APPENDIX 8

Boco Rock Wind Farm Noise Impact Assessment

Heggies Pty Ltd

HEGGIES

REPORT 40-1738-R1

Revision 3

Boco Rock Wind Farm
Noise Impact Assessment

PREPARED FOR

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27 NOVEMBER 2009

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Boco Rock Wind Farm

Noise Impact Assessment

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EXECUTIVE SUMMARY

Heggies Pty Ltd (Heggies) has completed a noise impact assessment of the Boco Rock Wind Farm. The methodology and criteria adopted in the assessment are based on the following:

- South Australian Environmental Protection Authority (SA EPA) *Environment Noise Guidelines for Wind Farms (February 2003)*
- World Health Organization (WHO) *'Guidelines for Community Noise'*
- Construction Noise Guidelines (Chapter 171-1 of the Environmental Noise Control Manual (ENCM))
- Australian and New Zealand Environment Conservation Council (ANZECC) '*Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration'*
- NSW *Environmental Criteria for Road Traffic Noise* (ECRTN May 1999)

Noise monitoring was conducted in March and April 2009 at eight nearby locations to determine baseline conditions and establish indicative criteria for surrounding residential receivers. An evaluation of night-time baseline data was also included.

Two alternative layouts have been considered; one consisting of one-hundred-and-twenty-five (125) wind turbines and the other one-hundred-and-seven (107) wind turbines spread over the project site area.

The 107 Wind Turbine Generator (WTG) layout, equipped with Siemens SWT-2.3-101, 101m rotor diameter, 100m hub height, 2.3 MW turbines was predicted to comply with all relevant noise criteria, SA EPA Guidelines and WHO limits at all respective receivers.

The 125 WTG layout, equipped with Repower MM92, 92.5m rotor diameter, 100m hub height, 2.05 MW turbines was predicted to comply to all relevant noise criteria, SA EPA Guidelines and WHO limits at all respective receivers.

WTG vibration levels have been evaluated and based upon overseas research available were found to be acceptable.

Construction noise and vibration impacts have been assessed and the 'worst case' scenarios modelled were found to be generally acceptable.

Blasting impact has been assessed and found to be acceptable. With a maximum instantaneous charge (MIC) of up to 36 kg, the airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear, and vibration levels below 2 mm/sec at all locations.

Construction traffic noise impact has been assessed and calculations indicated that noise levels along local roads could be increased by up to 3-7 dBA due to construction traffic. However, as there are typically large setbacks of dwellings from the road network, noise levels from construction traffic are considered to be acceptable under the ECRTN.

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1 INTRODUCTION

Heggies Pty Ltd (Heggies) have been engaged by Wind Prospect CWP Pty Ltd as the acoustical consultants for the Boco Rock Wind Farm located 8 km south west of Nimmitabel, and 30km north of Bombala, in NSW.

1.1 Objectives

This report describes the methodology and findings of the Noise Impact Study (NIS) for the Boco Rock Wind Farm forming part of the Environmental Impact Assessment for the proposed project.

This report details the main aspects of the proposed wind farm project, the acoustic criteria, the background noise measurements and the predicted noise levels 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 Wind Farm Assessment 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 Environment Protection Authority (SA EPA) Noise Guidelines for Wind Farms (February 2003)* (SA EPA 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 6 to 10 m/s.

The noise character of Wind Turbine Generator (WTG) noise emissions 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 EPA 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 to various physical characteristics such as topographic shielding and the extent and height of exposed vegetation.

Noise monitoring is completed for a period of approximately 2 weeks and correlated to synchronous wind speed and direction data 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 are normally repeated until an acceptable arrangement is developed.

A brief explanation and description of acoustic terminology is included in **Appendix D.**

2 ENVIRONMENTAL NOISE CRITERIA

2.1 Introduction

The New South Wales (NSW) Government Department of Planning (DOP) has issued information on the required inputs into the Environmental Assessment (EA).

The Director General's Requirements 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 (SA EPA, February 2003).

