HEGGIES
AUSTRALIA

REPORT 40-1143-R1

Revision 3

Cullerin Range Wind Farm

Noise Impact Assessment

PREPARED FOR

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Suite 104, Pacific Highway
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Cullerin Range Wind Farm

Noise Impact Assessment

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EXECUTIVE SUMMARY

Heggies Australia has completed a noise impact assessment of the proposed Cullerin Wind Farm.

Two alternative layouts, comprised of differing turbine types, have been assessed in accordance with the South Australian EPA *Noise Guidelines for Wind Farms (February 2003),* World Health Organisation limits and construction noise guidelines.

Noise monitoring was conducted in November 2005 for a two week period at four residences. The collected data was used to determine baseline conditions and establish indicative criteria for surrounding residential receivers.

A detailed computer noise model was used to predict wind turbine generator (WTG) noise levels for both layouts.

Layout A which includes 15 Repower MM82 WTG's was predicted to comply to all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers.

Layout B, which includes 15 Suzlon S88 WTG's was predicted to marginally exceed the nominated criteria at two non project involved receivers. A 3 dBA exceedance at Location C37 and a 2 dBA exceedance at Location C04 was indicated. Location specific baseline noise monitoring would be required at these properties to confirm the impact. It was determined that removal of WTG #1, #2 and #3 or consideration of a quieter WTG option would result in general compliance with the criteria at these properties.

Marginal exceedances of the WHO goals were predicted for Location C02 for Layout B. It is anticipated that detailed modelling of façade noise levels at critical bedroom positions would reduce the level of the predicted exceedance. Nonetheless the predicted impact could be mitigated by providing suitable acoustic upgrade of windows to critical rooms and providing for alternative ventilation.

Noise propagation enhancement due to temperature inversion conditions is not anticipated. An adaptive management approach could be implemented if undue noise impacts are identified during WTG operation that are related to temperature inversion effects.

Construction noise impact has been assessed and the 'worst case' scenario's modelled were found to be generally acceptable. Staging and the chosen route alignment for access road construction should be considered during detailed design to minimise noise potential short term noise impacts.

Blasting impact has been assessed and found to be acceptable. With a maximum MIC of up to 50 kg, the airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear.

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1 INTRODUCTION

Heggies Australia Pty Ltd (Heggies) have been engaged by Taurus Energy Pty Ltd as the acoustical consultants for the proposed Cullerin Range Wind Farm.

1.1 Objectives

This report describes the methodology and findings of the Noise Impact Study (NIS) and forms part of the Environmental Impact Assessment for the proposed Cullerin Range Wind Farm.

This report details the main aspects of the proposed wind farm project, the acoustic criteria, the background noise measurements and the predicted noise level at all potentially impacted receivers from the operation of the proposed wind farm.

It also addresses the acoustic impact of the wind farm during the construction phase, including blasting and transportation noise.

1.2 Methodology

1.2.1 Acceptability Limit Criteria

The methodology and acceptability limit criteria that have been applied to this study are based upon the *South Australia EPA Noise Guidelines for Wind Farms (February 2003)* (SA Guidelines). The principal acceptability limit criteria is that the wind farm $L_{A90(10\ min)}$ noise should not exceed the greater of an amenity limit of 35 dBA or the pre-existing background noise by more than 5 dBA (for any given wind speed).

The project requirements and wind farm acceptability limit criteria are discussed in more detail in **Section 6**.

1.2.2 Wind Farm Noise Level Prediction

The noise emission model used in this study to predict wind farm noise levels at sensitive receptors is based on ISO 9613 as implemented in the SoundPLAN computer noise model. The model predicts noise levels through spherical spreading and includes the effect of air absorption (as per ISO 9613), ground attenuation and shielding.

Predicted L_{Aeq} noise levels were calculated based upon sound power levels determined in accordance to the recognised standard IEC-61400-11 (*Wind Turbine Generator Systems - Part 11: Acoustic Noise Measurement Techniques*), where available, for the wind range 3 to 10 m/s.

The noise character of WTG noise emission is also assessed for any special audible characteristics, such as tonality or low frequency content, which would be deemed more annoying or offensive. If characteristics such as tonality are identified then the predicted noise level would be penalised by the addition of 5 dBA. It should be noted that the characteristic noise level modulation of WTG's, commonly referred to as 'swish', is considered to be a fundamental part of wind farm noise and is taken into account by the SA Guideline assessment procedure.

1.2.3 Ambient Noise Monitoring

In order to establish the intrusive noise limit, background noise monitoring is required to establish the pre-existing ambient noise environment as a function of wind speed. As wind speed increases the ambient noise level at most receivers generally also increases as natural sources such as wind in trees etc. begin to dominate. The variation of background noise with wind speed is usually quite site specific and related various physical characteristics such as topographic shielding and the extent and height of exposed vegetation.

Noise monitoring is completed for a period of approximately 14 days and correlated to synchronous wind speed and direction data for a reference height of 10 m at the wind farm monitoring mast. The captured data is screened for validity, with data monitored during periods of rain or where the average wind speed at the microphone position likely exceeded 5 m/s being discarded from the data set. Other data that was obviously affected by external noise sources (eg. pond pumps, grass mowing, birds at dawn etc.) was also removed from the data set. A regression analysis of all valid data is used to determine a line of 'best fit' from which the noise limit is established.

1.2.4 Assessment Procedure

In general the assessment procedure contains the following steps:

1. Predict and plot the L_{Aeq} 35 dBA noise level contour from the wind farm under reference conditions. Receivers outside the contour are considered to be within acceptable wind farm noise levels.
2. Establish the pre-existing background noise level at each of the relevant assessment receivers within the L_{Aeq} 35 dBA noise level contour through background noise monitoring.
3. Predict wind farm noise levels at all relevant assessment receivers for the wind range from cut-in to approximately 10 m/s.
4. Assess the acceptability of wind farm noise at each relevant assessment receiver to the established limits.

Furthermore, where the assessment of a receiver has shown unacceptable resulting wind farm noise levels, a process of noise mitigation and alternative wind farm layouts is considered. Steps 3 and 4 were repeated until an acceptable arrangement was developed.

2 WIND TURBINE OPERATIONAL NOISE CRITERIA

2.1 Introduction

The NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) has issued information on the required inputs into the Environmental Assessment.

DIPNR highlighted a number of specific issues including an assessment of the noise impacts to be undertaken in accordance with *Wind Farms - Environmental Noise Guidelines*, from the South Australia Environment Protection Authority (February 2003).

Furthermore, DIPNR has also highlighted a number of requirements in relation to noise for the proposed Cullerin Range Wind Farm, based on the NSW Industrial Noise Policy.

2.2 SA EPA Wind Farm Noise Guidelines

The South Australia EPA Noise Guidelines for Wind Farms (SA Guidelines) recommends the following noise criteria for new wind farms,

"*The predicted equivalent noise level ($L_{Aeq,\ 10min}$), adjusted for tonality in accordance with these guidelines, should not exceed:*

- *35 dBA, or*
- *the background noise level by more than 5 dBA,*

whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power of the WTG."

These guidelines also provide information on measuring the background noise levels, locations and requirements on the number of valid data points to be obtained and the methodology for excluding invalid data points. It also outlines the process for determining lines of best fit for the background data, and determination of the noise limit.

Although the Guideline explicitly states that the "swish" or modulation noise from wind turbines is a fundamental characteristic of such turbines, it does provide the possibility of penalising tonal or annoying characteristics of turbine noise.

A 5 dBA penalty should be applied to the measured noise level if an "authorised" officer determines that tonality is an issue and that tonality should be assessed in a way acceptable to the EPA.

The Guideline does not provide an assessment for the potential of low frequency noise or infrasound, but it does state that recent turbine designs do not appear to generate significant levels of infrasound, as the earlier turbine models did.

The guideline accepts that wind farm developers commonly enter into agreements with private landowners in which they are provided compensation. The guideline is intended to be applied to premises that do not have an agreement with the wind farm developers. This does not absolve the obligations of the wind farm developer entirely as appropriate action can be taken under the *Environmental Protection Act* if a development 'unreasonably interferes' with the amenity of an area. The guideline lists that there is unlikely to be unreasonable interference if;

- a formal agreement is documented between the parties

- the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect on the landowner's amenity
- the likely impact of exposure will not result in adverse health impacts (e.g. the level does not result in sleep disturbance)

The proponent Taurus Energy has discussed the possible noise implications of the various proposed turbine layouts with the involved residents whose property the turbines would be located on. These property owners have been provided copies of the Noise Assessment for their information, and have been advised that SA EPA Guidelines may be exceeded under certain turbine configurations.

It is possible that under certain turbine configurations noise levels at the residences of Wandella, Springvale and Fairview may exceed South Australian EPA Guidelines. The proponent intends to enter into noise agreements with these landowners once final selection and turbine layouts have been completed, and prior to commencement of construction. Those agreements would specify:

(a) that Taurus Energy would ensure that the properties met the World Health Organisation noise guidelines (see Section 2.4); and,

(b) Taurus would implement an adaptive management approach which could include the use of building treatments and turbine operation / management strategies if operational noise causes significant impact to the amenity of involved residents.

These noise agreements would only be required under those turbine configurations where the SA EPA Guidelines would be exceeded for that particular property

2.3 NSW Industrial Noise Policy (INP)

The NSW Department of Environment and Conservation requirements for the proposed Cullerin Range Wind Farm Environmental Assessment are based on the NSW Industrial Noise Policy.

The INP requirements include site selection for background measurements, description of the site, the equipment used, graphing of results and amenity noise criteria during each of the three periods (Day, Evening and Night) as per the Industrial Noise Policy.

The proposed site for the Cullerin Range wind farm is in a rural area and therefore the Amenity Criteria for rural residential receivers, as detailed in Table 2.1 in the NSW INP, is applicable.

The criteria vary as a function of time of day. The Day, Evening and Night Periods are defined as,

Day Period	7:00 am - 6:00 pm 8:00 am - 6:00 pm (Sundays and Public Holidays)
Evening Period	6:00 pm - 10:00 pm
Night Period	10:00 pm - 7:00 am 10:00 pm - 8:00 am (Sundays and Public Holidays)

The Amenity Criteria (L_{Aeq} level) for the residential noise sensitive locations for the Cullerin Range wind farm project are,

Day Period	50 dBA
Evening Period	45 dBA
Night Period	40 dBA

The Intrusiveness Criterion in the INP is based on the rating background level (RBL), where the Criterion is,

$$L_{Aeq,\ 15\ min} \leq RBL + 5\ dBA$$

This is almost identical to the SA Guidelines (Section 2.2), the difference being the measurement interval (15 and 10 minute) and the determination of the background noise level (rating level, based on 10th percentile of measured background levels, or using a line of best fit through the data points).

The INP states where the measured RBL is less than 30 dBA, then the RBL is considered to be 30 dBA.

