 Acoustics-Wind Farm Noise
- Vestas 0071-6683_VO2-V136-3-3.8MW Third Octave Noise Emission.
- Vestas 0067-3747_VO4-Performance Specification V136-3.80-Lal Lal
- Vestas 0067-3747_VO3-Performance Specification V136-3.80-Lal Lal
- Vestas 0071-0247_V00 General description 3 MW platform for 3.8 MW
- West Wind Energy September 2017; Yendon Section Site Visit route Lal Lal Wind farm
- West Wind Energy September 2017; Elaine Section Site Visit route Lal Lal Wind farm

6.0 Limitations

Dr Harry Grynberg (Technical Director – Environment) along with his support team from AECOM Australia Pty Ltd (AECOM) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Lal Lal Windfarms Asset Co Pty Ltd. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report. It is prepared in accordance with the scope of work and for the purpose outlined in the proposal dated.

It is acknowledged that the Audit Report may be used by Lal Lal Windfarms Asset Co Pty Ltd in reaching conclusions about the site. The scope of work performed in connection with the audit may not be appropriate to satisfy the needs of any other person. Any other person's use of, or reliance on, the Audit Report, or the findings, conclusions, recommendations or any other material presented to them, is at that person's sole risk.

This Report was prepared between 1 April 2018 and 30 April 2018, and is based on the conditions encountered and information reviewed at the time of preparation. AECOM disclaims responsibility for any changes that may have occurred after this time.

The methodology adopted and sources of information used by Dr Harry Grynberg and the support team are outlined in this report. Dr. Harry Grynberg and the support team have made no independent verification of this information beyond the agreed scope of works and we assume no liability for any inaccuracies in or omissions to that information. No indications were found during our investigations that information contained in this report as provided to Dr Harry Grynberg and the support team was false.

This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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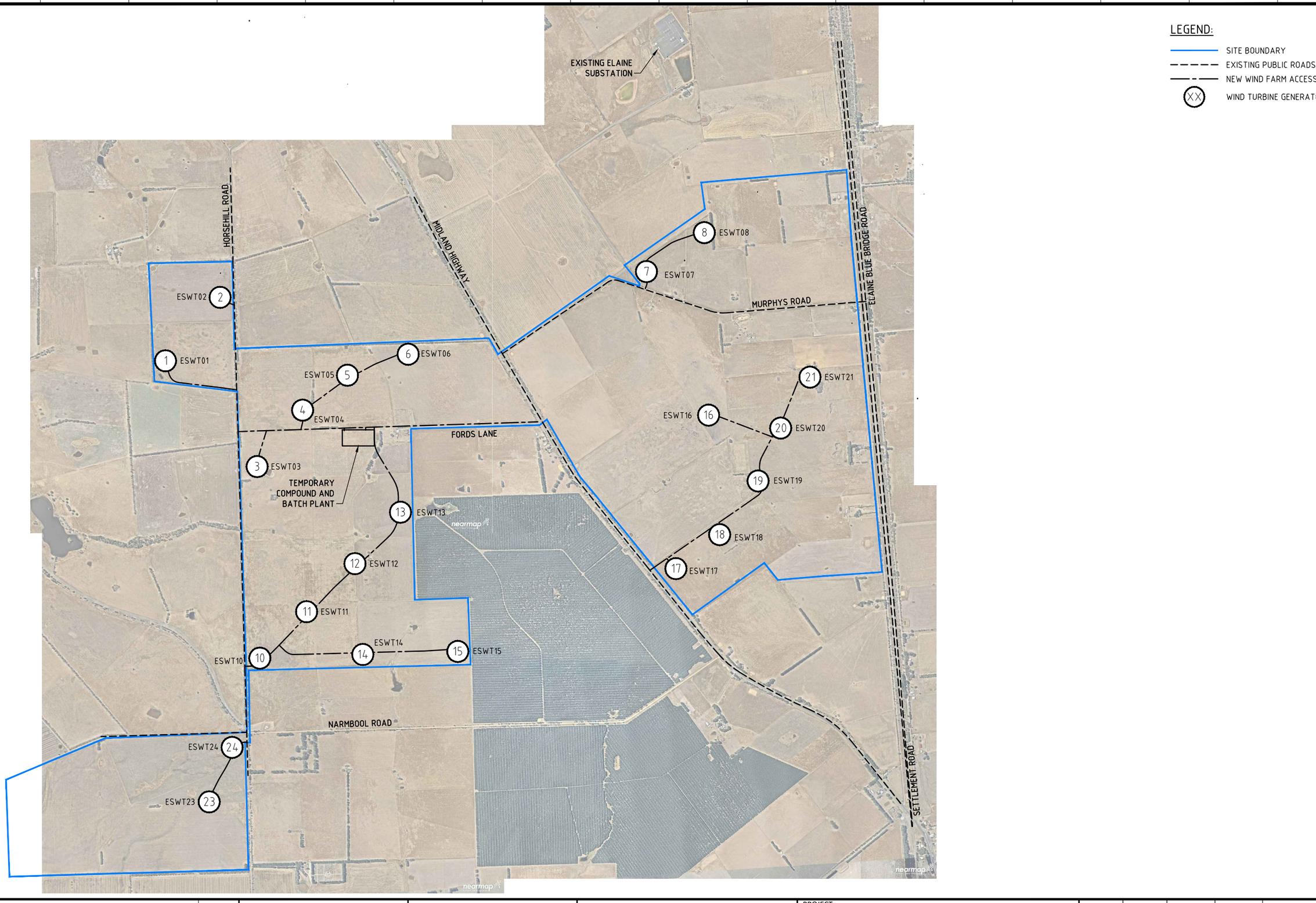
Appendix A

Wind Farm Layout



No	DESCRIPTION	DATE
–	FOR INFORMATION	10/11/2017

REVISION HISTORY

MACQUARIE

Vestas

Zenviron

PROJECT
LAL LAL WIND FARM

DRAWING TITLE
LAL LAL WIND FARM
ELAINE SITE OVERVIEW

DRAWN	AP	CHECKED	ZB	APPROVED	ZB
DRAWING STATUS	FOR INFORMATION				
SCALE	NTS	SIZE	A3		

DRAWING CODE
ELAINE SITE LAYOUT

REV
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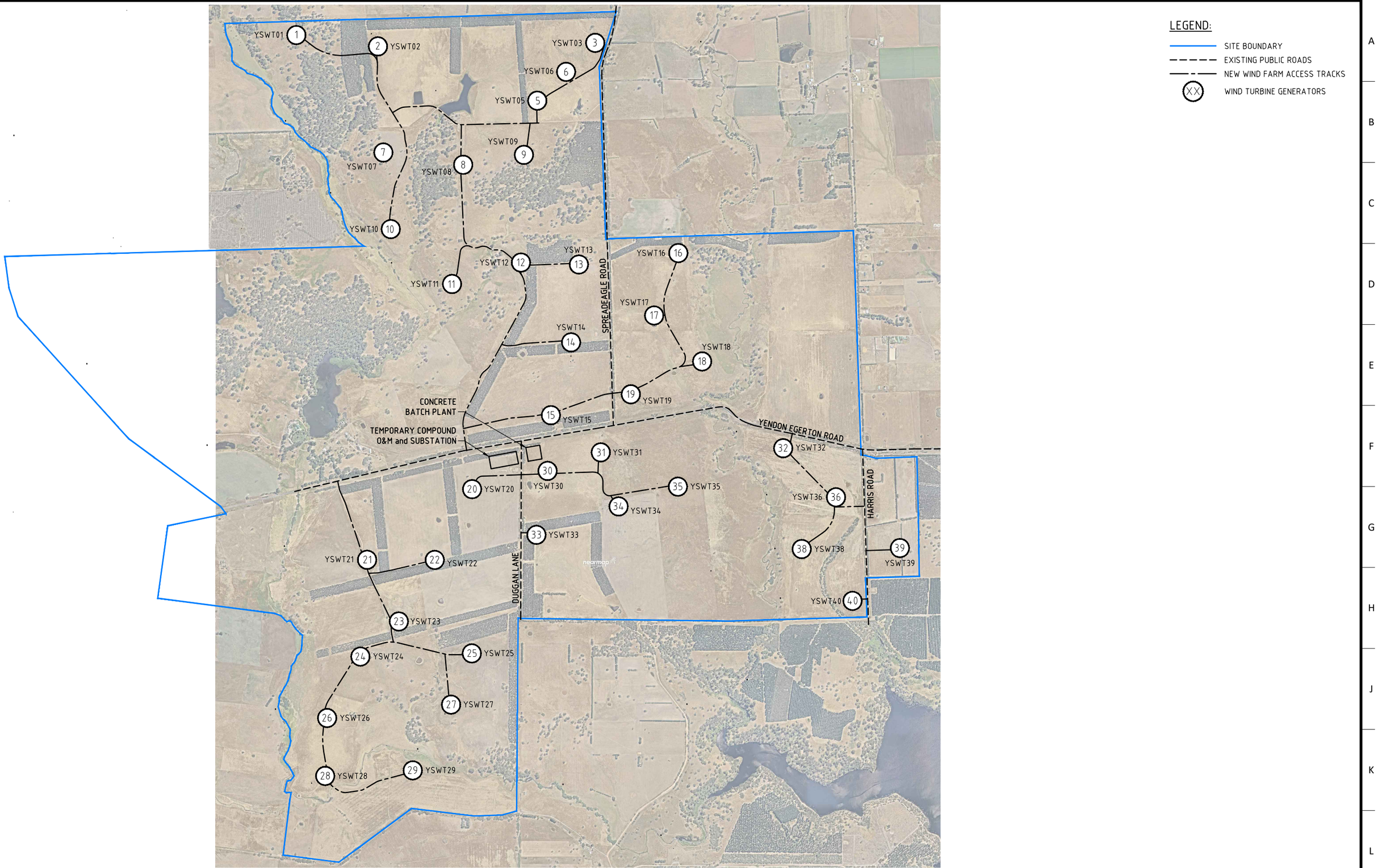