Furthermore, the Department of Environment and Climate Change (DECC) (formerly the NSW EPA), has highlighted a number of requirements in relation to site establishment and construction noise for the Boco Rock Wind Farm, based on *Environmental Noise Control Manual* (NSW EPA, 1994) with reference to the NSW *Industrial Noise Policy* (NSW EPA, 2000).

Subsequent discussions have been held with the appropriate representatives from the DOP and DECC with respect to slight modification to the SA EPA Guideline Procedures with respect to utilising a wind speed reference height equivalent to WTG hub height as opposed to 10m above ground level (AGL). Such an approach was deemed acceptable.

Initial layout investigations were based on 80m hub heights and, as no wind data was available at 10m AGL, wind data was extrapolated to 80m based on simultaneous data available from anemometers at 45m and 60m.

For the final proposed WTG layouts, a hub height of 100m was adopted. However, the wind reference height to which background noise levels are correlated was maintained at 80m for this assessment. This was deemed acceptable as there is only a minimal difference in wind speeds between 80m and 100m AGL (i.e. a maximum of 0.4m/s assuming a logarithmic wind profile) and as such there will be negligible affect on the background noise level correlation. It is important to note that WTG noise predictions assume a 100m turbine hub height.

2.2 SA EPA Wind Farm Noise Guidelines

The South Australia EPA Noise Guidelines for Wind Farms (SA EPA 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.

The Guideline explicitly states that the "swish" or modulation noise from wind turbines is a fundamental characteristic of such turbines; however, it specifies that tonal or annoying characteristics of turbine noise should be penalised.

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 Wind Prospect CWP 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.

These agreements would specify:

(a) That Wind Prospect CWP would ensure that the properties met the World Health Organisation noise guidelines (see **Section 2.4**); and,

(b) Wind Prospect CWP 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.

This noise agreement 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 Industrial Noise Policy (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 Boco Rock 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 Boco Rock 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 EPA 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 the 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 *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 (WHO) 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 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.

2.5 Construction Noise Guidelines

When dealing with noise emanating from construction works, the DECC recognises that higher levels of noise are likely to be tolerated by people in view of the relatively short duration of the works. As a result, the *"Environmental Noise Control Manual"* (ENCM) presents the DECC's recommended guidelines for the control of construction works noise.

Chapter 171-1 of the ENCM recommends the following approaches to mitigating adverse noise impacts from construction sites:

Noise Emission Objectives

The ENCM recommends that the $L_{A10(15minute)}$ noise levels arising from a construction site and measured within the curtilage of an occupied noise-sensitive premises (ie at boundary or within 30 m of dwelling, whichever is the lesser) should not exceed the noise levels indicated in **Table 2**. These noise goals are consistent with community reaction to construction noise.

Table 2 DECC-Recommended Noise Goals for Construction Works

Period of Noise Exposure	$L_{A10(15minute)}$ Construction Noise Goal
Cumulative noise exposure period not exceeding 4 weeks	$L_{A90(15minute)}$ plus 20 dBA
Cumulative noise exposure period of between 4 weeks and 26 weeks	$L_{A90(15minute)}$ plus 10 dBA
Cumulative noise exposure period longer than 26 weeks	$L_{A90(15minute)}$ plus 5 dBA

Preferred Hours of Construction

The DECC guidelines recommend confining permissible work times as outlined in **Table 3**.

Table 3 Preferred Daytime Construction Hours

Day	Preferred Construction Hours
Monday to Friday	7.00 am to 6.00 pm
Saturdays	7.00 am to 1.00 pm (if inaudible at residences) Otherwise, 8.00 am to 1.00 pm.
Sundays or Public Holidays	No construction

Works Undertaken Outside of Preferred Construction Hours

Where it is necessary for construction works to be undertaken outside the DECC's preferred daytime construction hours, the condition normally applied is that:

$L_{A10(15minute)}$ noise levels emitted by the works should not exceed the L_{A90} level during the relevant evening or night-time period by a margin of more than 5 dBA, *independent* of the duration of the construction activity.