In summary it is evident that the non project related residential receivers assessed under the *SA EPA Wind Farm Guideline* will generally comply to INP amenity criteria. Furthermore, intrusiveness is covered by the by the *SA EPA Wind Farm Guideline.*

2.4 World Health Organisation

As discussed in Section 2.2, the proponent intends to enter into noise agreements with the owners of project-involved residences in accordance with World Health Organisation guidelines, as it is necessary to ensure that the project does not result in an 'unreasonable interference' with the amenity of these areas or cause any adverse health affects.

The World Health Organisation (WHO) publication '*Guidelines for Community Noise'* identifies the main health risks associated with noise and derives acceptable environmental noise limits for various activities and environments.

The appropriate guideline limits are listed in **Table 1.**

Table 1 WHO Guideline values for environmental noise in specific environments

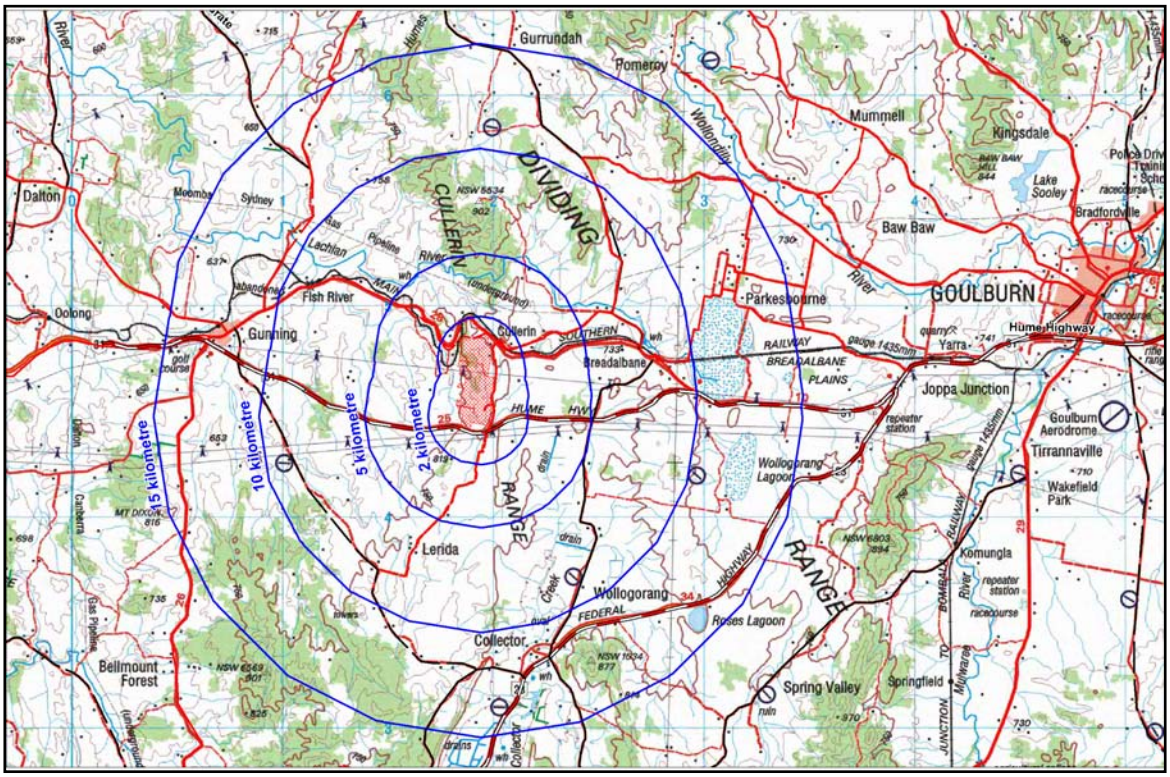
Specific Environment	**Critical Health Effect(s)**	**LAeq (dBA)**	**Time base (hours)**	**LAMax (dBA, Fast)**
Outdoor living area	Serious Annoyance, daytime & evening	55	16	-
	Moderate annoyance, daytime & evening	50	16	-
Dwelling indoors	Speech Intelligibility & moderate annoyance, daytime & evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance – window open, night-time	45	8	60

For the assessment of project involved residences the adopted external criteria of 45 dBA or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

3 GENERAL SITE DESCRIPTION

The proposed Cullerin Range wind farm site is located approximately 30 km west south west of Goulburn in NSW, between the Hume Highway and the Main Southern Railway. The location of the proposed wind farm is shown in **Figure 1.**

Figure 1 Location of proposed Cullerin Range Wind Farm



3.1 Characteristics of the site

The proposed site incorporates the farming properties Fairview, Springvale and Wandella. These properties include residential dwellings, however, as they form part of the project consortium with agreements, they have not been subject to the formal assessment process. However, an indicative assessment has been carried out to ensure no unreasonable impact and to provide the basis of the agreements between Taurus and the site landowners.

Topographically the proposed site broadly includes a raised ridge / plateau that runs in a north-south direction. The Main Southern Railway line runs to the north of the site and to the south a 132 kV high voltage transmission line crosses the site. The district is primarily used for agricultural (grazing) purposes.

Road traffic on the Old Hume Highway is intermittent and all residential dwellings surrounding the proposed site have an ambient background noise environment that is determined by pre-dominantly natural sources which are largely wind influenced. The Hume Highway to the south of the site carries continuous traffic, however, few sensitive receivers are located close to it.

The prevailing wind is from the West to West-northwest and East and the district receives only marginal rainfall.

3.2 Dwelling Locations

Residential dwellings surround the proposed site and are generally located along the Old Hume Highway, they are indicated on the map in **Figure 2.**

The locations considered in this assessment include all dwellings located within 5 km of a proposed WTG, **Table 2** lists the on-site and off-site receiver locations and their position. Other dwellings located beyond 5 km of a proposed WTG are not considered within this assessment, primarily as WTG noise is unlikely to be audible at these distances and compliance to noise criteria more critical at closer receivers.

Figure 2 Dwelling Locations

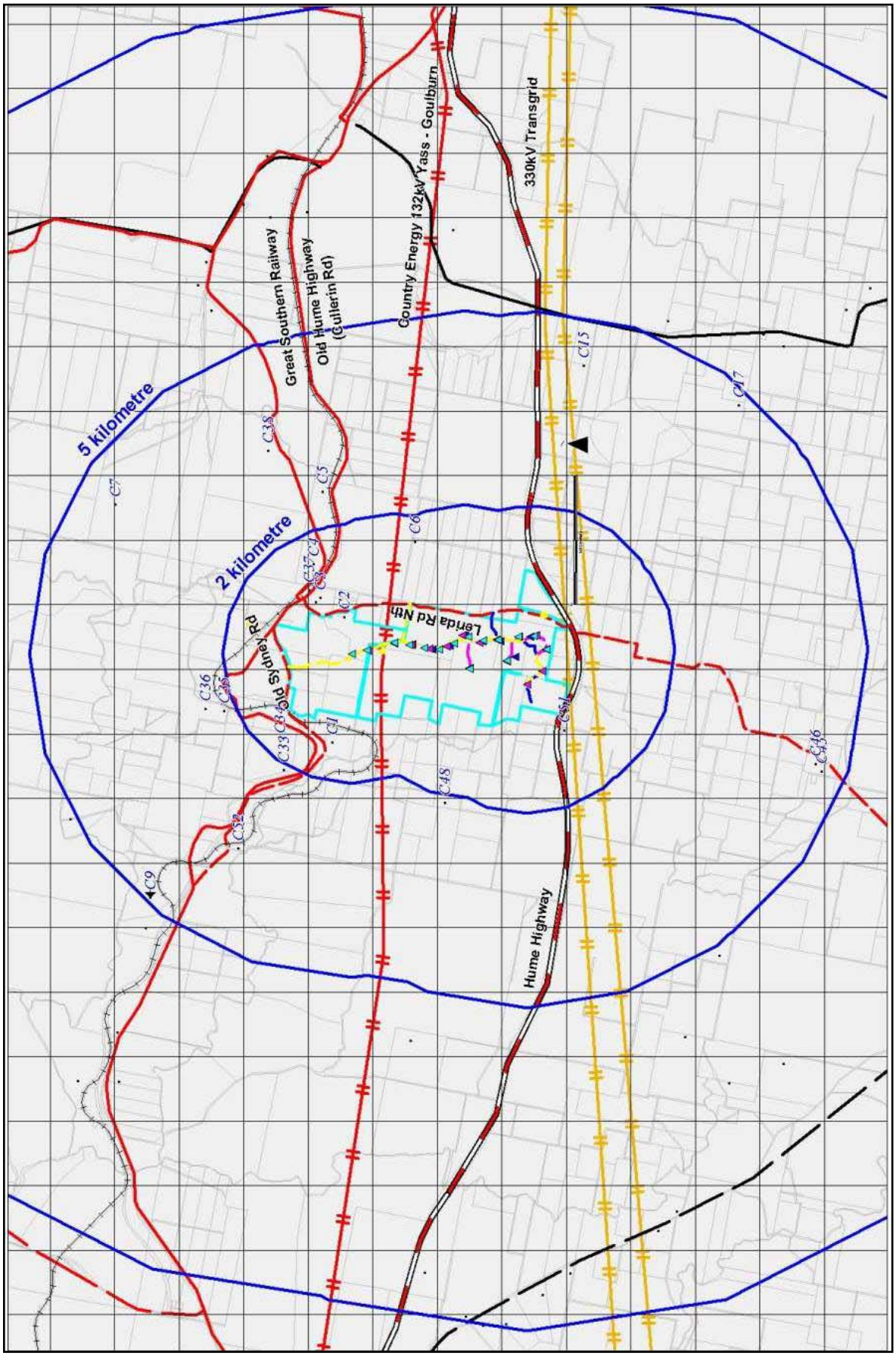


Table 2 Surrounding Receivers

Location	East (m)	North (m)	Elevation (m)
C01-Fairview *	717976.7	6147814	685
C02-Springvale *	719917.5	6147630	749
C03-Wandella *	720227.2	6148001	743
C04-Illawambra	720742.3	6148099	744
C05-Waiontha	721862.9	6147966	713
C06-Lerida Outstation *	721093.4	6146528	715
C07-Mutmutbilli	721669.5	6151176	689
C09-Lochleigh	715575	6150628	634
C15-Greendale	723817	6143912	746
C17-Bohara	723199.5	6141517	727
C33-Ponderosa	717556.1	6148560	705
C34-Shearing	717997.3	6148620	742
C35-Edwards	718459.8	6149482	728
C36-Edwards	718495.2	6149770	719
C37-Faybri	720340.1	6148165	730
C38-Enniskillen	722501	6148801	692
C45-Wood Park	717533.1	6140232	762
C46- House	717641.6	6140324	775
C47-Wandella	720153.8	6148065	748
C48-Cottage.*	717043.5	6146069	717
C51-Shearing Shed	718159.2	6144214	732
C52-House	716334.4	6149263	641

* denotes the location is involved with the project

4 PROPOSED WIND FARM LAYOUT

The proponent has developed two alternative turbine layouts for the proposed Cullerin Range Wind Farm, which are dependant upon the two alternative wind turbine types. Layout A utilises a total of 15 Repower MM82 WTG's, Layout B utilises a total of 15 Suzlon S88 WTG's. The two alternative layouts with WTG locations are listed in **Table 3.**

Table 3 Cullerin Range proposed alternative WTG layouts

Layout A			Layout B		
Name	Easting	Northing	Name	Easting	Northing
R1	719356	6147509	S1	719350	6147513
R2	719408	6147280	S2	719403	6147250
R3	719524	6146848	S3	719522	6146851
R4	719496	6146618	S4	719491	6146581
R5	719449	6146386	S5	719440	6146308
R6	719424	6146155	S6	719476	6146041
R7	719516	6145931	S7	719639	6145795
R8	719620	6145708	S8	719133	6145680
R9	719128	6145680	S9	719529	6145536
R10	719566	6145478	S10	719572	6145271
R11	719575	6145244	S11	719235	6145101
R12	719248	6145105	S12	719623	6144927
R13	719623	6144931	S13	718882	6144797
R14	719635	6144695	S14	719643	6144658
R15	719420	6144497	S15	719084	6144559

4.1 WTG Type and Details

The two alternative proposed wind turbines are all three bladed, upwind, pitch regulated and active yaw wind turbines. The rotor diameters vary between 82 and 90 m. They are all proposed to be mounted at a hub height of 80 m.