No	DESCRIPTION	DATE
A	FOR INFORMATION	29/08/2017

REVISION HISTORY

MACQUARIE

Vestas

Zenviron

PROJECT
LAL LAL WIND FARM

DRAWING TITLE
LAL LAL WIND FARM
YENDON SITE OVERVIEW

DRAWN	AP	CHECKED	ZB	APPROVED	ZB
DRAWING STATUS	FOR INFORMATION				
SCALE	NTS	SIZE	A3		

DRAWING CODE
YENDON SITE OVERVIEW

REV
-

Appendix B

Pre-construction Noise Assessment Report

Lal Lal Wind Farm

Pre-construction Noise Assessment

S5464C6

April 2018

sonus.

Prepared by	**Reviewed by**
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TABLE OF CONTENTS

GLOSSARY

A weighting	Frequency adjustment representing the response of the human ear.
Ambient noise level	Noise level in the absence of the noise from the wind farm.
dB(A)	A weighted noise level measured in decibels.
L_{A90}	The A weighted sound pressure level that is exceeded for 90 per cent of the time over which a given sound is measured. The L_{A90} measured over a 10 minute time period is commonly termed "background sound level" and "post-installation sound level" with respect to wind farms
L_{Aeq}	The A weighted equivalent continuous noise level – the energy-average of noise levels occurring over a measurement period.
NZS6808:2010	New Zealand Standard NZS 6808:2010 Acoustics – The assessment and measurement of sound from wind turbine generators
May 2013 UK IOA Good Practice Guide	UK Institute of Acoustics IOA A Good Practice Guide To The Application Of Etsu-R-97 For The Assessment And Rating Of Wind Turbine Noise

1 INTRODUCTION

An environmental noise assessment at the planning approval stage of the Lal Lal Wind Farm in Victoria was conducted by Marshall Day. The project was granted approval for the operation and construction of the Wind Farm subject to a number of conditions.

Following approval, background noise monitoring was conducted by Marshall Day and is summarised in the draft report with reference "Report No.001 01Draft 20170649". The background noise report summarises the measured background noise levels at 7 locations and provides the operational environmental noise criteria at these locations.

This report summarises an assessment of the prediction of noise from the proposed operation of 60 Vestas V136, 3.8MW turbines. The assessment includes:

- Prediction of the noise from the proposed wind farm using the ISO9613.2 noise model and the inputs recommended by the IOA Good Practice Guide;
- Prediction of the noise from the wind farm when operating under the curtailment strategy proposed by Vestas using the following noise models:
    - CONCAWE;
    - ISO9613.2 noise model using the IOA inputs; and
    - ISO9613.2 using hard ground.

The Planning Permit requires a Noise Compliance Assessment following the construction of the wind farm as well as requirements related to Noise Compliance Enforcement. Therefore, irrespective of the accuracy of the noise models, the wind farm will be required to comply with the noise criteria of the permit.

2 LOCATION OF THE WIND FARM AND THE SURROUNDING RESIDENCES

The coordinates of the final turbine layout and the residences in the vicinity of the wind farm are provided in Table 1 and Table 2, respectively.

The residences in the vicinity of the wind farm are also identified in the map provided as Appendix A.

Table 1: Coordinates of turbines.

Turbine ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
ESWT01	233512	5817821
ESWT02	233853	5818217
ESWT03	234084	5817161
ESWT04	234368	5817513
ESWT05	234648	5817731
ESWT06	235028	5817842
ESWT07	236515	5818378
ESWT08	236876	5818621
ESWT10	234101	5815965
ESWT11	234393	5816255
ESWT12	234695	5816555
ESWT13	234979	5816876
ESWT14	234744	5815988
ESWT15	235337	5816007
ESWT16	236903	5817482
ESWT17	236699	5816524
ESWT18	236972	5816736
ESWT19	237212	5817071
ESWT20	237353	5817401
ESWT21	237536	5817719
ESWT23	233785	5815068
ESWT24	233928	5815408
YSWT01	235749	5834082
YSWT02	236335	5834001
YSWT03	237895	5834026
YSWT05	237479	5833611
YSWT06	237758	5833776
YSWT07	236374	5833239
YSWT08	236947	5833151
YSWT09	237383	5833222
YSWT10	236427	5832689

Turbine ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
YSWT11	236867	5832295
YSWT12	237362	5832449
YSWT13	237778	5832435
YSWT14	237721	5831776
YSWT15	237577	5831353
YSWT16	238492	5832517
YSWT17	238318	5832069
YSWT18	238663	5831739
YSWT19	238151	5831503
YSWT20	237011	5830822
YSWT21	236257	5830315
YSWT22	236743	5830314
YSWT23	236485	5829872
YSWT24	236209	5829620
YSWT25	237009	5829643
YSWT26	235970	5829179
YSWT27	236860	5829275
YSWT28	235956	5828763
YSWT29	236585	5828803
YSWT30	237553	5830953
YSWT31	237935	5831086
YSWT32	239245	5831116
YSWT33	237473	5830494
YSWT34	238063	5830698
YSWT35	238489	5830840
YSWT36	239624	5830764
YSWT38	239378	5830392
YSWT39	240083	5830399
YSWT40	239743	5830020

Table 2: Coordinates of residences

Residence ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
Associated Residences		
J17aa	235026.4	5817386
L17aa	237170	5817965
L17ab	237848	5817275
K31aa	236084	5831076
K31ab	236079	5831300
J31aa	235760	5831259
H20aa	233938	5820296
Rented		
N31ac	239898.7	5831041
Residences		
N31ab	239974	5831555
M29aa	238304	5829565
K34aa	236976.3	5834575
H18aa	233207.2	5818510
N31aa	239978.7	5831899
N32aa	239833.1	5832255
N32ab	239817	5832604
N32ac	239814.2	5832666
K15aa	236990	5815534
N33aa	239620	5833196
P30aa	241058.8	5830668
L28aa	237842.2	5828237
N33ab	239458.4	5833703
G16aa	232610	5816865
M18ae	238478	5818196
K35aa	236864.4	5835269
P30ad	241164.8	5830144
L27aa	238045.6	5827952
M18ab	238255	5818880
P31aa	241199.9	5831198
G17aa	232345.3	5817030
I19aa	234649.2	5819546
M16aa	238711	5816662
L19ab	237955	5819290
P31ad	241340.5	5831005