2.6 Vibration Guidelines

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). Of these considerations, the human comfort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

The DECCW's *Assessing Vibration: A Technical Guideline* provides acceptable values for continuous and impulsive vibration based upon guidelines contained in BS 6472–1992, *Evaluation of human exposure to vibration in buildings (1–80 Hz)*.

Both preferred and maximum vibration limits are defined for various locations and are shown in **Table 4**, with the preferred night-time PPV criteria of 0.2 mm/s being the most relevant to the project.

Table 4 Preferred and maximum values for continuous and impulsive vibration

Location	Assessment period[1]	Preferred values RMS acceleration m/s²		Maximum values RMS acceleration m/s²		Peak Velocity PPV mm/s	
		z-axis	x- and y-axes	z-axis	x- and y-axes	Preferred	Maximum
Continuous vibration							
Critical areas[2]	Day- or night-time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime	0.010	0.0071	0.020	0.014	0.28	0.56
	night-time	0.007	0.005	0.014	0.010	0.20	0.40
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028	0.56	1.1
Workshops	Day- or night-time	0.04	0.029	0.080	0.058	1.1	2.2
Impulsive vibration							
Critical areas[2]	Day- or night-time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime	0.30	0.21	0.60	0.42	8.6	17.0
	night-time	0.010	0.0071	0.020	0.014	2.8	5.6
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92	18.0	36.0
Workshops	Day- or night-time	0.64	0.46	1.28	0.92	18.0	36.0

1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am

2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of this policy, and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472–1992

These limits relate to a long-term (16 hours for daytime), continuous exposure to vibration sources. Where vibration is intermittent, a higher level of vibration is typically acceptable.

2.6.1 Building Damage

In regard to potential building damage, the German Standard DIN4150 recommends a limit of 10 mm/s PPV within any building and the British Standard BS7385: Part 2 - 1993 sets a limit within buildings which depends upon the vibration frequency, but is as low as 7.5 mm/s PPV (at 4.5Hz). For the purposes of ensuring a reasonable factor of safety a conservative limit of approximately 5 mm/s PPV has been applied for this project.

2.7 Blasting Criteria

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

The DECC advocates the use of the Australian and New Zealand Environment Conservation Council (ANZECC) guideline *"Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration"* 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 "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 5**.

Table 5 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

2.8 Traffic Noise

The NSW *Environmental Criteria for Road Traffic Noise* (ECRTN May 1999) presents guidelines for the assessment of road traffic noise arising from new or redeveloped roads. The document provides road traffic noise guidelines for a range of road or residential developments, as well as guidelines that apply for other nominated sensitive land uses.

The road traffic guidelines recommended are based on the functional categories of the subject roads, as applied by the Roads Traffic Authority (RTA).

The functional categories are as follows:

- Arterial roads (including freeways) carrying predominantly through-traffic from one region to another, forming principal avenues of communication for urban traffic movements.
- Sub-arterial roads connecting the arterial roads to areas of development and carrying traffic from one part of a region to another. They may also relieve traffic on arterial roads in some circumstances.
- Collector roads connecting the sub-arterial roads to the local road system in developed areas.
- Local roads, which are the subdivisional roads within a particular developed area. These are used solely as local access roads

For this project, traffic associated with the construction stage has the potential to increase noise levels on existing arterial and local roads during the day (no night period construction proposed). As such, the relevant traffic noise criteria, as provided in Table 1 of ECRTN, are provided in **Table 6** below.