Table 4 summarises the relevant turbine input data used for noise level prediction.

Table 4 WTG Manufacturers Data

Wind Farm Layout	**Layout A**	**Layout B**
Make, Model, Power	Repower MM82, 2 MW	Suzlon S88, 2.1 MW
Rotor Diameter	82 m	88 m
Hub Height	80 m	80 m
Cut-in Wind Speed	3.5 m/s	4 m/s
Rated Wind Speed	13 m/s	14 m/s
Rotor Speed	8.5-17.1 rpm	15.6 rpm
Sound Power Level, $L_{WA,ref}$	103.5 dBA	106.3 dBA

Noise emission has been independently tested according to International Standard IEC 61400-11 for the Repower machines. Copies of the certification test which give the Sound Power Level variation with wind speed, frequency spectra and tonality assessment are contained in **Appendix B.**

Noise emission data for the Suzlon machines is based on manufacturer measurements and corrections for standard terrain in general accordance with IEC 61400-11. Further independent test result data for this WTG is anticipated.

5 OPERATIONAL NOISE LEVELS

5.1 Introduction

As discussed in **Section 1.2.2** a three dimensional computer noise model was used to predict L_{Aeq} noise levels from all WTGs at all surrounding residential dwellings.

The ISO 9613 noise model incorporates a 'hard ground' assumption and includes one third octave band calculated effects for air absorption, ground attenuation and topographic shielding.

ISO 9613 algorithms are not as sophisticated as other standards with respect to meteorological/atmospheric effects compared to CONCAWE and NORD2000 (same algorithms as WiTuProp). It should be noted that wind and temperature inversion propagation enhancement effects are minimal for greatly elevated sources such as WTG's.

An evaluation of all standards showed that the implemented ISO 9613 model was generally more conservative (predicted higher noise levels) than predictions from the CONCAWE (worst case Category 5) or NORD2000 (worst case wind propagation). The only exception were for receivers located at considerable distance from WTG's, where noise levels were typically less than 20 dBA. At these locations impacts and compliance are not an issue. In summary the implemented ISO 9613 model, was the most conservative noise model to use for all nearby potentially impacted assessment locations.

This is supported by other similar investigations. (Reference: *Wind Turbine Generator Noise Prediction - Comparison of Computer Models, Tickell, Ellis, Bastasch, Proceedings of ACOUSTICS 2004)*

The estimated accuracy of the prediction model is approximately ±3 dBA.

Whilst $L_{A90(10\ min)}$ noise levels are used for compliance monitoring, the assessment utilises predicted L_{Aeq} noise levels, as prescribed by SA Guidelines, and therefore infer a degree of conservatism which assists in other uncertainties in the noise prediction and assessment process.

5.2 Wind Turbine Noise Levels

For indicative purposes the WTG noise levels from the proposed wind farm were calculated for the reference wind condition of 8 m/s at all surrounding residential receivers. The resulting WTG noise levels are listed in **Predicted** noise contour plots resulting from proposed Layout A is depicted in **Figure 3** and Layout B is depicted in **Figure 4.**

Furthermore, noise levels from the proposed wind farm were calculated for all integer wind speeds in the range of 4 to 10 m/s at all surrounding assessment receivers within 5 km of a turbine. Whilst the rated wind speed of the WTG's is typically 13 - 14 m/s, published manufacturers sound power level test data (IEC 61400-11) has only been generated as high as 10 m/s. It should be noted that noise produced by WTG's begins to 'plateu off' at higher wind speeds and because of the higher masking background noise level at higher wind speeds, noise impacts and compliance are a non issue at these speeds. The covered wind range sufficiently covers the most noise critical operational conditions.

The predicted levels are displayed on the assessment graphs presented in **Appendix A1** and **Appendix A2.**

Table 5 for both layouts**.** 8 m/s wind speed, measured at the reference height of 10 metres, is the condition for which WTG sound power levels are typically quoted.

Predicted noise contour plots resulting from proposed Layout A is depicted in **Figure 3** and Layout B is depicted in **Figure 4**.

Furthermore, noise levels from the proposed wind farm were calculated for all integer wind speeds in the range of 4 to 10 m/s at all surrounding assessment receivers within 5 km of a turbine. Whilst the rated wind speed of the WTG's is typically 13 - 14 m/s, published manufacturers sound power level test data (IEC 61400-11) has only been generated as high as 10 m/s. It should be noted that noise produced by WTG's begins to 'plateu off' at higher wind speeds and because of the higher masking background noise level at higher wind speeds, noise impacts and compliance are a non issue at these speeds. The covered wind range sufficiently covers the most noise critical operational conditions.

The predicted levels are displayed on the assessment graphs presented in **Appendix A1** and **Appendix A2**.

Table 5 WTG LAeq noise level (dBA) at V_{ref} = 8 m/s

Receiver / Property	**Layout A** **Repower MM82**	**Layout B** **Suzlon S88**
C01*-Fairview	34.9	36.7
C02*-Springvale	43.8	46
C03*-Wandella	39.5	41.5
C04-Illawambra	36.9	38.6
C05-Waiontha	33.7	35
C06*-Lerida Outstation	37.4	39
C07-Mutmutbilli	26.6	26.8
C09-Lochleigh	17.1	17.8
C15-Greendale	29.4	30.3
C17-Bohara	27.5	28.3
C33-Ponderosa	28.4	30.2
C34-Shearing Shed	34.9	36.5
C35-Edwards	31.6	32.8
C36-Edwards	29	30.6
C37-Faybri	38.2	40
C38-Enniskillen	22	23
C45-Wood Park	27.6	28.5
C46- House	27.4	28.5
C47-Wandella 2	39.6	41.4
C48*-Cottage. unoccupied	35.6	37.5
C51-Shearing Shed	38.4	42.4
C52-House	20.9	22

* denotes the location is involved with the project

Predicted noise contour plots resulting from proposed Layout A is depicted in **Figure 3** and Layout B is depicted in **Figure 4**.