Residence ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
M15ab	238167.1	5815748
I30aa	234369.9	5830429
M19aa	238258.1	5819036
M18ac	238563.7	5818677
M28ab	238839	5828082
M28ac	238695.6	5828012
N34ab	239883.4	5834034
P29aa	241408.3	5829909
P30ac	241508.6	5830462
H13aa	233813	5813799
J14aa	235220.9	5814079
I30ab	234180.6	5830398
J27aa	235616.8	5827287
M27aa	238703	5827889
M35aa	238580.4	5835430
N34aa	239792	5834345
L35aa	237163.8	5835779
N28ab	239097.9	5828072
M15aa	238188.8	5815465
N28aa	239302.9	5828034
P31ab	241306.4	5831925
P32ac	241262.9	5832122
M27ab	238599.1	5827680
L15ab	238005.1	5815238
N27ac	239176.1	5827983
I34ab	234242.8	5834747
J27ac	235447	5827175
N27aa	239690.3	5827927
G17ab	231912	5817260
H29am	233914.5	5829643
L15aa	237984.8	5815127
P32ab	241324.6	5832300
I19ab	234381	5819964
N27ab	239427.2	5827791
H29af	233913.4	5829172
P32aa	241365.4	5832402

Residence ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
M18aa	238991	5818801
M27ac	238215.1	5827144
H29an	233715.2	5829429
H30aj	233680.7	5830381
J35ab	235107.8	5835652
J13aa	235860	5813836
N16aa	239228	5816486
J35ac	235030.7	5835652
H30aa	233592.4	5830921
I34aa	234434.7	5835000
I35aa	234913.6	5835651
J35aa	235110.5	5835776
H30ab	233531.4	5830941
H29al	233567.3	5829612
H32ab	233671	5832873
M36aa	238306.6	5836114
J36ab	235983.5	5836166
L36aa	237769.7	5836240
M14at	238252.3	5814930
O34aa	240172	5834871
L36ab	237563.9	5836300
L36ac	237539.5	5836311
H29aj	233459.2	5829807
H29ak	233468.5	5829691
H30ac	233451.6	5830958
H30ad	233422	5830922
H30ai	233426.5	5830360
L14aa	237310	5814264
J26ae	235463.2	5826697
I27af	234434.9	5827307
M14ar	238296	5814855
P31ac	241554	5831622
I35ab	234611.7	5835622
K13aa	236685	5813872
L26aa	237935.4	5826662
M36ab	238459.8	5836223
M36ac	238812.1	5836105

Residence ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
J26ad	235384.6	5826639
J36ac	235435.9	5836142
M14ac	238232	5814722
M14ad	238317.6	5814804
M36ad	238797.7	5836127
L36ae	237510.9	5836472
N35ab	239292	5835907
I27ad	234362.5	5827196
I27ag	234238.7	5827357
L20aa	237780	5820400
L36ad	237379.4	5836503
M19ab	238798	5819663
N35aa	239277.2	5836002
N35ae	239675.2	5835709
L20ac	237936.9	5820346
I35ac	234281.2	5835490
J26af	235218.9	5826618
L36ag	237356.7	5836562
H33ab	233337.8	5833421
N15af	239378	5815872
I27ae	234162	5827265
J36aa	235873.2	5836468
L26ad	237528.5	5826302
M20ab	238366	5820167
I26aa	234665.1	5826747
O35aa	240436.7	5835222
H29ab	233080.5	5829583
H29ad	233076.8	5829668
H29ai	233164	5829118
I26ab	234511.1	5826717
H29aa	233054.4	5829373
J26ac	235365.5	5826279
L26ah	237045	5826077
I26ah	234300.8	5826908
K26aa	236957.9	5825970
K26ab	236724.4	5826007
K26ac	236503.8	5826014

Residence ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
K25ac	236534.9	5825960
Unoccupied		
I34ac	234532	5834258
N16ab	239115	5816724
N35ah	239675.9	5835116
M14aa	238224	5814793
M14ae	238340	5814775
O35ag	240160	5835262
M14af	238337	5814709
M14ag	238360	5814694
M14au	238398	5814727
M14aq	238493.7	5814752
K25ae	236450.7	5825946
I34ac	234532	5834258
Unknown		
J17ab	235914.1	5817261
Unnamed House 1	239833.7	5832362
L18aa	237913	5818705
I14aa	234313.3	5814053
G17ac	232414.4	5817058
G17ad	232418	5817031
M15ad	238159	5815955
N34ac	239763.2	5833769
M19ae	238418.3	5818896
I28aa	234788	5827918
H14aa	232224	5814915
I34ad	234425.8	5834954
H30al	233716	5830656
M36af	238209.7	5836023
J36ad	236280.4	5836157
Unnamed House 2	235062.2	5827020

Residence ID	Coordinates (GDA 94 MGA Zone 54)	
	Easting	Northing
L36af	237809.6	5836231
N15ah	239080.7	5815898
M15ac	238970.7	5815742
M14ba	238373.8	5815007
M14as	238273.5	5814898
H30ak	233418.5	5830219
H30am	233400.7	5830328
Unnamed House 3	238839.1	5836073
Unnamed House 4	234160.3	5827493
M20aa	238027	5820287
M14az	238260.1	5814597
H29ac	233199	5829657
M14ah	238355	5814674
Unnamed House 5	234399.5	5827110
J26aa	235788.3	5826368
L20ab	237875	5820448
N15af	238875.8	5815169
Unnamed House 6	235786.7	5826361
H29ae	233088.9	5829861
N15ad	239200	5815479
Unnamed House 7	237515	5826262
L20ad	237785.6	5820610
M20am	238009.8	5820533
M20an	238062.7	5820515
I27ah	235953.7	5826108
Unnamed House 8	237099.8	5826067
Unnamed House 9	237041.3	5825994
Unnamed House 10	238884.3	5826477
Unnamed House 11	236510.5	5826020
Unnamed House 12	236523.6	5826016

3 RELEVANT NOISE LIMITS

The Permit details the relevant noise limits as follows:

NOISE LIMITS

22. Construction of the wind energy facility must comply with noise criteria specified in the EPA *Noise Control Guidelines, Construction and Demolition Site Noise*, Publication 1254, October 2008 at any dwelling existing on land in the vicinity of the proposed wind energy facility as at the date of the issue of this permit to the satisfaction of the Minister for Planning.

23. Except as provided below in this condition, the operation of the wind energy facility must comply with New Zealand Standard 6808:2010, Acoustics – Wind Farm Noise (the Standard) as modified by this condition to the satisfaction of the Minister for Planning.

    In determining compliance the following requirements apply:

    a) The operator must ensure that at any wind speed, wind farm sound levels, determined in accordance with the Standard at noise sensitive locations (as defined in the Standard) do not exceed a noise limit of 40dB LA90,10min or background (LA90,10min) plus 5dB, whichever is greater.
    b) Compliance must be assessed separately for all-time and night time. For the purpose of this requirement, night time is defined as 10.00pm to 7.00am, and
    c) Where special audible characteristics, including tonality, impulsive sound or excessive amplitude modulation occur, the measured noise level with the identified special audible characteristics will be modified by applying a penalty of up to + 6 dB L90 in accordance with section 5.4 of the Standard.

    Any dwelling on the subject land may be exempt from this condition. This exemption will be given effect through an agreement with the landowner and must be registered on title, unless varied through the written consent of the Minister for Planning. Such dwellings will be known as host dwellings.

4 NOISE PREDICTION MODEL

4.1 ISO 9613.2 Noise Prediction Model Using IOA Inputs

Noise predictions were conducted in accordance with the propagation model, ISO 9613-2:1996 "Acoustics – Attenuation of sound during propagation outdoors" (ISO 9613). ISO 9613 is known as a downwind model, which means that its assessment approach enables the conservative assumption of a receiver being downwind of all noise sources (that is, the wind being in multiple directions from each turbine to the receiver, even when turbines are on the opposite side of a receiver). The model inputs have been taken from the May 2013 UK IOA Good Practice Guide, including:

- Warranted sound power level data provided by Senvion;
- 10°C temperature;
- 70% relative humidity;
- 50% acoustically hard ground and 50% acoustically soft ground;
- barrier attenuation of no greater than 2 dB(A);
- 4m receiver height; and,
- Application of a 3 dB(A) correction where a "concave" ground profile exists as defined by the Institute of Acoustics[1].

No allowance (increase or decrease in noise prediction) has been made for the wake turbulence from a turbine on a downwind turbine. This is because having a turbine upwind tends to reduce the wind speed at downwind turbines and therefore also reduces the noise level. Cooper and Evans[2] conducted noise measurements of a turbine which was influenced by the wake of an upwind turbine. The paper concluded, "the data gathered as part of this assessment does not support the proposition that the wakes of adjacent turbines will increase the level of noise emissions from wind farms".