Table 6 Road Traffic Noise Criteria

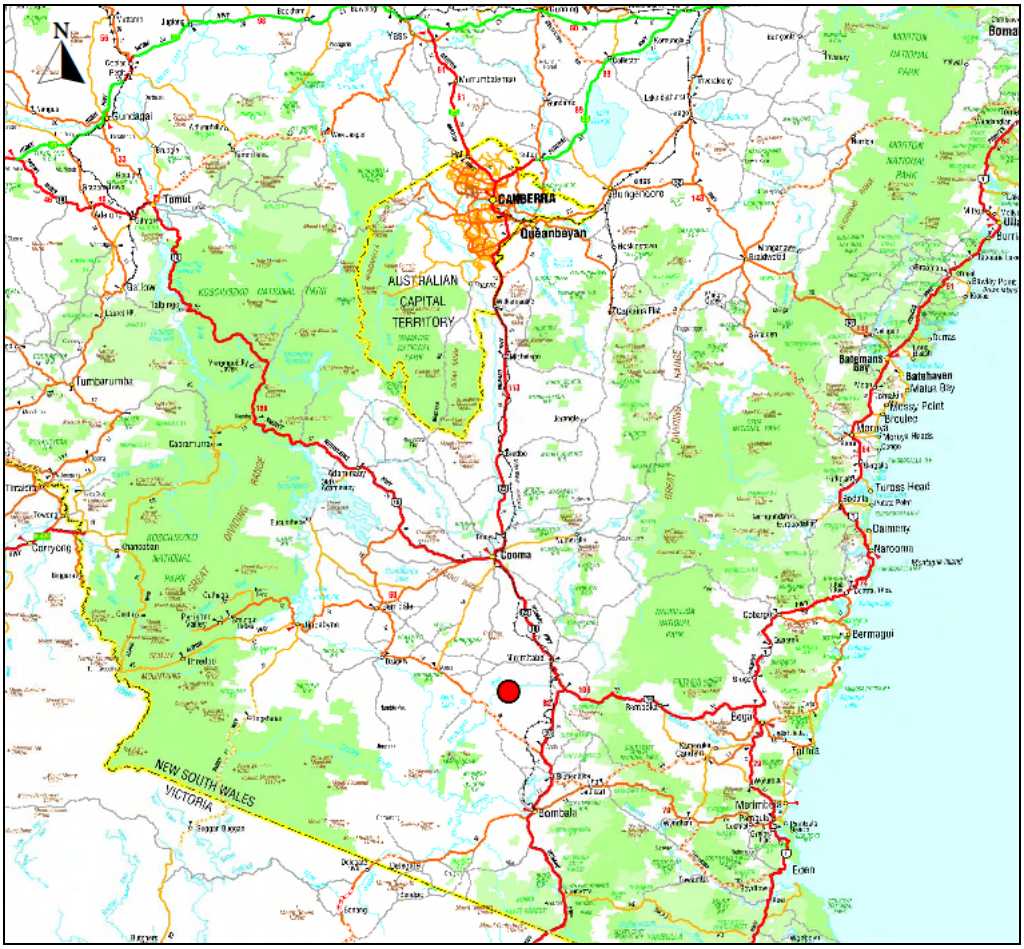
Type of Development	**Criteria**	
	Day 7am - 10pm (dBA)	**Where Criteria are Already Exceeded**
Redevelopment of existing freeway/arterial road	$L_{Aeq(15hour)}$ 60 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA.
Redevelopment of existing local roads	$L_{Aeq(1hour)}$ 55 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA.

3 GENERAL SITE DESCRIPTION

The Boco Rock Wind Farm is located approximately 6-8 km southwest of Nimmitabel in the southern tablelands of NSW. The proposed wind farm covers approximately 140 hectares, is situated along the high altitude plateau of the Monaro Plains and is to the west of the Monaro Highway.

The location of the Boco Rock Wind Farm is shown in **Figure 1** below.

Figure 1 Location of proposed Boco Rock Wind Farm



3.1 Characteristics of the site

The proposed site incorporates the farming properties Yandra, Riverside, Springfield, Roselea, Windella, Rockybah. Benbullen, Brooklyn, Sherwood, Coopers Hill, Glennfinnan, Old Springfield, Boco, Wyuna, Nestlebrae, Telembgrm, Avonlake and Kelton Plain. 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 Wind Prospect CWP and the site landowners.