Figure 3 Layout A - WTG LAeq Noise Contour Map at V_{ref} = 8 m/s

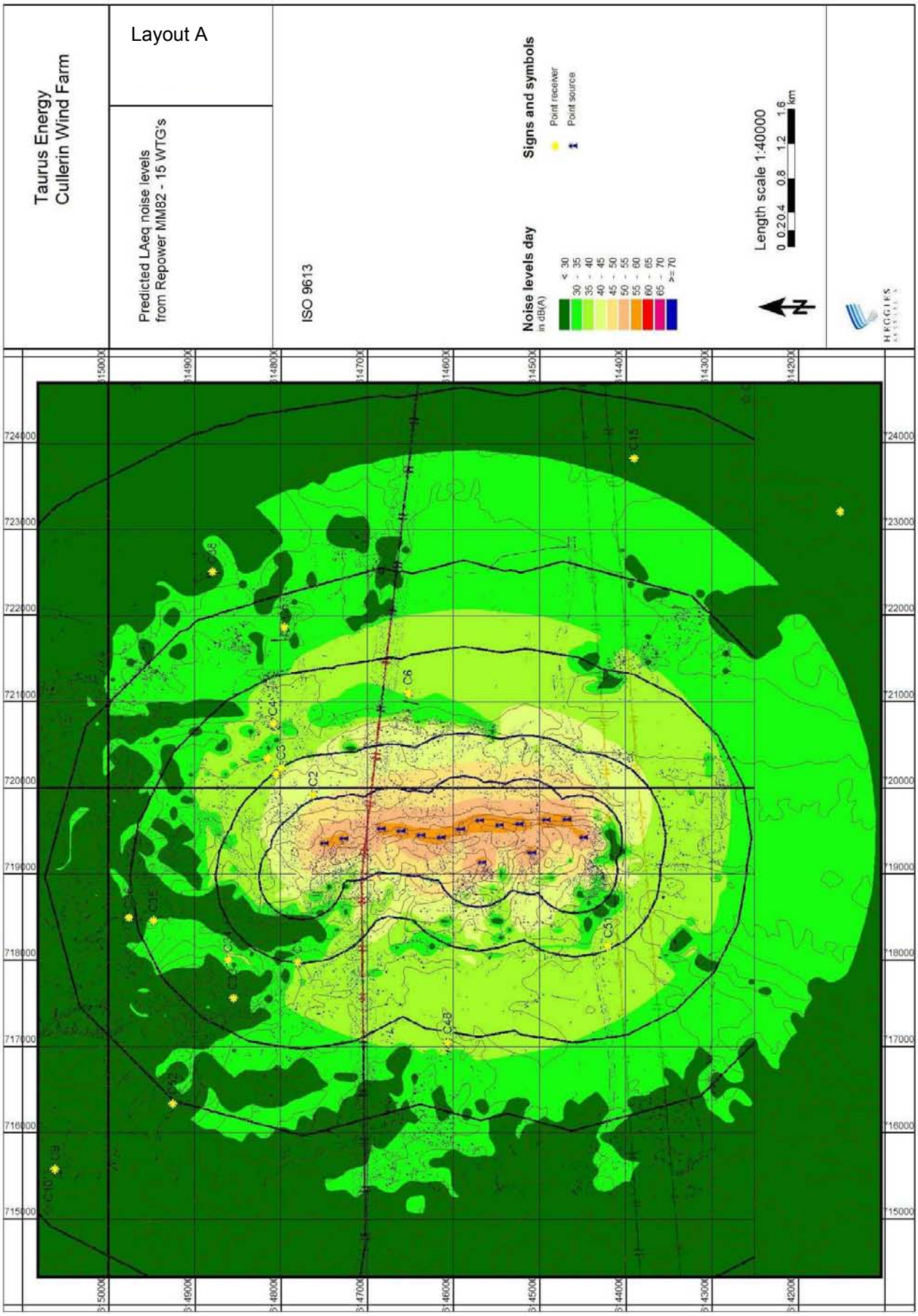
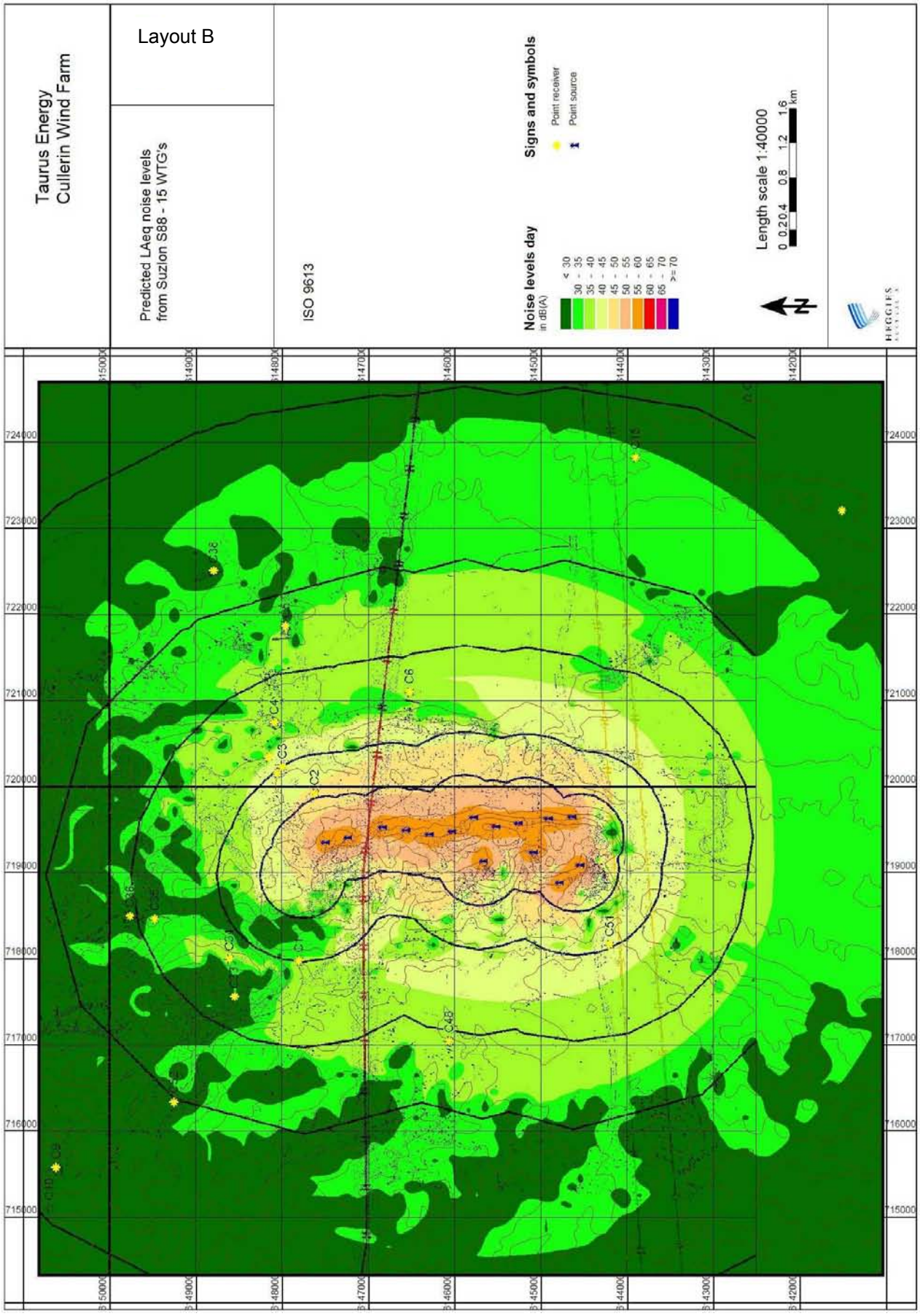


Figure 4 Layout B - WTG LAeq Noise Contour Map at V_{ref} = 8 m/s



5.3 Transformer Noise Levels

Subject to final agreement with Country Energy, the preferred location for the wind farm substation is at the centre of the site where the existing 32 kV line crosses the main ridge, approximately 800 metres south-west of the closest residential receiver, which is Location C02, Springvale.

An alternative location has been identified to the north of the site. The preferred location is indicated on **Figure 5.**

The substation transformers may possibly be enclosed by blast protection walls in which case they will also serve as noise walls.

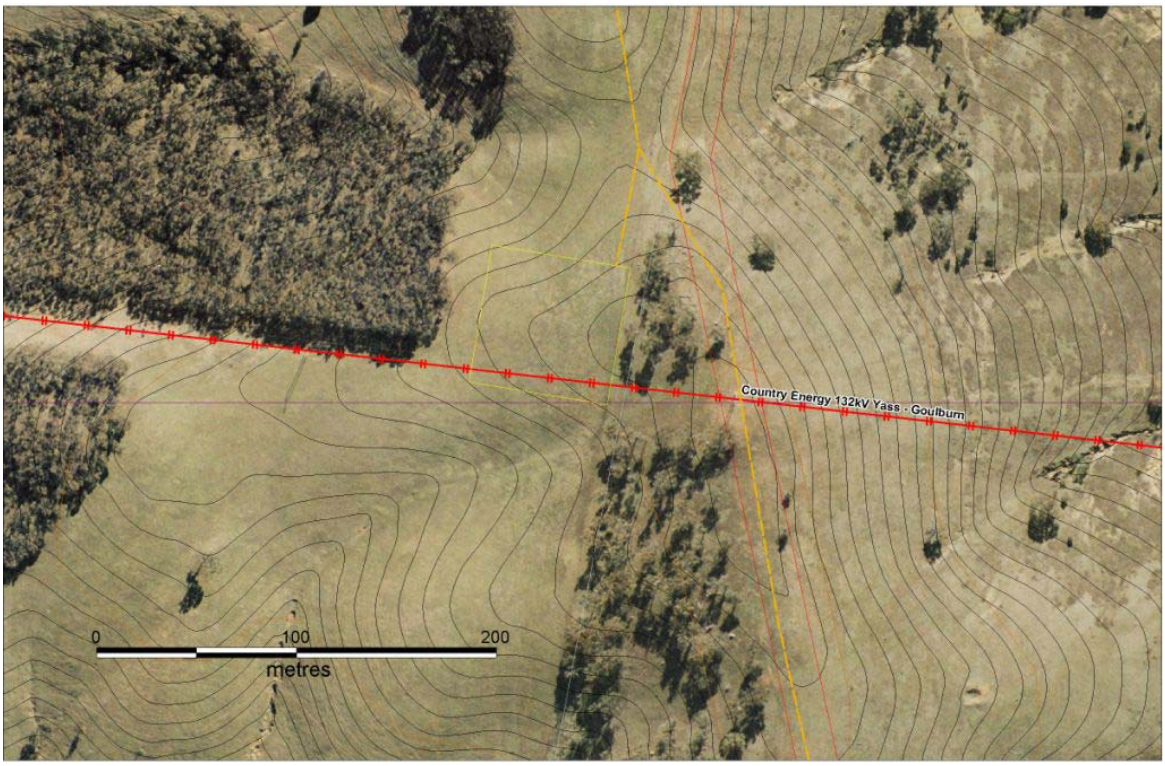
The substation would 'step up' the voltage from the incoming 22 or 33 kV voltage to the 132 kV voltage of the transmission line using a single 30-50 MVA transformer.

Australian Standard AS 2374 Part 6 1994: "Power Transformers – Determination of Transformer and Reactor Sound levels" indicates that a transformer of this capacity may produce sound power levels up to 98 dBA. The dominant frequency of such a transformer is 100 Hz.

Predicted noise levels from the transformer installation are expected to be less than 27 dBA at the most exposed receiver location, C02 Springvale, which is below the existing ambient background and predicted future WTG levels and as such will not effect the compliance assessment of the proposed wind farm.

The nearest project non-involved receiver to the transformer is C04 Illawambra, which is predicted to have transformer noise levels of approximately 20 dBA.

Figure 5 Proposed transformer location



6 BACKGROUND LEVELS AND NOISE LIMITS

6.1 Measurement Locations

The locations for the background noise measurements were chosen based on the potential for acoustic impact to the nearest receivers, as recommended by Table 3.1 of the NSW INP. The SA Guidelines recommend that the measurement locations should be located at least 5 metres from a reflecting surface (other than the ground) and locations within 20 metres of a residence are generally appropriate.

Monitoring equipment was generally placed in the vicinity of the residence at a suitable location that would be protected from the prevailing wind direction in order to protect the microphone from wind induced noise effects. Care was taken not to place the equipment in locations that would be affected by extraneous noise sources.

Background noise monitoring locations were selected based on the predicted wind farm noise level from preliminary 15 turbine base layout at reference conditions. Many of the potentially adversely affected locations have been monitored. Generally a selected monitoring location was used to provide an indicative background for nearby locations in that vicinity. The relative proximity of some receiver locations to one another and their similar wind exposure and surrounding trees meant that background noise monitoring was conducted at only one of the locations and the result was considered indicative of the wind induced noise at adjacent locations.

It is anticipated that further baseline background noise monitoring will be conducted before project commissioning.

Permission for noise monitoring was not granted at a number of locations and where possible nearby substitute locations were selected. Some properties were identified as not having a place of residence.

A total of 4 locations were monitored around the proposed wind farm site. These are listed in **Table 6** below and include the locations for which the monitoring was deemed indicative of and the similar characteristics that the monitoring site has with the assumed indicative locations.

Table 6 Measurement Locations

Location	Address	Indicative of assessment locations	Similar Characteristic for wind induced noise
C2*	Springvale	C2* C7	exposure to wind
C3*	Wandella	C3*, C4, C47*, C37, C38	geographic proximity
C6*	Lerida Outstation	C6, C5, C48*, C15, C17, C45, C46, C51	vegetation near dwelling, exposure to wind, proximity to Hume Hwy.
C33	Ponderosa	C33, C34, C35, C36, C1*, C34, C9, C52	geographic proximity, exposure to wind

* denotes the location is involved with the project

At each location noise monitoring equipment was placed in the vicinity of the residence and the position of the monitoring equipment was documented with photographs.