[1] Institute of Acoustics, "*A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*", May 2013
[2] Cooper J and Evans T, "*Influence of upwind turbines on wind turbine sound power output*", Australian Acoustical Society Proceedings of Acoustics 2012

4.2 Warranted Sound Power Levels

The final turbine selection is the Vestas 3.8MW wind turbine with a hub height of 93m above ground level and serrated blades. The overall sound power levels and one-third octave band spectra are provided in the Vestas document: *V136-3.8 MW Third Octave Noise Emission "*DMS 0071-6683_V02*".* The Sound Power levels in the document have been adjusted by subtracting 2 dB(A) to convert the average (L_{eq}) levels to L_{90} levels in accordance with NZS6808:2010 and IOA recommendations.

Table 3 summarises the data used for the turbines in their normal operating mode.

Table 3: 1/3 Octave Band Sound Power Levels for Vestas 3.8MW turbine (dB(A)) normal operating mode

Hub Height Wind Speed	1/3 Octave Band Centre Frequency																											Overall
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
3 m/s	45.2	49.8	54.3	58.5	62.1	65.5	68.6	71.3	73.6	75.7	77.3	78.6	79.7	80.3	80.7	80.6	80.3	79.6	78.6	77.1	75.4	73.4	71	68.1	65.1	61.7	57.8	53.8	90.2
4 m/s	44.6	49.3	53.9	58.2	62	65.5	68.7	71.4	73.8	76	77.7	79	80	80.7	81	81	80.6	79.9	78.8	77.3	75.5	73.4	70.9	68	64.8	61.3	57.2	53.1	90.5
5 m/s	46.4	51.2	55.8	60.2	63.9	67.5	70.7	73.4	75.8	78	79.7	81	82.1	82.8	83.1	83	82.6	81.8	80.8	79.2	77.4	75.3	72.7	69.7	66.6	63	58.9	54.7	92.5
6 m/s	49.7	54.5	59	63.3	67	70.5	73.8	76.4	78.8	81	82.6	84	85	85.6	85.9	85.9	85.5	84.7	83.6	82.1	80.3	78.2	75.7	72.7	69.6	66	61.9	57.7	95.4
7 m/s	53.1	57.8	62.3	66.6	70.3	73.8	77	79.6	81.9	84.1	85.8	87.1	88.1	88.7	89	89	88.5	87.8	86.7	85.2	83.4	81.3	78.8	75.8	72.7	69.1	65	60.9	98.5
8 m/s	56.4	61.1	65.5	69.8	73.4	76.8	80	82.6	84.9	87.1	88.7	90	91	91.6	91.9	91.8	91.4	90.7	89.6	88.1	86.3	84.2	81.7	78.8	75.7	72.2	68.2	64.1	101.4
9 m/s	58.8	63.4	67.8	72	75.6	79	82.1	84.7	87	89.1	90.7	92	93	93.6	93.9	93.8	93.4	92.7	91.6	90.1	88.4	86.3	83.8	80.9	77.9	74.4	70.4	66.4	103.4
10 m/s	59.2	63.7	68.1	72.3	75.8	79.2	82.3	84.9	87.1	89.2	90.8	92.1	93	93.7	94	93.9	93.5	92.8	91.7	90.2	88.5	86.5	84	81.2	78.1	74.7	70.8	66.7	103.5
11 m/s	59.5	64	68.3	72.5	76	79.3	82.4	84.9	87.1	89.2	90.8	92.1	93	93.7	93.9	93.9	93.5	92.8	91.7	90.2	88.6	86.6	84.2	81.3	78.3	74.9	71	67.1	103.5
12 m/s	60	64.5	68.7	72.8	76.2	79.5	82.5	85	87.2	89.3	90.8	92	93	93.6	93.9	93.8	93.4	92.8	91.8	90.3	88.7	86.7	84.4	81.6	78.7	75.3	71.5	67.6	103.5
13 m/s	60.4	64.8	69	73	76.4	79.6	82.6	85	87.2	89.3	90.8	92	92.9	93.6	93.9	93.8	93.4	92.8	91.8	90.3	88.7	86.8	84.5	81.7	78.9	75.6	71.8	68	103.5

4.3 Predicted Wind Turbine Operational Noise

The predicted L_{90} noise levels at residences in the vicinity of the wind farm are provided in Table 4.

Table 4: Predicted noise levels from wind turbine operation.

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
J17aa	Yes	32	32	34	37	40	43	45	45	45	45	45
L17aa	Yes	31	31	33	36	39	42	44	44	44	44	44
N31ac	Yes	31	31	33	36	39	42	44	44	44	44	44
L17ab	Yes	30	30	32	35	38	41	43	43	43	43	43
K31aa	Yes	28	28	30	33	36	39	41	41	41	41	41
J17ab	Yes	27	28	30	33	36	39	41	41	41	41	41
K31ab	Yes	27	27	29	32	35	38	40	40	40	40	40
N31ab	No	27	27	29	32	35	38	40	40	40	40	40
M29aa	No	26	27	29	32	35	38	40	40	40	40	40
K34aa	No	26	27	29	31	35	37	39	40	40	40	40
H18aa	No	26	26	28	31	34	37	39	39	39	39	39
J31aa	Yes	26	26	28	31	34	37	39	39	39	39	39
N31aa	No	25	25	27	30	33	36	38	38	38	38	38
N32aa	No	25	25	27	30	33	36	38	38	38	38	38
Unnamed House 1	No	24	25	27	30	33	36	38	38	38	38	38
N32ab	No	24	24	26	29	32	35	37	37	37	37	37
L18aa	No	24	24	26	29	32	35	37	37	37	37	37
N32ac	No	24	24	26	29	32	35	37	37	37	37	37
K15aa	No	23	24	26	29	32	35	37	37	37	37	37
N33aa	No	23	23	25	28	31	34	36	36	36	36	36
P30aa	No	23	23	25	28	31	34	36	36	36	36	36
L28aa	No	23	23	25	28	31	34	36	36	36	36	36
N33ab	No	22	23	25	28	31	34	36	36	36	36	36
G16aa	No	22	23	25	28	31	34	36	36	36	36	36
M18ae	No	22	23	25	28	31	34	36	36	36	36	36
K35aa	No	22	22	24	27	30	33	35	35	35	35	35
P30ad	No	22	22	24	27	30	33	35	35	35	35	35
I14aa	No	21	22	24	27	30	33	35	35	35	35	35
G17ac	No	21	22	24	27	30	33	35	35	35	35	35
G17ad	No	21	22	24	27	30	33	35	35	35	35	35
M15ad	No	21	22	24	27	30	33	35	35	35	35	35
N34ac	No	21	21	23	26	29	32	34	34	34	34	34

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
L27aa	No	21	21	23	26	29	32	34	34	34	34	34
M18ab	No	21	21	23	26	29	32	34	34	34	34	34
P31aa	No	21	21	23	26	29	32	34	34	34	34	34
G17aa	No	21	21	23	26	29	32	34	34	34	34	34
I19aa	No	21	21	23	26	29	32	34	34	34	34	34
M16aa	No	21	21	23	26	29	32	34	34	34	34	34
L19ab	No	21	21	23	26	29	32	34	34	34	34	34
P31ad	No	21	21	23	26	29	32	34	34	34	34	34
M15ab	No	21	21	23	26	29	32	34	34	34	34	34
I30aa	No	20	21	23	26	29	32	34	34	34	34	34
M19aa	No	20	21	23	26	29	32	34	34	34	34	34
I34ac	No	20	21	23	26	29	32	34	34	34	34	34
M18ac	No	20	21	23	26	29	32	34	34	34	34	34
M19ae	No	20	21	23	25	29	32	34	34	34	34	34
M28ab	No	20	20	23	25	29	31	33	34	34	34	34
M28ac	No	20	20	22	25	29	31	33	34	34	34	34
N34ab	No	20	20	22	25	28	31	33	33	33	33	33
P29aa	No	20	20	22	25	28	31	33	33	33	33	33
P30ac	No	20	20	22	25	28	31	33	33	33	33	33
I28aa	No	20	20	22	25	28	31	33	33	33	33	33
H13aa	No	20	20	22	25	28	31	33	33	33	33	33
J14aa	No	20	20	22	25	28	31	33	33	33	33	33
I30ab	No	20	20	22	25	28	31	33	33	33	33	33
J27aa	No	20	20	22	25	28	31	33	33	33	33	33
M27aa	No	20	20	22	25	28	31	33	33	33	33	33
M35aa	No	20	20	22	25	28	31	33	33	33	33	33
N34aa	No	20	20	22	25	28	31	33	33	33	33	33
L35aa	No	19	20	22	25	28	31	33	33	33	33	33
N28ab	No	19	20	22	25	28	31	33	33	33	33	33
M15aa	No	19	20	22	25	28	31	33	33	33	33	33
N28aa	No	19	20	22	25	28	31	33	33	33	33	33
P31ab	No	19	20	22	25	28	31	33	33	33	33	33
P32ac	No	19	20	22	24	28	31	33	33	33	33	33
M27ab	No	19	19	21	24	27	30	32	33	33	33	33
L15ab	No	19	19	21	24	27	30	32	32	32	32	32
N27ac	No	19	19	21	24	27	30	32	32	32	32	32