Topographically, the proposed site broadly includes a number of rolling hills to the north and a single ridge/escarpment, Sherwin Range, to the south which all run approximately in a north-south direction. The Maclaughlin River runs through the north of the site and runs to the east of the escarpment in the southern part of the site. The Snowy River runs to the west of the site. The surrounding district is primarily used for agricultural (grazing) purposes with areas of the project site covered in native vegetation.

The Monaro Highway is sufficiently far away to the east of the project site that background noise levels would not be affected by road traffic noise. All properties surrounding the proposed site have an ambient background noise environment that is determined by pre-dominantly natural sources which are largely wind influenced.

The prevailing wind is from the North through to the West and occasionally from the East. The district receives only marginal rainfall.

3.2 Dwelling Locations

Properties to the north and northwest are generally located along or accessed from Springfield Road and Avonlake Road. Properties to the south and southeast are generally located along or accessed from Ando Road. The assessment locations include all dwellings located within 6 km of a proposed WTG. **Figure 2** shows the current proposed 125WTG layout and all nearby dwellings**.**

Figure 2 Dwelling Locations

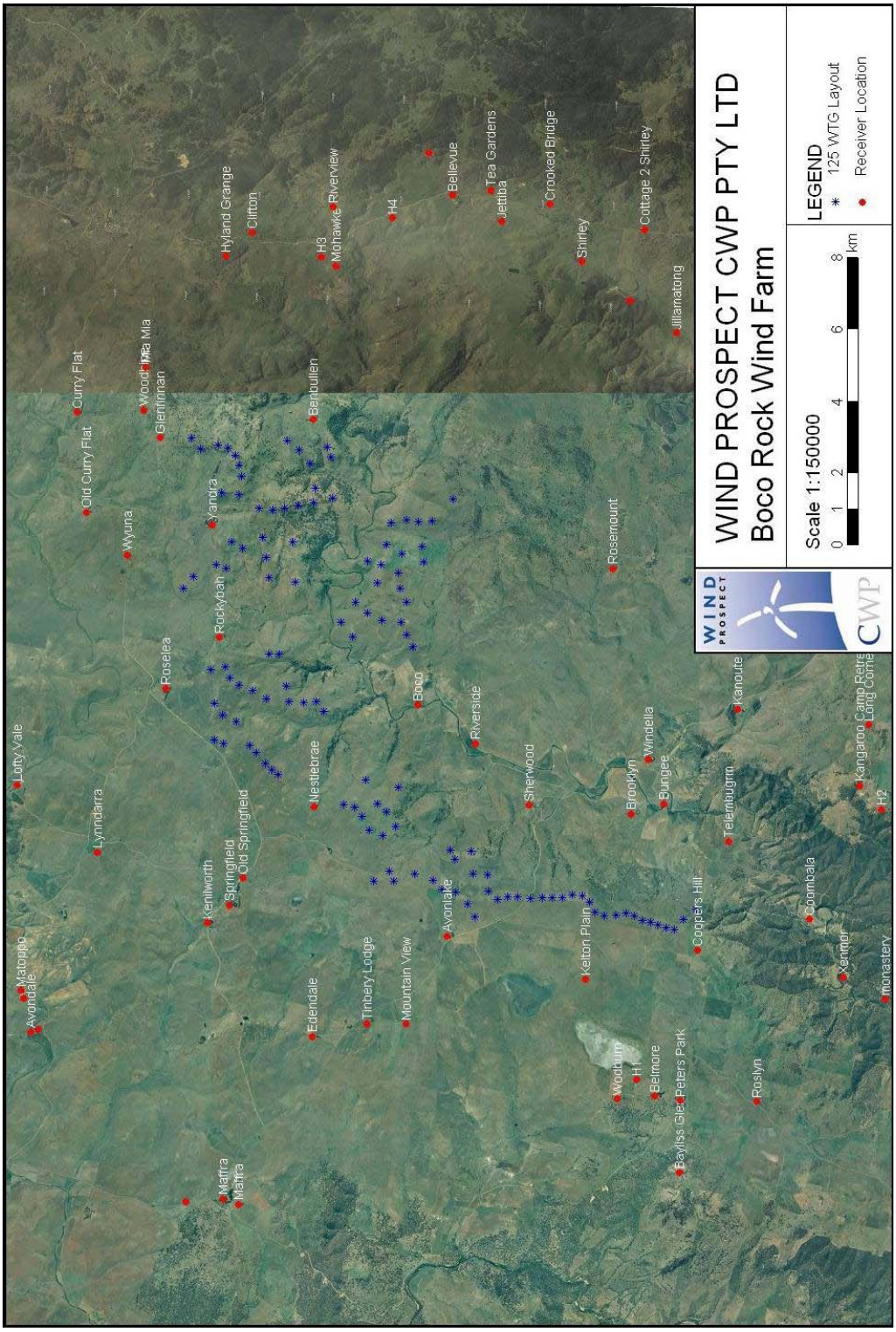


Table 7 lists the on-site and off-site receiver locations and their position. Other dwellings located beyond 6 km of a proposed WTG are not considered within this assessment, primarily as WTG noise is unlikely to be audible at these distances and compliance to noise criteria more critical at closer receivers.