A weather station was placed at location C2, capable of measuring wind speed, direction, rainfall, temperature and humidity. Furthermore meteorological data for the monitoring period was sourced from the nearest Bureau of Meteorology station in Goulburn. This data was used to identify and exclude any data during rain periods, which may have affected the background noise levels.

The measured data for rain confirmed that the monitoring period was very dry and as a result only approximately 30 data points was rejected due to rain, which fell on 15th November 2005. The meteorological conditions during the monitoring period were deemed representative of 'typical' operating conditions.

The horizontal distance between each of the assessment locations and the all WTG's for the proposed Layout A wind farm is shown in **Table 7**.

Table 7 Distance Between the Assessment Location and WTG's for Layout A

Assess.	Distance to WTG (km)														
Location	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
C01*	1.41	1.53	1.82	1.93	2.05	2.20	2.43	2.67	2.42	2.83	3.03	2.99	3.32	3.53	3.62
C02*	0.57	0.62	0.88	1.10	1.33	1.56	1.75	1.94	2.10	2.18	2.41	2.61	2.71	2.95	3.17
C03*	1.00	1.09	1.35	1.56	1.79	2.01	2.19	2.37	2.57	2.61	2.83	3.06	3.13	3.36	3.60
C04	1.51	1.57	1.75	1.94	2.15	2.35	2.49	2.64	2.91	2.87	3.08	3.35	3.36	3.58	3.84
C05	2.55	2.55	2.59	2.72	2.88	3.04	3.11	3.18	3.56	3.39	3.56	3.88	3.77	3.96	4.24
C06*	2.00	1.85	1.60	1.60	1.65	1.71	1.69	1.69	2.14	1.85	1.99	2.33	2.17	2.34	2.63
C07	4.34	4.50	4.83	5.05	5.28	5.50	5.67	5.84	6.05	6.07	6.29	6.54	6.57	6.79	7.05
C09	4.90	5.09	5.47	5.61	5.75	5.90	6.13	6.37	6.09	6.52	6.71	6.63	6.99	7.19	7.24
C15	5.73	5.55	5.20	5.10	5.02	4.93	4.75	4.57	5.01	4.53	4.45	4.72	4.32	4.25	4.44
C17	7.12	6.90	6.48	6.30	6.15	5.98	5.75	5.51	5.82	5.37	5.20	5.34	4.94	4.78	4.81
C33	2.08	2.25	2.61	2.74	2.88	3.04	3.28	3.52	3.28	3.68	3.88	3.85	4.18	4.39	4.47
C34	1.75	1.95	2.34	2.50	2.66	2.85	3.09	3.33	3.15	3.51	3.73	3.73	4.03	4.25	4.36
C35	2.17	2.40	2.84	3.05	3.25	3.46	3.70	3.95	3.86	4.15	4.38	4.45	4.70	4.93	5.08
C36	2.42	2.65	3.10	3.31	3.52	3.73	3.97	4.22	4.14	4.42	4.65	4.73	4.97	5.20	5.35
C37	1.18	1.29	1.55	1.76	1.99	2.21	2.38	2.56	2.77	2.80	3.02	3.25	3.31	3.54	3.78
C38	3.40	3.45	3.56	3.71	3.89	4.06	4.14	4.23	4.60	4.43	4.61	4.92	4.82	5.01	5.29
C45	7.50	7.29	6.91	6.68	6.45	6.22	6.03	5.86	5.68	5.63	5.41	5.17	5.14	4.93	4.66
C46	7.39	7.18	6.79	6.56	6.33	6.10	5.91	5.74	5.56	5.50	5.29	5.04	5.02	4.80	4.54
C47*	0.97	1.08	1.37	1.59	1.82	2.05	2.23	2.42	2.60	2.65	2.88	3.10	3.18	3.41	3.64
C48*	2.72	2.66	2.60	2.51	2.43	2.38	2.48	2.60	2.12	2.59	2.66	2.41	2.82	2.93	2.85
C51	3.51	3.31	2.97	2.75	2.53	2.32	2.19	2.09	1.76	1.89	1.75	1.41	1.63	1.55	1.29
C52*	3.49	3.66	4.00	4.12	4.24	4.38	4.61	4.84	4.54	4.98	5.16	5.08	5.44	5.64	5.68

* denotes the location is involved with the project

The horizontal distance between each of the assessment locations and the all WTG's for the proposed Layout **B** wind farm is shown in **Table 8.**

Table 8 Distance between the assessment location and WTG's for Layout B

Assess. Location	Distance to WTG (km)														
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**
C01*	1.41	1.53	1.82	1.95	2.10	2.32	2.62	2.43	2.76	3.00	2.99	3.32	3.15	3.57	3.44
C02*	0.58	0.64	0.87	1.13	1.41	1.65	1.86	2.10	2.13	2.38	2.62	2.72	3.02	2.98	3.18
C03*	1.00	1.12	1.35	1.60	1.87	2.10	2.28	2.57	2.56	2.81	3.07	3.13	3.48	3.39	3.63
C04	1.51	1.59	1.75	1.97	2.21	2.42	2.55	2.91	2.84	3.06	3.36	3.36	3.79	3.61	3.91
C05	2.55	2.56	2.59	2.75	2.94	3.07	3.11	3.56	3.37	3.54	3.89	3.77	4.35	3.98	4.40
C06*	2.00	1.84	1.60	1.60	1.67	1.69	1.63	2.14	1.85	1.97	2.34	2.17	2.81	2.37	2.81
C07	4.34	4.53	4.83	5.08	5.35	5.58	5.75	6.05	6.03	6.27	6.54	6.58	6.96	6.83	7.10
C09	4.89	5.11	5.46	5.63	5.80	6.02	6.31	6.09	6.45	6.68	6.63	6.99	6.70	7.22	7.01
C15	5.74	5.53	5.20	5.08	4.99	4.83	4.58	5.01	4.59	4.46	4.73	4.32	5.01	4.24	4.78
C17	7.13	6.88	6.48	6.28	6.09	5.86	5.57	5.82	5.44	5.22	5.34	4.94	5.42	4.74	5.12
C33	2.08	2.26	2.60	2.77	2.94	3.17	3.46	3.28	3.61	3.86	3.84	4.18	3.99	4.42	4.28
C34	1.75	1.96	2.34	2.53	2.72	2.97	3.27	3.15	3.44	3.70	3.73	4.03	3.92	4.29	4.20
C35	2.16	2.42	2.84	3.08	3.32	3.59	3.87	3.86	4.09	4.36	4.45	4.70	4.70	4.97	4.96
C36	2.41	2.68	3.09	3.34	3.59	3.86	4.14	4.14	4.36	4.63	4.73	4.97	4.99	5.24	5.24
C37	1.19	1.31	1.55	1.80	2.06	2.29	2.47	2.76	2.75	2.99	3.26	3.32	3.67	3.58	3.82
C38	3.40	3.46	3.56	3.74	3.95	4.09	4.15	4.59	4.42	4.59	4.94	4.83	5.40	5.03	5.45
C45	7.50	7.26	6.91	6.64	6.37	6.13	5.95	5.68	5.67	5.44	5.16	5.14	4.76	4.90	4.60
C46	7.39	7.15	6.79	6.52	6.25	6.00	5.82	5.56	5.54	5.31	5.04	5.01	4.64	4.77	4.47
C47*	0.98	1.11	1.37	1.63	1.90	2.13	2.33	2.59	2.61	2.85	3.10	3.18	3.51	3.45	3.67
C48*	2.72	2.64	2.60	2.50	2.41	2.43	2.61	2.13	2.54	2.65	2.40	2.82	2.24	2.96	2.54
C51	3.51	3.28	2.97	2.72	2.46	2.25	2.17	1.76	1.90	1.76	1.39	1.63	0.93	1.55	0.99
C52*	3.49	3.67	4.00	4.14	4.29	4.50	4.79	4.55	4.91	5.14	5.07	5.44	5.14	5.67	5.45

* denotes the location is involved with the project

The SA Guidelines require measurements to be conducted in 10 minute intervals, while the NSW INP request 15 minute interval data. Given that almost all wind data, including the wind farm site monitored data, is in 10 minute intervals, this period was used for all measurements.

The specific equipment used at each site, site descriptions including photographs and data obtained are shown in the following sections.

The local noise data is correlated to the wind speed at a reference wind data location. It is usual for this location to be at 10 metres above ground level. The reference wind tower at the proposed Cullerin Range Wind Farm has wind monitoring equipment located at 10 metres, 30 metres 50 metres and 65 metres above ground level.

6.2 Measurement Details

The monitoring period, equipment type and serial number of the noise logger are summarised in **Table 9**.

The SA Guidelines considers sufficient data to be approximately 2,000 measurement intervals. All data points below the cut-in wind speed of the proposed turbines and any adversely affected data (rain, external extraneous noise sources etc.) should be excluded. The cut-in wind speed for the proposed turbines is 3-4 m/s. The number of measurement intervals and valid data points for each location is also shown in **Table 9**.

The measured background noise levels (L_{A90}) are then plotted against the reference wind tower wind speed to obtain a background versus wind speed characteristic for each location.

The line of best fit for the data set is then determined, as required by the SA Guideline using a linear, second order (quadratic) or third order (cubic) polynomial. The Guideline requires that the correlation coefficient for each line type be reported and the one with the highest correlation coefficient used. As required, the R^2 value, which is a measure of the correlation coefficient for each of the three type of line of best fit are also shown. At each location the cubic polynomial gave the highest correlation and was therefore used for the line of best fit.

Table 9 Measurement Details for each Location

Measurement Location	Measurement Period (2005)	Noise Logger	No. of monitoring intervals	No. of valid data points	Correlation Coefficient (R^2)		
					linear	Quadratic	Cubic
C02* Springvale	9th to 23rd November	ARL Type 1, EL-316 (Serial no. 16-004-010)	2017	1759	0.55	0.55	0.56
C03* Wandella	9th to 23rd November	ARL Type 1, EL-316 (Serial no. 16-203-502)	1965	1698	0.58	0.58	0.59
C06* Lerida Outstation	9th to 23rd November	ARL Type 1, EL-316 (Serial no. 16-302-490)	2010	1584	0.35	0.36	0.36
C33 Ponderosa	9th to 23rd November	ARL Type 1, EL-316 (Serial no. 16-302-485)	2011	1794	0.60	0.60	0.61

* denotes the location is involved with the project

The Rating Background Level (RBL) for each location during each time period is shown in **Table 10,** as per the DIPNR requirements.

Table 10 RBL for each Period at each Location

Location	Rating Background Level (dBA)		
	Day	Evening	Night
C02* Springvale	29	30	27
C03* Wandella	29	31	28
C06* Lerida Outstation	33	30	27
C33 Ponderosa	27	30	28

* denotes the location is involved with the project

With only one exception all of the calculated rating background levels were 30 dBA or less. The RBL in this case is considered to be 30 dBA and the intrusiveness criteria therefore becomes 35 dBA.