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
I34ab	No	19	19	21	24	27	30	32	32	32	32	32
J27ac	No	19	19	21	24	27	30	32	32	32	32	32
N27aa	No	19	19	21	24	27	30	32	32	32	32	32
G17ab	No	19	19	21	24	27	30	32	32	32	32	32
H14aa	No	19	19	21	24	27	30	32	32	32	32	32
H29am	No	19	19	21	24	27	30	32	32	32	32	32
L15aa	No	19	19	21	24	27	30	32	32	32	32	32
N16ab	No	19	19	21	24	27	30	32	32	32	32	32
P32ab	No	19	19	21	24	27	30	32	32	32	32	32
I19ab	No	19	19	21	24	27	30	32	32	32	32	32
N27ab	No	19	19	21	24	27	30	32	32	32	32	32
H29af	No	19	19	21	24	27	30	32	32	32	32	32
P32aa	No	18	19	21	24	27	30	32	32	32	32	32
I34ad	No	18	19	21	24	27	30	32	32	32	32	32
H30al	No	18	18	20	23	26	29	31	31	31	31	31
M18aa	No	18	18	20	23	26	29	31	31	31	31	31
M27ac	No	18	18	20	23	26	29	31	31	31	31	31
N35ah	No	18	18	20	23	26	29	31	31	31	31	31
H29an	No	18	18	20	23	26	29	31	31	31	31	31
H30aj	No	18	18	20	23	26	29	31	31	31	31	31
J35ab	No	18	18	20	23	26	29	31	31	31	31	31
J13aa	No	18	18	20	23	26	29	31	31	31	31	31
N16aa	No	18	18	20	23	26	29	31	31	31	31	31
M36af	No	18	18	20	23	26	29	31	31	31	31	31
J35ac	No	18	18	20	23	26	29	31	31	31	31	31
J36ad	No	18	18	20	23	26	29	31	31	31	31	31
H30aa	No	18	18	20	23	26	29	31	31	31	31	31
I34aa	No	18	18	20	23	26	29	31	31	31	31	31
I35aa	No	17	18	20	23	26	29	31	31	31	31	31
J35aa	No	17	18	20	23	26	29	31	31	31	31	31
Unnamed House 2	No	18	18	20	23	26	29	31	31	31	31	31
H30ab	No	17	18	20	23	26	29	31	31	31	31	31
H29al	No	17	18	20	23	26	29	31	31	31	31	31
H32ab	No	17	18	20	23	26	29	31	31	31	31	31
M36aa	No	17	18	20	23	26	29	31	31	31	31	31
L36af	No	17	18	20	23	26	29	31	31	31	31	31

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N15ah	No	17	18	20	23	26	29	31	31	31	31	31
J36ab	No	17	18	20	23	26	29	31	31	31	31	31
L36aa	No	17	18	20	23	26	29	31	31	31	31	31
M14at	No	17	18	20	23	26	29	31	31	31	31	31
M15ac	No	17	18	20	23	26	29	31	31	31	31	31
O34aa	No	17	18	20	23	26	29	31	31	31	31	31
M14ba	No	17	18	20	22	26	29	31	31	31	31	31
L36ab	No	17	18	20	23	26	29	31	31	31	31	31
L36ac	No	17	18	20	22	26	29	31	31	31	31	31
H20aa	Yes	17	17	19	22	26	28	30	31	31	31	31
H29aj	No	17	17	19	22	26	28	30	31	31	31	31
H29ak	No	17	17	19	22	26	28	30	31	31	31	31
H30ac	No	17	17	19	22	26	28	30	31	31	31	31
H30ad	No	17	17	19	22	25	28	30	31	31	31	31
H30ai	No	17	17	19	22	25	28	30	31	31	31	31
L14aa	No	17	17	19	22	25	28	30	31	31	31	31
M14as	No	17	17	19	22	26	28	30	31	31	31	31
H30ak	No	17	17	19	22	25	28	30	31	31	31	31
J26ae	No	17	17	19	22	25	28	30	30	30	30	30
H30am	No	17	17	19	22	25	28	30	30	30	30	30
I27af	No	17	17	19	22	25	28	30	30	30	30	30
M14aa	No	17	17	19	22	25	28	30	30	30	30	30
M14ar	No	17	17	19	22	25	28	30	30	30	30	30
P31ac	No	17	17	19	22	25	28	30	30	30	30	30
I35ab	No	17	17	19	22	25	28	30	30	30	30	30
K13aa	No	17	17	19	22	25	28	30	30	30	30	30
L26aa	No	17	17	19	22	25	28	30	30	30	30	30
M36ab	No	17	17	19	22	25	28	30	30	30	30	30
M36ac	No	17	17	19	22	25	28	30	30	30	30	30
Unnamed House 3	No	17	17	19	22	25	28	30	30	30	30	30
J26ad	No	17	17	19	22	25	28	30	30	30	30	30
J36ac	No	17	17	19	22	25	28	30	30	30	30	30
M14ac	No	17	17	19	22	25	28	30	30	30	30	30
M14ad	No	17	17	19	22	25	28	30	30	30	30	30
M36ad	No	17	17	19	22	25	28	30	30	30	30	30
L36ae	No	17	17	19	22	25	28	30	30	30	30	30

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
M14ae	No	17	17	19	22	25	28	30	30	30	30	30
N35ab	No	17	17	19	22	25	28	30	30	30	30	30
Unnamed House 4	No	17	17	19	22	25	28	30	30	30	30	30
I27ad	No	16	17	19	22	25	28	30	30	30	30	30
I27ag	No	17	17	19	22	25	28	30	30	30	30	30
L20aa	No	17	17	19	22	25	28	30	30	30	30	30
L36ad	No	17	17	19	22	25	28	30	30	30	30	30
O35ag	No	17	17	19	22	25	28	30	30	30	30	30
M14af	No	16	17	19	22	25	28	30	30	30	30	30
M19ab	No	16	17	19	22	25	28	30	30	30	30	30
M20aa	No	16	17	19	22	25	28	30	30	30	30	30
N35aa	No	16	17	19	22	25	28	30	30	30	30	30
N35ae	No	16	17	19	22	25	28	30	30	30	30	30
L20ac	No	16	17	19	22	25	28	30	30	30	30	30
M14az	No	16	17	19	22	25	28	30	30	30	30	30
H29ac	No	16	17	19	22	25	28	30	30	30	30	30
I35ac	No	16	17	19	22	25	28	30	30	30	30	30
J26af	No	16	17	19	22	25	28	30	30	30	30	30
M14ag	No	16	17	19	22	25	28	30	30	30	30	30
M14ah	No	16	17	19	22	25	28	30	30	30	30	30
M14au	No	16	17	19	22	25	28	30	30	30	30	30
L36ag	No	16	17	19	22	25	28	30	30	30	30	30
Unnamed House 5	No	16	17	19	22	25	28	30	30	30	30	30
H33ab	No	16	16	19	21	25	27	30	30	30	30	30
J26aa	No	16	17	19	22	25	28	30	30	30	30	30
L20ab	No	16	17	19	21	25	27	30	30	30	30	30
N15af	No	16	17	19	21	25	27	30	30	30	30	30
N15af	No	16	17	19	22	25	28	30	30	30	30	30
Unnamed House 6	No	16	17	19	21	25	28	30	30	30	30	30
I27ae	No	16	16	18	21	25	27	29	30	30	30	30
J36aa	No	16	16	18	21	25	27	29	30	30	30	30
L26ad	No	16	16	18	21	24	27	29	30	30	30	30
M14aq	No	16	16	19	21	25	27	29	30	30	30	30
M20ab	No	16	16	18	21	24	27	29	30	30	30	30
H29ae	No	16	16	18	21	24	27	29	29	29	29	29
I26aa	No	16	16	18	21	24	27	29	29	29	30	30

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N15ad	No	16	16	18	21	24	27	29	29	29	29	29
O35aa	No	16	16	18	21	24	27	29	29	29	29	29
Unnamed House 7	No	16	16	18	21	24	27	29	29	29	29	29
H29ab	No	16	16	18	21	24	27	29	29	29	29	29
H29ad	No	16	16	18	21	24	27	29	29	29	29	29
H29ai	No	16	16	18	21	24	27	29	29	29	29	29
I26ab	No	16	16	18	21	24	27	29	29	29	29	29
L20ad	No	16	16	18	21	24	27	29	29	29	29	29
M20am	No	16	16	18	21	24	27	29	29	29	29	29
H29aa	No	16	16	18	21	24	27	29	29	29	29	29
M20an	No	16	16	18	21	24	27	29	29	29	29	29
J26ac	No	16	16	18	21	24	27	29	29	29	29	29
L26ah	No	16	16	18	21	24	27	29	29	29	29	29
I27ah	No	16	16	18	21	24	27	29	29	29	29	29
Unnamed House 8	No	16	16	18	21	24	27	29	29	29	29	29
Unnamed House 9	No	15	16	18	21	24	27	29	29	29	29	29
Unnamed House 10	No	15	16	18	21	24	27	29	29	29	29	29
I26ah	No	16	16	18	21	24	27	29	29	29	29	29
K26aa	No	16	16	18	21	24	27	29	29	29	29	29
K26ab	No	15	16	18	21	24	27	29	29	29	29	29
K26ac	No	15	16	18	21	24	27	29	29	29	29	29
Unnamed House 11	No	16	16	18	21	24	27	29	29	29	29	29
Unnamed House 12	No	16	16	18	21	24	27	29	29	29	29	29
K25ac	No	15	16	18	21	24	27	29	29	29	29	29
K25ae	No	15	16	18	21	24	27	29	29	29	29	29

5 VESTAS CURTAILMENT STRATEGY

Notwithstanding the predicted compliance using the IOA prediction methodology, Vestas has also devised a curtailment strategy to further reduce noise from the wind farm. The curtailment strategy involves operating selected turbines in a noise reduced mode at the wind speeds and wind directions with the highest predicted noise levels.

The noise propagation in the various wind directions has been determined based on measured propagation in different directions[3] for the four noise reduced modes summarised in Tables 6 through to 9 below, and the following Vestas Documents:

- Project-Specific Performance Specification for "Lal Lal" V136-3.80 MW 50/60 Hz (Low HH), "0067-3747 V04"
- V136-3.45 MW Third octave noise emission "DMS 0055-9919_V04"

The Sound Power levels in these documents have been adjusted by subtracting 2 dB(A) to convert the average (L_{eq}) levels to L_{90} levels in accordance with NZS6808:2010 and IOA recommendations.

[3] Evans T and Cooper J, "*Influence of wind direction on noise emission and propagation from wind turbines*" Proceedings of Acoustics 2012 - Fremantle

Table 7: 1/3 Octave Band Sound Power Levels for Vestas 3.8MW turbine (dB(A)) noise reduced power mode (S01)

Hub Height Wind Speed	1/3 Octave Band Centre Frequency																											Overall
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
3 m/s	45.9	53.0	56.4	58.6	64.0	72.4	74.2	73.3	79.2	75.3	75.4	79.5	82.0	73.8	74.1	77.0	76.7	82.8	78.6	77.6	76.5	74.5	72.5	70.9	62.3	60.5	59.7	56.5	90.2
4 m/s	45.6	52.5	55.4	59.0	64.2	72.0	75.1	73.2	78.1	76.8	76.3	78.8	81.5	75.1	75.3	77.4	77.9	82.9	79.8	78.7	77.3	75.4	73.1	70.8	62.4	59.3	59.0	57.4	90.5
5 m/s	47.8	54.6	57.1	61.5	66.3	72.9	76.6	75.0	78.5	79.3	78.7	80.5	82.5	78.3	78.5	79.8	80.2	84.2	82.2	81.2	79.8	78.1	75.4	72.5	64.7	59.8	58.0	56.4	92.4
6 m/s	51.4	57.9	60.5	65.0	69.6	74.8	78.5	77.8	80.3	81.9	81.8	83.5	84.7	82.2	82.6	83.3	83.5	86.5	85.5	84.6	83.3	81.7	78.8	75.3	68.2	62.1	58.2	55.8	95.4
7 m/s	54.7	60.9	63.5	68.3	72.6	76.7	80.4	80.5	82.0	84.5	84.8	86.2	86.6	85.8	86.6	86.7	86.9	88.8	88.9	88.1	86.7	85.2	82.2	78.1	71.5	64.2	58.4	55.4	98.4
8 m/s	58.0	63.9	66.8	71.3	75.6	78.6	82.1	83.1	83.9	86.6	87.5	89.0	88.8	88.9	90.0	89.8	89.8	91.1	91.8	91.0	89.7	88.3	85.2	80.8	74.6	66.7	59.0	55.1	101.2
9 m/s	59.3	65.1	68.0	72.6	76.8	79.5	83.0	84.1	84.7	87.6	88.7	90.1	89.7	90.3	91.4	91.1	91.1	92.0	93.0	92.3	91.0	89.6	86.5	81.9	75.9	67.7	59.4	55.2	102.4
10 m/s	59.4	65.2	68.1	72.6	76.8	79.5	82.9	84.2	84.8	87.6	88.7	90.2	89.7	90.2	91.4	91.2	91.1	92.0	93.0	92.3	91.0	89.6	86.5	81.9	76.0	67.8	59.4	55.1	102.4
11 m/s	59.9	65.7	68.9	72.8	77.1	79.8	82.7	84.5	85.4	87.1	88.6	90.7	90.1	90.0	91.3	91.3	90.9	92.3	92.7	92.2	91.0	89.6	86.6	82.3	76.3	68.7	59.7	54.7	102.4
12 m/s	60.2	66.0	69.4	72.9	77.2	80.0	82.5	84.6	85.8	86.8	88.5	91.1	90.4	89.9	91.1	91.4	90.7	92.4	92.5	92.0	91.0	89.6	86.6	82.5	76.5	69.2	59.8	54.3	102.4
13 m/s	60.4	66.2	69.7	72.9	77.3	80.1	82.4	84.7	85.9	86.6	88.5	91.2	90.5	89.8	91.1	91.5	90.6	92.4	92.4	92.0	91.0	89.5	86.6	82.6	76.6	69.5	59.8	54.1	102.4

Table 8: 1/3 Octave Band Sound Power Levels for Vestas 3.8MW turbine (dB(A)) noise reduced power mode (S02)

Hub Height Wind Speed	1/3 Octave Band Centre Frequency																											Overall
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
3 m/s	45.9	53.0	56.4	58.6	64.0	72.4	74.2	73.3	79.2	75.3	75.4	79.5	82.0	73.8	74.1	77.0	76.7	82.8	78.6	77.6	76.5	74.5	72.5	70.9	62.3	60.5	59.7	56.5	90.2
4 m/s	45.6	52.5	55.4	59.0	64.2	72.0	75.1	73.2	78.1	76.8	76.3	78.8	81.5	75.1	75.3	77.4	77.9	82.9	79.8	78.7	77.3	75.4	73.1	70.8	62.4	59.3	59.0	57.4	90.5
5 m/s	47.8	54.6	57.1	61.5	66.3	72.9	76.6	75.0	78.5	79.3	78.7	80.5	82.5	78.3	78.5	79.8	80.2	84.2	82.2	81.2	79.8	78.1	75.4	72.5	64.7	59.8	58.0	56.4	92.4
6 m/s	51.4	57.9	60.5	65.0	69.6	74.8	78.5	77.8	80.3	81.9	81.8	83.5	84.7	82.2	82.6	83.3	83.5	86.5	85.5	84.6	83.3	81.7	78.8	75.3	68.2	62.1	58.2	55.8	95.4
7 m/s	54.7	60.9	63.5	68.3	72.6	76.7	80.4	80.5	82.0	84.5	84.8	86.2	86.6	85.8	86.6	86.7	86.9	88.8	88.9	88.1	86.7	85.2	82.2	78.1	71.5	64.2	58.4	55.4	98.4
8 m/s	57.7	63.7	66.5	71.1	75.4	78.5	82.1	82.9	83.8	86.5	87.3	88.8	88.7	88.7	89.7	89.6	89.6	90.9	91.6	90.8	89.5	88.1	85.0	80.6	74.4	66.6	59.1	55.3	101.0
9 m/s	58.1	64.0	66.7	71.5	75.8	78.7	82.4	83.2	83.9	87.1	87.9	89.0	88.8	89.4	90.4	90.1	90.3	91.2	92.2	91.4	90.0	88.6	85.5	80.9	74.8	66.6	59.0	55.4	101.5
10 m/s	58.3	64.2	67.1	71.6	75.9	78.8	82.3	83.3	84.1	86.9	87.8	89.2	89.0	89.3	90.4	90.1	90.2	91.3	92.1	91.4	90.0	88.6	85.5	81.0	74.9	66.9	59.1	55.2	101.5
11 m/s	58.9	64.7	67.9	71.8	76.1	79.1	82.0	83.6	84.6	86.4	87.7	89.8	89.3	89.1	90.2	90.3	89.9	91.5	91.8	91.2	90.0	88.6	85.6	81.4	75.3	67.8	59.2	54.5	101.5
12 m/s	59.2	65.1	68.4	71.9	76.3	79.3	81.8	83.8	85.0	86.0	87.6	90.2	89.6	88.9	90.2	90.5	89.8	91.6	91.6	91.1	90.0	88.6	85.7	81.6	75.5	68.4	59.3	53.9	101.5
13 m/s	59.4	65.3	68.7	72.0	76.4	79.3	81.6	83.9	85.2	85.8	87.6	90.3	89.7	88.9	90.1	90.5	89.7	91.6	91.5	91.1	90.0	88.6	85.7	81.7	75.6	68.6	59.2	53.6	101.5

Table 9: 1/3 Octave Band Sound Power Levels for Vestas 3.8MW turbine (dB(A)) noise reduced power mode (S03)

Hub Height Wind Speed	1/3 Octave Band Centre Frequency																											Overall
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
3 m/s	45.9	53.0	56.4	58.6	64.0	72.4	74.2	73.3	79.2	75.3	75.4	79.5	82.0	73.8	74.1	77.0	76.7	82.8	78.6	77.6	76.5	74.5	72.5	70.9	62.3	60.5	59.7	56.5	90.2
4 m/s	45.6	52.5	55.4	59.0	64.2	72.0	75.1	73.2	78.1	76.8	76.3	78.8	81.5	75.1	75.3	77.4	77.9	82.9	79.8	78.7	77.3	75.4	73.1	70.8	62.4	59.3	59.0	57.4	90.5
5 m/s	47.8	54.6	57.1	61.5	66.3	72.9	76.6	75.0	78.5	79.3	78.7	80.5	82.5	78.3	78.5	79.8	80.2	84.2	82.2	81.2	79.8	78.1	75.4	72.5	64.7	59.8	58.0	56.4	92.4
6 m/s	51.4	57.9	60.5	65.0	69.6	74.8	78.5	77.8	80.3	81.9	81.8	83.5	84.7	82.2	82.6	83.3	83.5	86.5	85.5	84.6	83.3	81.7	78.8	75.3	68.2	62.1	58.2	55.8	95.4
7 m/s	54.7	60.9	63.5	68.3	72.6	76.7	80.4	80.5	82.0	84.5	84.8	86.2	86.6	85.8	86.6	86.7	86.9	88.8	88.9	88.1	86.7	85.2	82.2	78.1	71.5	64.2	58.4	55.4	98.4
8 m/s	56.4	62.4	65.0	70.0	74.3	77.6	81.6	81.8	82.8	86.1	86.5	87.5	87.7	87.9	88.8	88.5	88.8	90.0	90.8	90.0	88.5	87.1	84.0	79.5	73.2	65.2	58.6	55.5	100.1
9 m/s	55.8	61.9	64.4	69.6	73.8	77.2	81.4	81.4	82.2	86.0	86.3	87.0	87.2	87.6	88.5	88.1	88.6	89.6	90.6	89.7	88.2	86.8	83.6	79.0	72.7	64.5	58.2	55.5	99.8
10 m/s	56.0	62.1	64.9	69.3	73.6	77.3	80.7	81.3	82.7	84.8	85.5	87.3	87.4	86.6	87.6	87.7	87.6	89.5	89.6	88.9	87.6	86.1	83.1	79.0	72.6	65.3	58.4	54.7	99.2
11 m/s	55.9	62.1	65.1	68.9	73.4	77.3	80.2	81.2	82.9	84.1	85.1	87.3	87.4	86.0	86.9	87.4	87.0	89.3	88.9	88.3	87.1	85.6	82.7	78.9	72.4	65.6	58.5	54.2	98.8
12 m/s	55.8	61.9	65.0	68.6	73.1	77.1	79.7	80.9	82.8	83.5	84.6	87.1	87.2	85.5	86.4	87.0	86.5	89.0	88.3	87.8	86.7	85.2	82.3	78.6	72.1	65.6	58.3	53.8	98.4
13 m/s	55.7	61.8	65.0	68.4	73.0	77.0	79.5	80.8	82.8	83.2	84.4	87.1	87.1	85.2	86.1	86.9	86.2	88.9	88.0	87.5	86.4	84.9	82.1	78.5	72.0	65.6	58.3	53.6	98.2

Table 10: 1/3 Octave Band Sound Power Levels for Vestas 3.8MW turbine (dB(A)) noise reduced power mode (S04)

Hub Height Wind Speed	1/3 Octave Band Centre Frequency																											Overall
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
3 m/s	45.9	53.0	56.4	58.6	64.0	72.4	74.2	73.3	79.2	75.3	75.4	79.5	82.0	73.8	74.1	77.0	76.7	82.8	78.6	77.6	76.5	74.5	72.5	70.9	62.3	60.5	59.7	56.5	90.2
4 m/s	45.6	52.5	55.4	59.0	64.2	72.0	75.1	73.2	78.1	76.8	76.3	78.8	81.5	75.1	75.3	77.4	77.9	82.9	79.8	78.7	77.3	75.4	73.1	70.8	62.4	59.3	59.0	57.4	90.5
5 m/s	47.8	54.6	57.1	61.5	66.3	72.9	76.6	75.0	78.5	79.3	78.7	80.5	82.5	78.3	78.5	79.8	80.2	84.2	82.2	81.2	79.8	78.1	75.4	72.5	64.7	59.8	58.0	56.4	92.4
6 m/s	51.3	57.8	60.4	64.9	69.5	74.7	78.4	77.7	80.2	81.8	81.7	83.4	84.6	82.1	82.5	83.2	83.4	86.4	85.4	84.5	83.2	81.6	78.7	75.2	68.1	62.0	58.1	55.7	95.3
7 m/s	52.9	59.3	62.3	65.8	70.5	75.7	78.4	78.8	81.7	81.5	82.0	84.9	85.7	82.3	82.9	84.1	83.5	87.2	85.4	84.8	83.7	82.1	79.4	76.4	69.2	63.9	58.7	54.9	95.9
8 m/s	53.2	59.6	62.9	65.8	70.6	76.1	78.2	79.0	82.2	81.1	81.9	85.3	86.0	82.0	82.6	84.1	83.2	87.4	85.0	84.6	83.6	82.0	79.4	76.6	69.4	64.6	59.1	54.7	95.9
9 m/s	53.4	59.9	63.3	65.8	70.7	76.3	78.1	79.1	82.6	80.8	81.8	85.6	86.3	81.7	82.4	84.1	83.0	87.5	84.8	84.4	83.5	81.8	79.3	76.8	69.5	65.1	59.4	54.6	95.9
10 m/s	53.5	60.0	63.4	65.8	70.7	76.3	78.0	79.2	82.8	80.7	81.7	85.6	86.4	81.7	82.3	84.1	82.9	87.5	84.7	84.3	83.4	81.8	79.3	76.8	69.5	65.2	59.5	54.6	95.9
11 m/s	53.5	60.0	63.4	65.8	70.7	76.4	78.0	79.2	82.8	80.6	81.7	85.7	86.4	81.7	82.3	84.1	82.9	87.6	84.7	84.3	83.4	81.8	79.3	76.8	69.5	65.3	59.5	54.6	95.9
12 m/s	53.6	60.1	63.6	65.8	70.7	76.5	77.9	79.3	83.0	80.5	81.7	85.8	86.5	81.5	82.2	84.1	82.8	87.6	84.5	84.2	83.4	81.7	79.3	76.9	69.6	65.5	59.7	54.5	95.9
13 m/s	53.6	60.0	63.5	65.8	70.7	76.4	78.0	79.2	82.9	80.6	81.7	85.7	86.4	81.6	82.2	84.1	82.9	87.6	84.6	84.3	83.4	81.8	79.3	76.8	69.6	65.4	59.6	54.5	95.9

The Vestas Strategies are summarised in Tables 13 and 14 below:

Table 21: Vestas Curtailment Strategy 24 hour criteria

WTG	Start Mitigation Wind Direction	End Mitigation Wind Direction	3	4	5	6	7	8	9	10	11	12	13
ESWT17	310.0	40.0											
YSWT02	110.0	270.0							SO4	SO3			
YSWT03	110.0	270.0							SO4				
YSWT05	110.0	270.0							SO3				
YSWT06	110.0	270.0							SO2				
YSWT16	240.0	330.0											
YSWT18	160.0	300.0							SO4	SO4	SO4	SO4	SO4
YSWT25	210.0	20.0							SO4	SO4			
YSWT27	210.0	20.0							SO4				
YSWT31	210.0	20.0							SO3				
YSWT32	160.0	300.0						SO4	SO4	SO4	SO4	SO4	SO4
YSWT33	210.0	20.0							SO4	SO4			
YSWT34	210.0	20.0						SO3	SO4	SO4			
YSWT35	210.0	20.0							SO4	SO4			
YSWT36	160.0	300.0							SO4	SO4	SO3	SO3	SO3
YSWT38	330.0	100.0							SO4	SO4			
YSWT39	160.0	300.0							SO4	SO3			
YSWT40	330.0	100.0							SO4				

Table 22: Vestas Curtailment Strategy Night time criteria

WTG	Start Mitigation Wind Direction	End Mitigation Wind Direction	3	4	5	6	7	8	9	10	11	12	13
ESWT01	80.0	180.0							SO2				
ESWT02	80.0	180.0							SO3				
ESWT17	310.0	40.0											
YSWT02	110.0	270.0							SO4	SO4	SO3		
YSWT03	110.0	270.0							SO4	SO4			
YSWT05	110.0	270.0							SO3	SO4			
YSWT06	110.0	270.0							SO2	SO3			
YSWT16	240.0	330.0											
YSWT18	160.0	300.0							SO4	SO4	SO4	SO4	SO4
YSWT25	210.0	20.0							SO4	SO4	SO4		
YSWT27	210.0	20.0							SO4	SO4	SO4		
YSWT31	210.0	20.0							SO3	SO4	SO4		
YSWT32	160.0	300.0						SO4	SO4	SO4	SO4	SO4	SO4
YSWT33	210.0	20.0							SO4	SO4	SO4		
YSWT34	210.0	20.0						SO3	SO4	SO4	SO4		
YSWT35	210.0	20.0							SO4	SO4	SO4		
YSWT36	160.0	300.0							SO4	SO4	SO4	SO3	SO3
YSWT38	330.0	100.0							SO4	SO4	SO4		
YSWT39	160.0	300.0							SO4	SO4	SO4		
YSWT40	330.0	100.0							SO4	SO4	SO4		

The noise at residences in the vicinity, with the Vestas curtailment strategy operating, has been predicted using a number of noise models. The inputs to each noise model and the predicted noise levels are summarised below:

5.1 CONCAWE Noise Propagation Model

Noise Model Inputs

The CONCAWE[4] sound propagation model considers the following influences:

- sound power levels and locations of noise sources;
- separation distances between noise sources and receivers;
- topography of the area;
- influence of the ground;
- air absorption; and,
- meteorological conditions.

The CONCAWE system divides meteorological conditions into six separate "weather categories", depending on wind speed, wind direction, time of day and level of cloud cover. Weather Category 1 provides the weather conditions associated with the "lowest" propagation of noise, whilst Weather Category 6 provides "worst-case" (i.e. highest noise level) conditions. Weather Category 4 provides "neutral" weather conditions for noise propagation (that is, conditions which do not account for the effects of temperature inversion or wind on propagation).

The assessment of the wind farm has been based on the following input conditions:

- weather category 6 (night with no clouds and wind from the wind farm to the dwelling under consideration);
- atmospheric conditions at 10^{o}C and 80% relative humidity;
- wind direction from all WTGs to the particular residence under consideration, even in circumstances where WTGs are located in opposite directions from the residence; and,
- maximum barrier attenuation from topography of 2 dB.

[4] CONCAWE - The oil companies' international study group for conservation of clean air and water – Europe, 'The propagation of noise from petrochemical complexes to neighbouring communities', May 1981.

Predicted Noise Levels

Based on the Vestas curtailment strategy, the highest predicted noise level for any wind direction is summarised in the tables below:

Table 23: Predicted noise levels for Vestas Strategy using CONCAWE for 24 Hour Criteria

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N31ab	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**41**	**43**	**45**	**47**
Prediction							38	40	40	40	40	40
M29aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**41**	**43**	**45**	**47**
Prediction							39	39	40			
K34aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**42**	**44**	**47**	**49**
Prediction								39	41			
N31aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							36	38	38	38	38	38
N32aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							35	37	37	37	37	37

Table 24: Predicted noise levels for Vestas Strategy using CONCAWE for Night Time Criteria

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N31ab	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**45**
Prediction							38	40	40	40	40	40
M29aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**45**
Prediction							39	40	40	40		
K34aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**42**	**45**	**48**
Prediction								39	39	41		
H18aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**47**	**50**	**53**
Prediction								40				
N31aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							36	38	38	38	38	38
N32aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							35	37	37	37	37	37

5.2 ISO9613.2 Noise Propagation Model with IOA inputs

Noise Model Inputs

The inputs for the ISO9613.2 noise propagation model and IOA inputs are in accordance with section 4 of this report.

Predicted Noise Levels

Based on the Vestas curtailment strategy, the highest predicted noise level for any wind direction is summarised in the tables below:

Table 25: Predicted noise levels for Vestas Strategy using ISO9613.2 with IOA Inputs for 24 Hour Criteria

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N31ab	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**41**	**43**	**45**	**47**
Prediction							36	38	38	38	38	38
M29aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**41**	**43**	**45**	**47**
Prediction							37	37	38			
K34aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**42**	**44**	**47**	**49**
Prediction								37	39			
N31aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							35	37	37	37	37	37
N32aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							34	36	36	36	36	36

Table 26: Predicted noise levels for Vestas Strategy using ISO9613.2 with IOA Inputs for Night Time Criteria

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N31ab	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**45**
Prediction							36	38	38	38	38	38
M29aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**45**
Prediction							37	38	38	38		
K34aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**42**	**45**	**48**
Prediction								37	37	39		
H18aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**47**	**50**	**53**
Prediction								38				
N31aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							35	37	37	37	37	37
N32aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							34	36	36	36	36	36

5.3 ISO9613.2 Noise Propagation Model with Hard Ground

Noise Model Inputs

An ISO9613.2 model has also been developed which uses acoustically hard ground. For the alternate model, the receiver height is reduced to 1.5m above ground level. All other model inputs are in accordance with the IOA Good Practice Guide.

Predicted Noise Levels

Based on the Vestas curtailment strategy, the highest predicted noise level for any wind direction is summarised in the tables below:

Table 27: Predicted noise levels for Vestas Strategy using ISO9613.2 with Hard Ground for 24 Hour Criteria

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N31ab	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**41**	**43**	**45**	**47**
Prediction							38	40	40	40	40	40
M29aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**41**	**43**	**45**	**47**
Prediction							39	39	40			
K34aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**42**	**44**	**47**	**49**
Prediction								39	41			
N31aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							37	39	39	39	39	39
N32aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							36	38	38	38	38	38

Table 28: Predicted noise levels for Vestas Strategy using ISO9613.2 with Hard Ground for Night Time Criteria

Name	Associated	Predicted Noise Level (dB(A)) for integer Hub Height Wind Speeds (m/s)										
		3	4	5	6	7	8	9	10	11	12	13
N31ab	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**45**
Prediction							38	40	40	40	40	40
M29aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**45**
Prediction							39	40	40	40		
K34aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**42**	**45**	**48**
Prediction								39	39	41		
H18aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**43**	**47**	**50**	**53**
Prediction								40				
N31aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							37	39	39	39	39	39
N32aa	**No**											
Criteria		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Prediction							36	38	38	38	38	38

Based on the above tables, the Vestas curtailment strategy is predicted to achieve the noise criteria for all noise models. It is therefore considered that the curtailment strategy will ensure compliance with the noise criteria.

APPENDIX A: Lal Lal Wind Farm General Layout