Table 7 Surrounding Receivers

Location	East (m)	North (m)
Avonlake*	684924	5947624
Belmore	680461	5941821
Benbullen*	699314	5951354
Boco*	691374	5948433
Brooklyn*	688326	5942494
Bungee	688606	5941567
Clifton	704525	5953058
Coombala	685402	5937496
Coopers Hill*	684531	5940643
Curry Flat	699524	5957935
Edendale	682127	5951369
Glenfinnan*	698804	5955622
H1	680925	5942328
H2	688457	5935512
H3	703854	5951128
Hyland Grange	703866	5953807
Kangaroo Camp Retreat	689115	5936116
Kanoute	691256	5939524
Kelton Plain*	683714	5943770
Kenilworth	685288	5954313
Lofty Vale	689125	5959604
Lynndarra	687266	5957378
Mia Mia	700779	5956037
Mohawke	703603	5950719
monastery	683155	5935393
Mountain View	682479	5948755
Nestlebrae*	688537	5951337
Old Curry Flat	696738	5957694
Old Springfield*	686537	5953315
Peters Park	680341	5941115
Riverside*	690289	5946823
Rockybah*	693247	5953985
Roselea*	691826	5955463
Rosemount	695166	5942991
Roslyn	680312	5938990
Sherwood*	688579	5945345
Springfield*	685789	5953700

Location	East (m)	North (m)
Telembugrm*	687560	5939773
Tinbery Lodge	682470	5949856
Windella*	689840	5942014
Wodburn	680399	5942869
Woodbine	699584	5956091
Wyuna*	695544	5956531
Xenmor	683772	5936565
Yandra*	696387	5954178

Note: * Denotes the location is involved with the project

4 PROPOSED WIND FARM LAYOUT

The proponent has developed two base turbine layouts for the proposed Boco Rock Wind Farm. The 107 WTG layout, comprising Siemens SWT-2.3-101, 2.3 MW turbines is listed in **Table 8** and the 125 WTG layout, comprising Repower MM92, 2.05 MW turbines is listed in Table 9.

Table 8 Boco Rock Proposed 109 WTG Layout (Siemens SWT-2.3-101 2.3 MW)