The entire set of noise logger results, showing the measured L_{A90}, L_{Aeq} and L_{A10} noise levels are shown in **Appendix C.**

6.3 Location C02 - Springvale

The property of Springvale is located directly to the North East of the proposed wind farm, the homestead residence. The measurement location is shown in **Figure 6.**

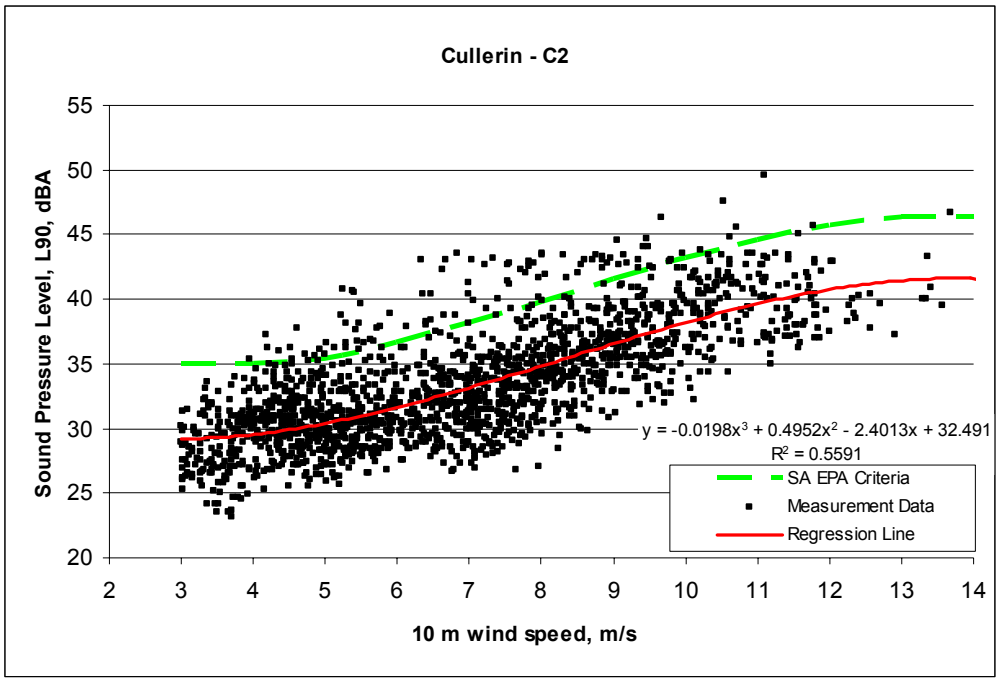
Figure 6 Springvale Measurement Location

The weather station used to monitor the wind speed and rain at this location was a Davis Integrated Sensor Suite (ISS) with the Vantage Pro Weather Envoy and Weather Link software for Windows.

The measurement location was protected from strong winds and no data was rejected on the basis of high local wind speed (ie wind speed greater than 5 m/s).

The results of the background noise monitoring, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 7**.

Figure 7 Background Noise Measurements and Noise Criteria Curve - Springvale



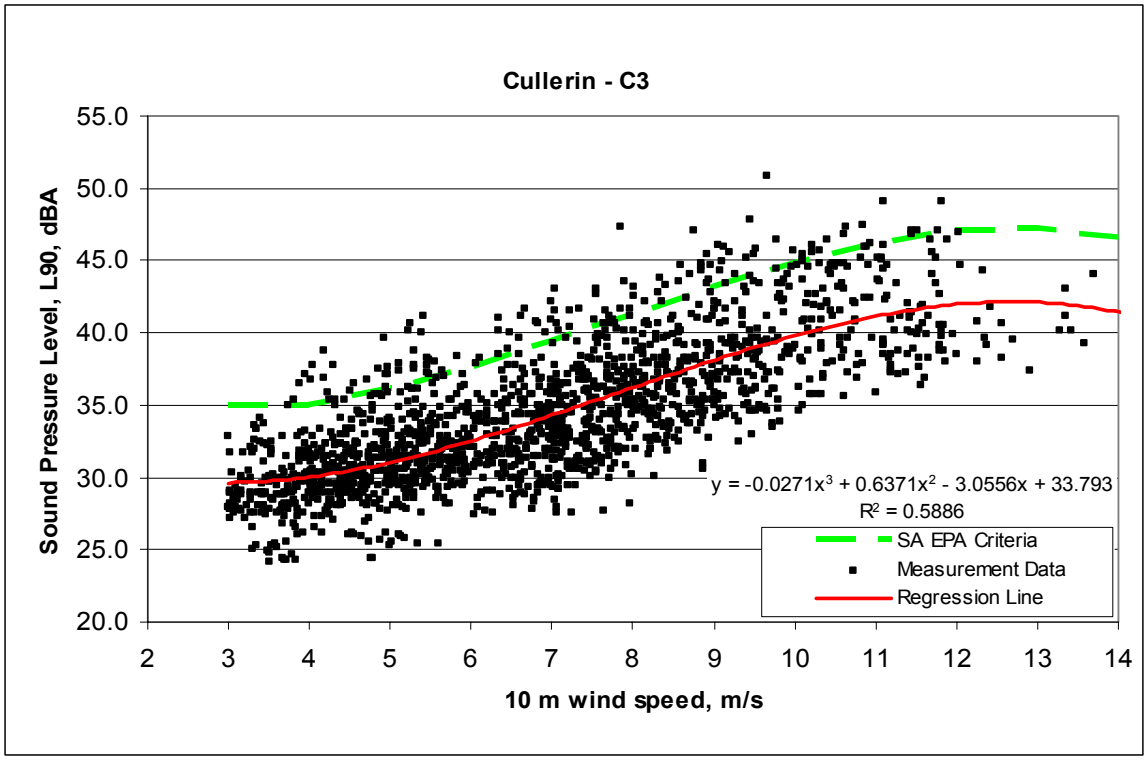
6.4 Location C03 - Wandella

The property of Wandella is located directly to the North East of the proposed wind farm, the residence. The measurement location is shown in **Figure 8**.

Figure 8 Wandella Measurement Location

The results of the background noise monitoring, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 9.**

Figure 9 Background Noise Measurements and Noise Criteria Curve - Wandella



6.5 Location C06 - Lerida Outstation

The residence of Lerida Outstation is located directly to the North East of the proposed wind farm. The measurement location is shown in **Figure 10**.

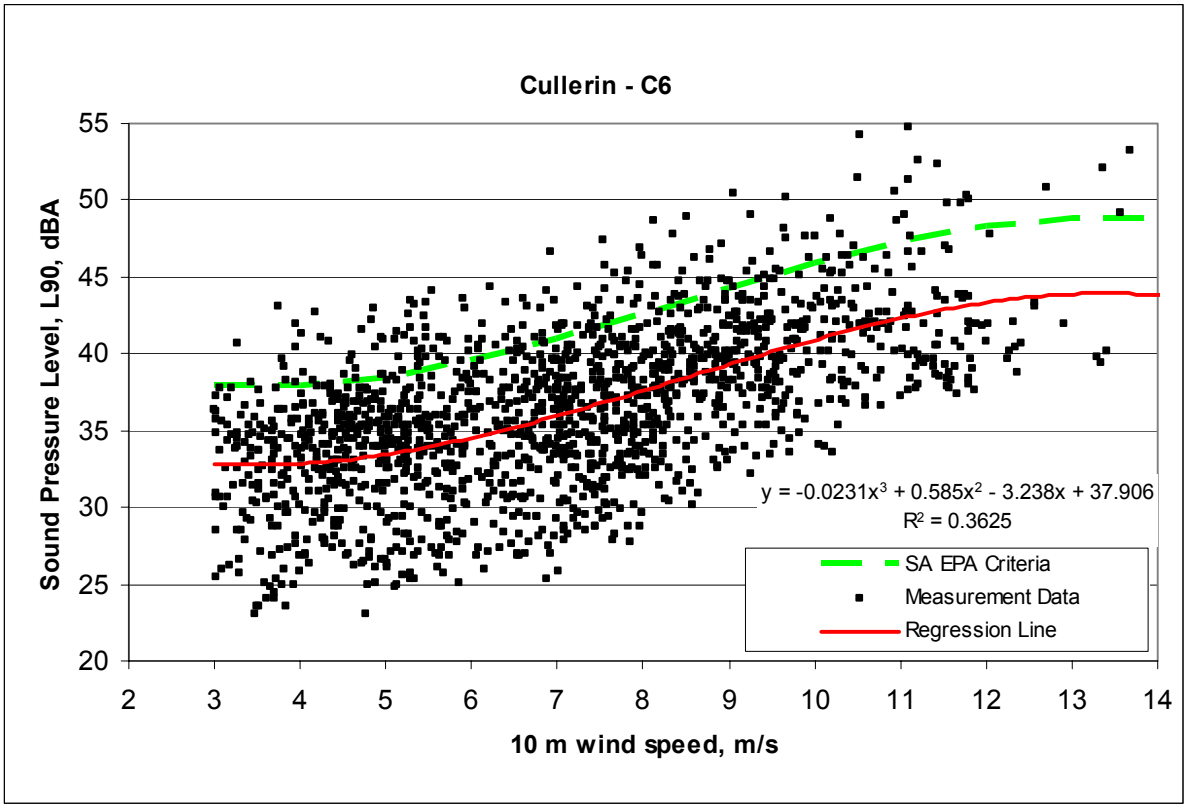
Figure 10 Lerida Outstation Measurement Location

The noise monitoring data showed that high noise levels were experienced daily at a time corresponding with dawn, and likely the result of bird flocks. Data that was clearly affected by extraneous noise sources was removed from the baseline data set.

Noise levels at this location were slightly higher than measured at others. This is likely a result of birds, proximity to grasslands and the Hume Hwy.

The results of the background noise monitoring, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 11.**

Figure 11 Background Noise Measurements and Noise Criteria Curve - Lerida Outstation



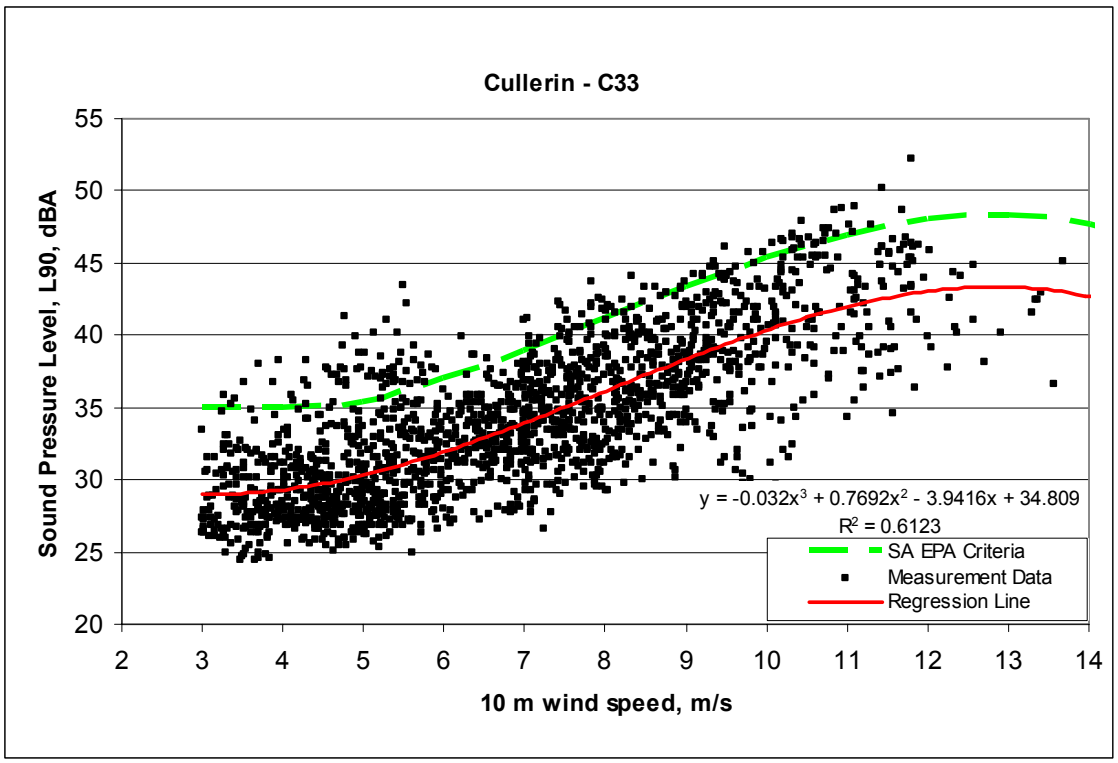
6.6 Location C33 - Ponderosa

The property of Ponderosa is located to the North West of the proposed wind farm, the residence being elevated with a southerly outlook. The measurement location is shown in **Figure 12**.

Figure 12 Ponderosa Measurement Location

The results of the background noise monitoring, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 13**.

Figure 13 Background Noise Measurements and Noise Criteria Curve - Ponderosa



7 ACOUSTIC ASSESSMENT OF PROPOSED WIND FARM

7.1 Predicted Noise Levels

An assessment of the acceptability of wind farm noise levels at all assessment receivers located within a distance of 5 km of the proposed wind farm was made in accordance with SA EPA Guideline criteria and the pre-existing background noise level regression analysis detailed in **Section 6**. The assessment figures are contained in **Appendix A1** and **Appendix A2**.

7.1.1 Layout A - Repower MM82

Appendix A1 contains the predicted WTG noise level curves for Layout A. The predicted curves show that all locations comply to their respective criteria.

7.1.2 Layout B - Suzlon S88

Appendix A2 contains the predicted WTG noise level curves for Layout B, superimposed over SA EPA Guideline Criteria and World Health Organisation based limits. The predicted curves show that most locations comply to their respective criteria.

Location C02, Springvale, is predicted to marginally exceed the WHO based limit by up to approximately 1.5 dBA in the wind speed range 6-12 m/s. It is anticipated that façade noise levels at critical locations (outside bedrooms) would likely be less than the predicted free field level. Refer to discussion in **Section 7.5.**

Location C37 Faybri is predicted to marginally exceed SA EPA Guideline Criteria by approximately 3 dBA in the wind speed range 3-7 m/s. Location C04, Illawambra, is predicted to marginally exceed SA EPA Guideline Criteria by approximately 2 dBA in the wind speed range 3-6 m/s.

It is worth noting that the criteria for both these locations is based on monitoring conducted at Location C03. Whilst geographically similar these locations would in practice have differing background noise level characteristics, where monitoring would be required to confirm each background.

7.2 Assessment of Tonality and Infrasound

WTG manufacturers are obliged to conduct independent tests in accordance with IEC 61400-11. A part of this assessment is to conduct a tonal audibility test. The tonal audibility ΔLta is typically assessed using the methodology outlined in '*Joint Nordic Method Version 2 – Objective Method for Assessing the Audibility of Tones in Noise'*.

For the proposed WTG's the following ΔLta values were determined.

Table 11 Audible Tonality Assessment to IEC 61400-11

	Manufacturer / WTG - ΔLta Value - Audible Tonality	
Wind Speed	**Suzlon S88***	**Repower MM82**
6		-14.4
7		-13.3
8		-14
9		-14.4
10		-14.4

* Detailed WTG measurements are currently being conducted, expected to be completed in mid 2006

For the wind speed range analysed (6 – 10 m/s) tonality was not deemed to be audible and hence no penalty has been applied.

Infrasound is not tested as an obligatory part of IEC 61400-11. It is noted that in general modern WTG's do not exhibit significant infrasound emissions.

7.3 Temperature Inversions

The SA EPA Guideline does not require or suggest temperature inversions be included during wind farm noise assessments. The NSW Industrial Noise Policy states that temperature inversions be included in an assessment if they are deemed to be a prevalent feature of the environment, which generally requires they occur for greater than 30% of the total night-time during winter (Approximately 2 nights per week between hours of 6 pm to 7am). Currently there is insufficient data available to accurately determine the prevalence of temperature inversions, however, subjective comments received from local residents indicated that it was an effect that they had experienced and had some degree of familiarity with.

Temperature inversion is an atmospheric condition in which temperature increases with height above ground. Such conditions may increase noise levels by focussing sound wave propagation paths at a single point. Typically temperature inversions occurring within the lowest 50 m to 100 m of atmosphere can affect noise levels measured on the ground. Temperature inversions are most commonly caused by radiative cooling of the ground at night leading to cooling of the air in contact with the ground. Such conditions are especially prevalent on cloudless nights with little wind.

Conventional approaches to assessing noise propagation under temperature inversion conditions require knowledge of the temperature gradient and assume that the noise source is located below the temperature inversion, typically near to the ground. The effect of temperature inversions on noise propagation from WTG's is therefore not typical of other sources.

WTG's for the Cullerin Project are located on top of Cullerin Range, the hub height (assumed acoustic centre of the WTG) is located between 160 m - 200 m higher than receiver locations on the surrounding area. It is therefore unlikely that conventional temperature inversion conditions, in the lower 100 m of the atmosphere, would affect noise propagation from such an elevated source.

A further consideration must be that temperature inversions require little to no wind in order to minimise atmospheric mixing and hence develop. During calm conditions the WTG's are unlikely to operate, as cut-in speed is 3 m/s.

Notwithstanding the above, an adaptive management approach could be implemented if undue noise impacts are identified during WTG operation that are related to temperature inversion effects.

7.4 Atmospheric Stability and Wind Profile

The wind velocity at a location can be represented by a vertical profile (gradient) that generally is at a minimum at ground level and increases with altitude. The wind velocity profile is primarily determined by physical factors such as surface roughness and topographic (relief) effects which are reasonably constant over time, however can also be affected by more variable local atmospheric conditions including atmospheric stability and turbulence.

Atmospheric stability is determined by the total heat flux to the ground, primarily being the sum of incoming solar and outgoing thermal radiation and heat exchanged with the air. During clear summer days (incoming radiation dominates) air is heated from below and rises, causing significant thermal mixing, vertical air movements and turbulence. This process limits large variations in the vertical wind velocity profile.

During clear nights (outgoing radiation dominates) air is cooled from below, air density is greatest closer to the ground and minimal thermal mixing occurs. This leads to a stable atmosphere where horizontal layers of air are largely decoupled and allows for a higher wind velocity gradient.

The noise assessment methodology outlined in the SA EPA Guidelines, as do many other similar wind farm noise assessment methodologies, by necessity rely on the independently verified reference sound power data available for specific wind turbines measured at a manufacturer's test site. The measurement procedure has been standardised to require sound power data to be measured coincidentally with reference wind speed measurements at an altitude of 10 metres. This is then applied at a specific site (e.g. at Cullerin Range) by using a reference wind speed altitude of 10 metres (as measured at the monitoring tower positioned on Cullerin Range) to relate background noise levels to wind conditions present at the same time. The turbine noise power can then be applied and compared with background data at those same conditions of wind speed at 10m above ground level with good accuracy.

The assessment procedure inherently assumes a fixed relationship between the 10 metre reference altitude and that at which the WTG operates, and that the relationship is the same during IEC 61400-11 test conditions. In practice, as discussed above, the wind velocity profile will vary as a result of ground roughness and atmospheric (stability) effects. The varying profile will likely result in variation in WTG noise emission levels, however, the extent to which levels will vary is difficult to quantify, as the IEC 61400-11 wind profile test conditions are not made available to allow comparison with the subject site.

Accordingly, while the proposed layouts meet the requirements of the SA EPA Guidelines, some uncertainty remains as to the likely noise conditions that will result under specific atmospheric conditions over time. The SA EPA Guidelines noise limits are generally set within the requirements of the WHO Guidelines which relate to health impacts, and it is highly unlikely that the remaining uncertainty could lead to health impacts. However, it is possible that under certain conditions the amenity of existing dwellings could be reduced notwithstanding compliance with SA EPA Guidelines. These conditions are likely to be variable and intermittent, and not result in a long-term loss in amenity.

Notwithstanding the above, an adaptive management approach could be implemented if undue noise impacts are identified during WTG operation that are related to elevated WTG noise levels during stable atmosphere conditions.

7.5 Project Involved Residences

The proponent Taurus Energy intends to enter into noise agreements with project involved residences of Fairview Springvale and Wandella prior to construction. Under the SA EPA Guidelines these residences are not required to comply to the 35 dBA or background + 5 dBA limits. However, it is necessary to ensure that the project does not result in an 'unreasonable interference' with the amenity of these areas or cause any adverse health affects.

The World Health Organisation (WHO) publication '*Guidelines for Community Noise'* identifies the main health risks associated with noise and derives acceptable environmental noise limits for various activities and environments.

For the assessment of project involved residences the adopted external criteria of 45 dBA or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

The predicted noise levels depicted in **Appendix A1** and **A2** are predicted free field noise levels. The noise level at the bedroom façade of a particular location is likely to be less than the predicted free field value as the orientation the building will offer some shielding from some turbine sources.

Therefore, the WHO guideline noise goals, shown in **Table 1,** are likely to be met for all project involved receivers and layouts with the possible exception of 'open window' at night-time at the most exposed façade (south westerly) of location C02 Springvale. The marginal predicted exceedance would indicate that internal noise level criteria would likely be satisfied with a 'closed window' or provision of a small amount of building acoustic treatment to affected rooms.

8 NOISE MITIGATION

8.1 Introduction

Where exceedances of SA EPA Guideline noise criteria or WHO limits are predicted a number of measures are proposed to minimise the impact or reduce WTG noise levels.

The proposed mitigation measures vary dependant upon the receiver (project involved or not involved) the magnitude of the exceedance, number of affected receivers etc.