WTG no.	Easting	Northing	WTG no.	Easting	Northing	WTG no.	Easting	Northing	WTG no.	Easting	Northing
1	697079.2	5947458	33	685651	5940690	65	698555.5	5951837	97	695350.5	5949014
2	687734.8	5949793	34	686437	5949679	66	698243.2	5950882	98	695324.6	5948274
3	689060	5948990	35	686725.1	5949239	67	698113.5	5953399	99	695760.7	5948324
4	686429	5949123	36	689544	5952531	68	694594	5954992	100	694221.2	5948752
5	685314	5942019	37	689720	5952714	69	695268	5954084	101	695452.8	5952686
6	685239	5941774	38	690021.1	5952945	70	694917	5954701	102	694890.4	5952608
7	685390.7	5942261	39	690269	5953865	71	695166	5953796	103	693243.7	5950271
8	685470.8	5943164	40	690378	5954117	72	695722	5953341	104	693662.5	5950592
9	685543.6	5942813	41	691063.7	5953898	73	685998.3	5944387	105	694216.8	5950185
10	685547.7	5943443	42	690882	5953523	74	688370	5949329	106	686627.1	5947073
11	696481	5948045	43	691404.3	5954122	75	689417	5952335	107	693904.7	5949660
12	686479.7	5948025	44	692762.5	5952598	76	686630.4	5946509			
13	688607.5	5949577	45	692760.5	5952311	77	696029.1	5952768			
14	693736.8	5948912	46	691378.1	5951957	78	698083.6	5951461			
15	685923.7	5946234	47	691477.9	5951394	79	698787.2	5954759			
16	688176.6	5950155	48	691167.7	5951077	80	690215.6	5953133			
17	689264	5949903	49	695888	5951937	81	691905.2	5953488			
18	687305.2	5947553	50	697108	5950831	82	691889.6	5952113			
19	685085.7	5941303	51	697385	5951300	83	691758.6	5953070			
20	685461.9	5946852	52	696772.7	5952291	84	685987.4	5943787			
21	685950	5945309	53	696828.4	5952868	85	693350.9	5949564			
22	688581.7	5950428	54	697726.7	5953359	86	694775	5951867			
23	696428.1	5949201	55	697254.3	5953921	87	685982.4	5944993			
24	695351.1	5949852	56	697222.1	5953441	88	686072.7	5944069			
25	694743	5949566	57	698529.5	5953698	89	698542	5950987			
26	694587.6	5948950	58	698582	5954018	90	686646.9	5948528			
27	692960.5	5948576	59	698489.6	5954502	91	687282.4	5946971			
28	686184.3	5947607	60	696503.3	5948774	92	686019	5945675			
29	696451.6	5948431	61	695808.2	5949311	93	685510.5	5942510			
30	693291	5948764	62	692153.5	5953783	94	685145	5941548			
31	687965	5949062	63	692348.7	5954226	95	685929	5947130			
32	685387	5941027	64	696897	5951793	96	685973.3	5944698			

Table 9 Boco Rock Proposed 125 WTG Layout (Repower MM92 2.05 MW)

WTG no.	Easting	Northing	WTG no.	Easting	Northing	WTG no.	Easting	Northing	WTG no.	Easting	Northing
1	697079.3	5947458	33	686133.8	5947390	65	696828.4	5952868	97	691904.9	5953433
2	687869.5	5949807	34	686633.8	5946898	66	697726.8	5953359	98	691889.7	5952113
3	689060.1	5948990	35	696451.6	5948431	67	697254.4	5953921	99	691758.7	5953070
4	686429.1	5949123	36	693291.1	5948764	68	697222.1	5953441	100	686036.4	5943853
5	686006.8	5945949	37	687965.1	5949062	69	698520.1	5953754	101	693700.1	5949440
6	685297.1	5941966	38	685387.1	5941027	70	698582.1	5954018	102	694775.1	5951867
7	685215.2	5941754	39	685651.1	5940690	71	698489.7	5954502	103	698310.1	5953551
8	685342.8	5942192	40	686437.1	5949679	72	696503.3	5948774	104	685978.1	5944973
9	685480.1	5943238	41	686725.2	5949239	73	695760.7	5948324	105	686064.1	5944127
10	685472.4	5942402	42	695263.4	5949473	74	692412.8	5953810	106	698542.1	5950987
11	685500.8	5942933	43	689544.1	5952531	75	692348.7	5954226	107	686647	5948528
12	685575	5943492	44	689720.1	5952714	76	696897.1	5951793	108	687282.5	5946971
13	685845.1	5943645	45	690021.2	5952945	77	698712.3	5952101	109	686019.1	5945675
14	696481.1	5948045	46	690269.1	5953865	78	698463.4	5951758	110	685543.6	5942653
15	686479.8	5948025	47	690378.1	5954117	79	698243.2	5950882	111	685158.1	5941522
16	687061.7	5947430	48	691063.8	5953898	80	698024.6	5953446	112	685798.8	5947060
17	688607.6	5949577	49	690882.1	5953523	81	694594	5954992	113	695882.8	5953654
18	693651.5	5948929	50	691404.4	5954122	82	695268.1	5954084	114	685973.4	5944698
19	685923.8	5946234	51	692110.6	5953706	83	694917.1	5954701	115	695808.2	5949311
20	688233.1	5950012	52	692762.6	5952598	84	695166.1	5953796	116	695023.2	5948990
21	689264.1	5949903	53	692760.6	5952311	85	695722.1	5953341	117	695324.6	5948274
22	687305.2	5947553	54	691522.8	5952688	86	685985	5944422	118	695561.4	5948881
23	685085.7	5941303	55	691417.2	5951635	87	688370	5949329	119	694221.2	5948752
24	685462	5946852	56	691451.9	5951277	88	689417.1	5952335	120	695452.9	5952686
25	685950.1	5945309	57	691167.8	5951077	89	686630.5	5946509	121	694890.5	5952608
26	688568.8	5950519	58	696989.4	5951367	90	686152.5	5946469	122	693243.7	5950271
27	696428.1	5949201	59	695888.1	5951937	91	696029.2	5952768	123	693662.6	5950592
28	695351.2	5949852	60	697108.1	5950831	92	698083.7	5951461	124	694216.9	5950185
29	694743.1	5949566	61	691437	5952042	93	698787.2	5954759	125	693914	5949858
30	694587.7	5948950	62	697385.1	5951300	94	687710.1	5949418			
31	692960.5	5948576	63	696829.5	5952159	95	688505.8	5950225			
32	686219.1	5947764	64	696792.9	5952502	96	690215.6	5953133			

4.1 WTG Type and Details

The preferred WTG manufacturer and model is currently in the finalisation process, with preference for turbines suitable under class 2 wind speeds at 100m hub height for both layouts. The investigated wind farm layouts for this assessment include a 125 WTG comprising Repower MM92 2.05 MW wind turbines and a 107 WTG layout comprising Siemens SWT-2.3-101 2.3 MW wind turbines; both are three bladed, upwind, pitch-regulated, active yaw turbines.

Although the Repower 3.XM is the largest available machine, and was used for the visual impact assessment of the 107 WTG layout, the lack of available spectral sound power data for this turbine has necessitated noise modelling based on the Siemens SWT-2.3-101 turbine, which is of similar geometry to the Repower 3.XM. Furthermore, the available sound power data for the Repower 3.XM (sound power level vs. wind speed, see **Appendix B**) suggests that it is marginally quieter than that of the Siemens SWT-2.3-101 and it is expected that noise modelling based on the Siemens turbine, is likely to be conservative relative to the Repower 3.XM.

Table 10 summarises the relevant turbine input data used for noise level prediction.

Table 10 WTG Manufacturers Data

Make, model, power	**Siemens SWT-2.3-101, 2.3 MW**	**Repower MM92, 2.05 MW**
Rotor diameter	101 m	92.5 m
Hub height	100 m	100 m
Cut-in wind speed	3.5 m/s	3 m/s
Rated wind speed	12 - 13 m/s	11.2 m/s
Rotor speed	6 – 16 rpm	7.8 - 15 rpm
'Standard Mode' Sound Power Level, $L_{WA,ref}$	107 dBA	104.2 dBA

Noise emissions for the proposed WTG's have been provided by the WTG manufacturers and have either been independently tested according to International Standard IEC 61400-11 or are warranted noise levels calculated in accordance with the International Standard. Copies of the certification test or manufacturers documentation that give the sound power level variation with wind speed, frequency spectra and tonality assessment are contained in **Appendix B.**