8.2 Assessment of Mitigated Wind Farm

8.2.1 Layout A

The layout was shown to fully comply to criteria and goals. No mitigation was required for Layout A.

8.2.2 Layout B

The predicted marginal exceedance for Location C02, Springvale, would be re-evaluated in detail with house orientation and layout taken into consideration. Should any residual impact be predicted for facades that include noise sensitive uses, such as bedrooms, then consideration would be given to providing mechanical ventilation (to remove requirement for open windows) or building acoustic treatments (improved glazing for example).

The predicted marginal exceedances for Location C37, Faybri, and Location C04, Illawambra, would be re-evaluated with background noise monitoring to be conducted at the actual properties. Location C04 Illawambra, in particular, is likely to have a higher background noise level due to the surrounding trees in the area.

Source ranking in this assessment indicates that WTG's # 1, #2 and #3 would need to be removed from the layout to achieve compliance with the current baseline criteria adopted for this location. Alternatively, quieter wind turbines could be selected or a noise control mode be instigated. It is noted that the proponent has carried out the assessment for this layout option based on the noisiest likely wind turbine from the 87 to 92 m blade diameter WTGs under consideration in this project.

9 ASSESSMENT OF CONSTRUCTION NOISE LEVELS

The NSW EPA construction noise guidelines recommend noise level goals and hours for work.

The hours of work for construction sites is limited from 7:00 am to 6:00 pm weekdays and 7:00 am to 1:00 pm on Saturdays, with no construction taking place on Sundays or Public Holidays.

For construction programmes that are shorter in duration (less than 4 weeks) it is considered acceptable for construction noise levels to exceed background noise levels by up to 20 dBA. For construction periods of less than 26 weeks (6 months) it is considered acceptable for construction noise levels to be up to 10 dBA above background noise levels.

9.1 Construction Noise

Construction activities include;

- construction of access roads,
- establishment of turbine tower foundations and electrical substation,
- digging of trenches to accommodate underground power cables,
- erection of turbine towers and assembly of WTG's.

The equipment required to complete the above tasks will typically include;

- excavator/grader, bulldozer, dump trucks, roller
- concrete batch plant
- bucket loader, rock breaker, drill rig, excavator/grader, bulldozer, trucks (dump, flat beds, concrete)
- excavator, flat bed trucks
- cranes, fork lift, and various 4WD and service vehicles.

The anticipated construction period is anticipated to be less than 6 months, with civil works expected to span approximately 3 months, however, due to the large area of the wind farm site intensive works will be located within a distance of potential impact for each surrounding residential receiver for only very short and intermittent periods of time. It is therefore considered appropriate that construction noise levels up to 20 dBA above background noise levels would be considered acceptable for short term intensive civil works that are anticipated to produce high noise levels.

Computer noise models of typical construction scenarios were developed which included all anticipated mobile equipment for the activity operating simultaneously at full load. A de-rating factor of 5 dBA was selected to convert modelled full load simultaneous operation to typical operations of multiple mobile construction vehicles.

A concrete batch plant is proposed to be established on the access road, approximately 500 metres north of the Hume Highway to the South East of the site. The nearest affected receiver would be approximately 2.4 km from the batch plant

Two 'worst case' area of works was chosen;

- for the northern area of the site
- for the southern area of the site

The resulting predicted construction noise level for the relevant 'worst case' scenario is detailed in **Table 12** together with typical background noise levels obtained during the background noise monitoring campaign.

Table 12 'Worst case' Construction L_{Aeq} Noise Levels (dBA)

				Construction in 'Worst Case' Southern Area of Wind Farm				Construction in 'Worst Case' Northern Area of Wind Farm			
	Typical Background LA90	Limit	Concrete Batch Plant	Access road construction	Turbine foundation establishment	Trench excavation	WTG erection	Access road construction	Turbine foundation establishment	Trench excavation	WTG erection
C01-Fairview		52	11	16	25		12	16	29	12	11
C02-Springvale	32	52	15	7	25		13	55	44	32	33
C03-Wandella	33	53	13	7	25		11	51	41	36	37
C04-Illawambra		53	13	8	24		9	43	47	32	32
C05-Waiontha		58	11	9	22		7	24	40	25	26
C06-Lerida Outstation	38	58	20	4	23		4	25	26	19	18
C07-Mutmutbilli		52	2		15		0	16	22	7	7
C09-Lochleigh		52			15		1	8	20	4	4
C15-Greendale		58	11	13	21	7	5	21	18	14	14
C17-Bohara		58	10	12	20	5	4	7	15	11	11
C33-Ponderosa	32	52		4	22		8	19	32	14	15
C34-Shearing Shed		52	9	15	23		19	25	35	19	19
C35-Edwards		52	7	12	20		6	24	32	15	17
C36-Edwards		52	6	12	19		5	23	30	14	15
C37-Faybri		53	13		15		9	38	39	24	25
C38-Enniskillen		53	8		14			20	26	11	11
C47-Wandella 2		53	13	8	24		10	52	52	37	37
C48-Cottage. unoccupied		58	10	21	30	14	16	18	29	14	14
C51-Shearing Shed		58	8	19	38	14	27	15	25	11	10
C52-House		52			19		5	7	16		

The predicted 'worst case' construction noise impacts are for most receiver locations below the existing typical daytime background noise level. Some northern receivers (Springvale, Wandella, Illawambra) are anticipated to receive elevated construction noise levels when civil works are located nearby, however, due to the anticipated short period of localised works would likely be considered satisfactory.

Location C02 Springvale is the only location predicted to marginally exceed (3 dBA) short term construction noise guidelines. This impact is a result of access road construction when all associated machinery is operated in close proximity to the residence. Consideration should be given to staging of works in this vicinity or alternative to locating the access road further from residents to minimise impacts.

In consideration that the predicted levels represent typical 'worst case' construction scenarios and are generally within limits which would be considered acceptable, it is unlikely that construction noise will cause any unnecessary impact.

9.2 Blasting

9.2.1 Applicable Criteria

The ground vibration and airblast levels which cause concern or discomfort to residents are generally lower than the relevant building damage limits.

The NSW EPA advocates the use of the ANZECC guidelines for assessing potential residential disturbance arising from blast emissions. The ANZECC guidelines for control of blasting impact at residences are as follows:

- The recommended maximum level for airblast is 115 dB Linear. The level of 115 dB Linear may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 120 dB Linear at any time.
- The recommended maximum for ground vibration is 5 mm/s, Peak Vector Sum (PVS) vibration velocity. It is recommended however, that 2 mm/s (PVS) be considered as the long term regulatory goal for the control of ground vibration. The PVS level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.
- Blasting should generally only be permitted during the hours of 9:00 am to 5:00 pm Monday to Saturday. Blasting should not take place on Sundays and public holidays.
- Blasting should generally take place no more than once per day.

The Australian Standard 2187.2-1993 "*Explosives - Storage, Transport and Use. Part 2: Use of Explosives*" does not present human comfort criteria for ground vibration from blasting. It does however make mention of human comfort level for airblast in saying the "a limit of 120 dB for human comfort is commonly used". This is consistent with the ANZECC guidelines.

AS 2187.2-1993 nominates building damage assessment criteria as presented in **Table 13**.

Table 13 Blast Emission Building Damage Assessment Criteria (AS 2187)

Building Type	Vibration Level	Airblast Level (dB re 20 µPa)
Sensitive (and Heritage)	PVS 5 mm/s	133 dB(Linear) Peak
Residential	PVS 10 mm/s	133 dB(Linear) Peak
Commercial/Industrial	PVS 25 mm/s	133 dB(Linear) Peak

9.2.2 Blasting Assessment

As part of the civil works it is expected that infrequent blasting will be required to clear obstacles and prepare WTG foundations. It is anticipated that a single blast per every 2-3 days may be required for a period of approximately 2 weeks.

Blasting may be required in some areas to clear large rock outcrops to prepare turbine foundations.

The proposed wind farm site is a green field site where no previous blasting or blast monitoring has been conducted and therefore no specific site laws exist. We have therefore adopted a site law derived from measurement data at a different site to give an indicative result.

The 5% site laws for ground vibration and airblast are:

Ground Vibration $PVS\ (5\%) = 16202\ (SD_1)^{-2.03}$

Airblast $SPL(5\%) = 189.3 - 31.8 \log (SD_2)$

where PVS (5%) and SPL (5%) are the levels of ground vibration (Peak Vector Sum - mm/s) and airblast (dB Linear) respectively, above which 5% of the total population (of data points) will lie, assuming that the population has the same statistical distribution as the underlying measured sample.

SD_1 and SD_2 are the ground vibration and airblast scaled distances, where:

$$SD_1 = \frac{\text{Distance}}{\sqrt{\text{MIC}}} \quad (m.kg^{-0.5})$$

and,

$$SD_2 = \frac{\text{Distance}}{\sqrt[3]{\text{MIC}}} \quad (m.kg^{-0.33})$$

Based on the blast emissions site laws, calculations were also conducted to indicate the allowable MIC's for compliance with the general EPA Human Comfort criteria of 115 dB Linear (airblast) and 5 mm/s (ground vibration).

The closest anticipated distance between blasting and residences would be approximately 800 metres. At this distance the predicted maximum MIC of up to 50 kg is likely to produce an airblast overpressure below the acceptable level of 115 dB Linear.

It is evident that the anticipated blasting is likely to meet all human comfort limits and building damage assessment criteria are easily met.

10 CONCLUSION

WTG noise has been predicted and assessed against relevant criteria prescribed by the SA EPA Guideline and World Health Organisation goals where appropriate.

Layout A which includes 15 Repower MM82 WTG's was predicted to comply to all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers.

Layout B, which includes 15 Suzlon S88 WTG's, was predicted to marginally exceed the nominated criteria at two non project involved receivers. A 3 dBA exceedance at Location C37 and a 2 dBA exceedance at Location C04 was indicated. Location specific baseline noise monitoring would be required at these properties to confirm the impact. It was determined that removal of WTG #1, #2 and #3 or consideration of a quieter WTG option would result in general compliance with the criteria at these properties.

Marginal exceedances of the WHO goals were predicted for Location C02 for Layout B. It is anticipated that detailed modelling of façade noise levels at critical bedroom positions would reduce the level of the predicted exceedance. Nonetheless the predicted impact could be mitigated by providing suitable acoustic upgrade of windows to critical rooms and providing for alternative ventilation.

Noise propagation enhancement due to temperature inversion conditions is not anticipated. An adaptive management approach could be implemented if undue noise impacts are identified during WTG operation that are related to temperature inversion effects.

Construction noise impact has been assessed and the 'worst case' scenario's modelled were found to be generally acceptable. Staging and the chosen route alignment for access road construction should be considered during detailed design to minimise potential short term noise impacts.

Blasting impact has been assessed and found to be acceptable. With a maximum MIC of up to 50 kg, the airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear.