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Rye Park Wind Farm

Environmental Noise Assessment

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EXECUTIVE SUMMARY

The Rye Park Wind Farm is proposed to comprise up to 109 wind turbine generators (turbines) and be located 12 km northeast of Yass and 42 km west of Crookwell, New South Wales (NSW).

The Rye Park Wind Farm Environmental Noise Assessment report was commissioned to address the Director General's Requirements (DGRs) relating to operational and construction noise and vibration.

The DGRs require operational noise to be assessed against the South Australian *Environmental Noise Wind Farm Guidelines 2003* (the SA Guidelines). The SA Guidelines compare the predicted noise levels from the wind farm against criteria developed from measured background noise levels.

The assessment of operational noise from the proposed Rye Park Wind Farm has been based on 109 Vestas V112-3.0 MW turbines with a hub height of 80m above ground level (AGL). Noise predictions indicate that the layout will achieve the environmental noise criteria established in accordance with the SA Guidelines.

Notwithstanding the consideration of "worst case" turbine selections at this stage of the project, the assessment of operational noise from the proposed Rye Park Wind Farm will be repeated during the procurement stage to demonstrate that the final turbine selection and final layout following "micro-siting" will achieve compliance with the project criteria prior to construction.

A construction noise and vibration framework has also been developed in this assessment to achieve the relevant DGRs for general construction activity and road transport.

GLOSSARY

A-weighting	Frequency adjustment applied to measured noise levels to replicate the frequency response of the human ear.
AGL	Above ground level.
Ambient noise level	The noise level with the presence of all existing noise sources in the environment.
Background noise level	The noise level in the absence of intermittent noise sources.
Day	The period defined by the INP as 7am to 6pm Monday to Saturday, and 8am to 6pm on Sunday.
dB(A)	A-weighted noise or sound power level in decibels.
DECC	Department of Environment and Climate Change
DGRs	Director-General's Requirements
DPI	NSW Department of Planning and Infrastructure.
EPA	Environment Protection Authority
Evening	The period defined by the INP as 6pm to 10pm Monday to Sunday.
Equivalent noise level	Energy averaged noise level.
INP	New South Wales Environment Protection Authority's Industrial Noise Policy 2000.
L_{A90}	A-weighted noise level exceeded 90% of the time measured in decibels, representing the background noise level.
L_{Aeq}	A-weighted equivalent noise level measured in decibels.
Night	The period defined by the INP as 10pm to 7am Monday to Saturday, and 10pm to 8am on Sunday.
NSW	New South Wales.
RBL	Rating Background Level.
Sound power level	A measure of the sound energy emitted from a source of noise.
Worst-case	Conditions resulting in the highest noise level at or inside residences.

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INTRODUCTION

The Rye Park Wind Farm is proposed to comprise up to 109 wind turbine generators (turbines) and be located 12 km northeast of Yass and 42 km west of Crookwell, New South Wales (NSW).

An assessment of environmental noise from the proposed development was previously conducted by SLR (Reference 640.01808-R1) in August 2013. This assessment reported on the noise related aspects of the DGRs and included measured background noise levels and predicted noise levels from the wind farm.

Since this time, minor changes have been made to the turbine arrangement and Sonus has been engaged to conduct an independent assessment of the noise from the wind farm in accordance with the Director-General's Requirements (DGRs), using the background noise levels and associated criteria previously reported by SLR.

Sonus Pty Ltd has been engaged by the proponent to conduct an environmental noise assessment of the proposed Rye Park Wind Farm, located 12 km northeast of Yass and 42 km west of Crookwell, New South Wales (NSW).

The DGRs specify that the assessment must be conducted in accordance with the following guidelines:

- Wind Turbines – the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines* (2003) (operational noise);
- Collector Substation - *NSW Industrial Noise Policy* (EPA 2000) (operational noise);
- Site Establishment and Construction - *Interim Construction Noise Guideline* (Department of Environment and Climate Change (DECC 2009) (construction noise);
- Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW EPA, 1999) (construction noise); and
- Vibration – *Assessing Vibration: A Technical Guideline* (DECC, 2006) (construction vibration).

The assessment of operational noise from the proposed Rye Park Wind Farm has been based on 109 Vestas V112 - 3.0 MW turbines. The proposed locations of the turbines and the associated collector substations are provided in Appendix A.

Noise predictions have been made for residences within approximately 2km of the wind farm. The locations of the residences and their relative distance to the closest turbine are provided in Appendix B. Appendix B also provides the status of the landowner with respect to whether a landowner agreement has been entered into.

The assessment of operational noise from the proposed Rye Park Wind Farm will be repeated during the procurement stage to demonstrate that the final turbine selection and final layout following “micro-siting” will achieve compliance with the project criteria prior to construction.

DIRECTOR GENERAL'S REQUIREMENTS

The DGRs specify the relevant guidelines for each aspect of noise from the project to be considered. These requirements are discussed below and the relevant section of the DGRs is provided in Appendix C.

Wind Turbines

The DGRs require operational noise to be assessed against the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines 2003* (the SA Guidelines). The SA Guidelines were developed with the core objective to balance the advantage of developing wind energy projects with protecting the amenity of the surrounding community from adverse noise impacts.

Criteria - Landowners without Commercial Agreements

The SA Guidelines state:

> *The predicted equivalent noise level ($L_{Aeq,10}$), adjusted for tonality in accordance with these guidelines, should not exceed:*
>
> - *35 dB(A), or*
> - *the background noise level ($L_{A90,10}$) by more than 5 dB(A),*
>
> *whichever is the greater, at all relevant receivers for each integer wind speed[1] from cut-in to rated power of the WTG.*

Where the wind farm noise exhibits a tonal characteristic, a 5 dB(A) penalty is to be applied to the criteria, in accordance with the SA Guidelines.

In addition, the SA Guidelines note that:

> *The criteria have been developed to minimise the impact on the amenity of premises that do not have an agreement with the wind farm developers.*

[1] Where wind speed is referenced in this report, it is taken to be the wind speed measured at hub height in accordance with the NSW Draft Guidelines, unless specifically noted otherwise.

Criteria - Landowners with Commercial Agreements

The landowners of a number of residences have entered into commercial agreements with the developers of the wind farm (identified in Appendix B).

It is understood that each of these landowners has an agreement with the wind farm developer and suitable noise criteria for each residence will be agreed between the developer and the landowner. Notwithstanding this agreement, a contemporary approach by authorities has been to reference the World Health Organisation (WHO) *Guidelines for Community Noise*[2] (the WHO Guidelines). The WHO Guidelines recommend an indoor noise level of 30 dB(A) to protect against sleep disturbance. The indoor limit of 30 dB(A) equates to an outdoor noise level of approximately 45 dB(A) with windows open.

Based on the above, it is proposed that the noise at residences of landholders, with an agreement, achieve the recommendations of the WHO Guidelines in lieu of the external noise criterion provided by the SA Guidelines.

Background Noise Monitoring and Resultant Criteria

Background noise monitoring was outlined in report number 640.02808-R1, dated 2 August 2013 (the SLR report). Criteria for integer hub height wind speeds have been developed for the wind farm based on the results of the SLR analysis.

The 20 locations where background noise monitoring was conducted are summarised in Table 1.

[2] "WHO Guidelines for Community Noise" World Health Organisation, 1999.

Table 1: Monitoring locations.

Residence ID	Coordinates (UTM WGS84 H55)	
	Easting	Northing
R02*	678095	6185733
R06	681484	6184020
R14*	677807	6183115
R19	676412	6181665
R24	674877	6183534
R25*	677075	6178323
R30*	682495	6177218
R32*	680416	6176683
R34*	681817	6174338
R36*	679988	6173811

Residence ID	Coordinates (UTM WGS84 H55)	
	Easting	Northing
R41*	681802	6168516
R44*	679986	6166322
R46*	681835	6164679
R49*	680667	6162540
R51*	680970	6161588
R52*	684135	6161246
R54*	683515	6155819
R56	686567	6153140
R60*	684244	6149529
R128*	678848	6183498

* Denotes a project involved residence

For each monitoring location, the background noise levels corresponding to integer wind speeds at hub height have been developed based on the regression analysis in the SLR report. The background noise level ($L_{A90,10}$) at the monitoring locations for the wind speeds within the operating range of the turbines is provided in Table 2.

Table 2: Background noise levels (dB(A))

Residence ID	Background Noise Level (dB(A)) for integer wind speeds at Hub Height													
	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s	13m/s	14m/s	15m/s	16m/s	17m/s	18m/s
R02*	29	30	31	32	34	36	38	41	45	48	53	58	63	69
R06	26	26	27	29	30	32	33	35	37	38	39	41	41	42
R14*	25	26	27	28	30	32	34	36	39	42	45	49	53	57
R19	31	31	31	32	33	34	35	37	39	41	44	47	51	56
R24	29	30	31	32	33	34	36	38	41	43	46	49	53	57
R25*	23	24	24	24	25	26	28	30	32	35	39	43	48	54
R30*	27	28	29	29	31	32	33	35	37	39	41	44	47	50
R32*	30	31	31	32	33	35	36	38	40	42	44	46	48	51
R34*	25	27	29	31	34	36	38	41	43	45	47	49	50	51
R36*	22	22	22	23	24	25	27	28	30	33	36	39	42	46
R41*	20	21	22	24	26	28	31	33	35	37	38	39	40	40

Residence ID	Background Noise Level (dB(A)) for integer wind speeds at Hub Height													
	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s	13m/s	14m/s	15m/s	16m/s	17m/s	18m/s
R44*	24	24	25	27	28	30	32	35	37	40	43	45	48	51
R46*	26	26	27	28	30	32	35	37	41	44	49	53	59	64
R49*	25	26	27	28	29	31	33	35	36	38	40	42	44	46
R51*	25	26	27	28	30	32	34	36	38	40	42	44	46	47
R52*	29	29	29	30	31	33	34	36	39	41	44	48	51	55
R54*	28	29	30	31	33	35	38	41	45	49	53	58	63	68
R56	26	27	28	29	31	33	35	36	38	40	42	44	46	47
R60*	31	32	33	34	36	37	39	40	42	42	43	42	41	39
R128*	27	28	29	30	32	34	36	39	42	45	49	53	58	63

* Denotes a project involved residence

The background noise levels in Table 2 have been used to establish noise criteria for each residence in accordance with the SA Guidelines. At residences where background noise monitoring has not been carried out, the location indicated by SLR to best represent the background noise at that residence has been used.

Collection Substations

The DGRs reference the New South Wales Environment Protection Authority's *Industrial Noise Policy 2000* (the INP) for the assessment of collector substation noise levels.

The INP establishes objective criteria based on the existing ambient noise environment and the envisaged amenity of the area. The most stringent criteria provided by the two methods are then selected. If the noise levels are exceeded, then all feasible and reasonable noise reduction measures should be implemented.

In accordance with the INP, the Rating Background Level (RBL) is used to characterise the existing ambient noise environment for each of the day, evening and night periods. The RBL is determined from the lower tenth percentile of the background noise level (L_{A90}) in the environment and effectively represents the "lulls". That is, the RBL effectively "selects" the quietest periods at the monitoring locations. Where the RBL is measured to be below 30 dB(A), then it is set to 30 dB(A). The RBL requires a different procedure to the SA Guidelines background noise data analysis.

As specified in the previous section, the ambient noise environment was monitored at 20 residences in the vicinity of the wind farm. Background noise levels presented in the SLR report are often below 30 dB(A). Therefore, in accordance with the INP, an RBL of 30 dB(A) has been considered for all residences in the assessment.

The INP requires that noise from industrial sources should not exceed the measured RBL by more than 5 dB(A). Therefore the most stringent criterion in accordance with the INP's ambient noise method is 35 dB(A). A noise level of 35 dB(A) is more onerous than the amenity based noise criterion of 40 dB(A) for a dwelling in a rural environment and therefore becomes the assessment criterion for the collector substations in accordance with the INP.

It is noted that if noise assessed under the INP is found to have a character that has the potential to be annoying, such as tonality, modulation or dominant low-frequency content, a modifying correction factor is to be applied to the measured level. A collector substation has the potential to exhibit tonality if it is audible. Therefore a 5 dB(A) correction is applied, effectively reducing the criterion to 30 dB(A).

Based on the above, to achieve the INP criteria, it is recommended that noise from the proposed collector substations achieves a level of 30 dB(A) at all residences.

Construction

The construction of a wind farm comprises activities such as road construction, civil works, excavation, foundation construction, electrical infrastructure works and turbine erection. These require processes such as heavy vehicle movements, crushing and screening, concrete batching, loaders, excavators, generators, cranes and, subject to local conditions, possibly blasting.

To assess construction noise in accordance with the DGRs, the Department of Environment & Climate Change *Interim Construction Noise Guideline 2009* (the ICN Guideline) is used.

The ICN Guideline provides an emphasis on implementing "feasible" and "reasonable" noise reduction measures and does not set mandatory objective criteria. However, the ICN

Guideline does establish a quantitative approach, whereby "management levels" are defined based on the existing RBL. The management levels as defined by the ICN Guideline are provided in Table 6.

Table 3: The ICN Guideline management levels.

Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Traffic Noise

In accordance with the DGRs, traffic noise associated with the construction of the wind farm is to be assessed against the NSW Environment Protection Authority, *Environmental Criteria for Road Traffic Noise* (the ECRTN).

Traffic noise criteria are provided for a range of scenarios. The most appropriate classification for the Rye Park Wind Farm construction site and its associated traffic is considered to be "land use developments with the potential to create additional traffic on local roads". However, it should be noted that this criterion applies to an ongoing operation, as distinct to a temporary construction process and as such provides a conservative approach.

The criteria are equivalent ($L_{Aeq,\ 1hour}$) noise levels of no greater than 55 dB(A) during the day-time (7am to 10pm) and 50 dB(A) during the night-time (10pm to 7am). This noise level is to be achieved outside, at a distance of 1.5m from the facade of a dwelling.

Construction Vibration

To assess construction vibration levels in accordance with the DGRs, the DECC document "Assessing Vibration: A Technical Guideline", February 2006 (the Technical Guideline) is referenced.

The Technical Guideline provides an emphasis on implementing feasible and practicable vibration reduction measures and does not set mandatory standards or objective criteria.

The Technical Guideline does establish a quantitative approach, whereby goal vibration levels are established based on human response to continuous, intermittent and impulsive vibration. Continuous vibration is uninterrupted for an extended period of time. Intermittent vibration is an interrupted form of continuous vibration, and impulsive vibration is a sudden event or events.

For construction activity occurring during the day time, the Technical Guideline can be interpreted to provide the vibration criteria in Table 4. This is based on the core document,

British Standard BS 6472-1992 “Evaluation of human exposure to vibration in buildings (1-80Hz)”, being used as the technical basis for the Technical Guideline.

Table 4: Vibration Criteria

Continuous mm/s^2 Vertical (rms.)	Impulsive mm/s^2 Vertical (rms)	Intermittent $m/s^{1.75}$ Vibration Dose Value
10-20	30-60	0.2-0.4

Continuous and impulsive vibration criteria are provided as “rms” values for acceleration. The term “rms” relates to a mathematical process that is effectively an average. The “rms” value for acceleration is expressed in millimetres per second squared (mm/s^2). The intermittent vibration criterion is derived from a prescribed mathematical process performed on the results and therefore its quantity and units ($m/s^{1.75}$) differ from those for continuous and intermittent vibration.

OPERATIONAL NOISE

Turbine Noise

Layout and Details

Noise from the Rye Park Wind Farm has been assessed based on the layout consisting of 109 turbines, with the coordinates provided in Appendix A.

The predictions of the turbine noise have been based on 109 Vestas V112 - 3.0 MW turbines with a hub height of 80m AGL and sound power level data provided in Table 5 below[3]. It is understood that the total sound power levels will be warranted to the proponent if the Vestas V112 - 3.0 MW turbine is selected.

Table 5: Vestas V112 - 3.0 MW Sound Power Levels.

Hub Height Wind Speed (m/s)	SWL (dB(A)) for each Octave Band Centre Frequency								Total SWL (dB(A))
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
5	74	85	88	91	91	87	81	70	96
6	76	87	91	93	93	89	84	72	98
7	79	90	93	96	95	92	86	75	101
8	81	92	96	98	98	94	89	77	103
9	83	94	97	100	100	96	90	79	105
10	86	95	99	101	100	96	94	86	106
11	89	96	98	100	101	99	94	85	107
12	89	94	97	99	101	101	95	86	107
13	89	94	97	99	101	101	95	86	107
14	89	94	96	98	101	101	97	91	107
15	89	94	96	98	101	101	97	91	107
16	89	94	96	98	101	101	97	91	107
17	89	94	96	98	101	101	97	91	107
18 (rated power)	89	94	96	98	101	101	97	91	107

[3] The sound power level data which has been provided, corresponds to integer wind speeds referenced at 10 m above ground level, in accordance with the international standard IEC61400-111 under which it is measured. For the assessment, linear interpolation has been conducted to obtain sound power levels for integer wind speeds at hub height.

The predictions have been conducted without a penalty for the presence of tonal characteristics. To provide certainty, it is recommended that a guarantee is sought from the manufacturer as part of the procurement process. The general form of the guarantee should be that a penalty for tonality is not applicable at any residence when tested using a 1/3 octave band analysis based on correction factors of the INP.

Noise Propagation Model - CONCAWE

The CONCAWE [4] model takes into account the influence of geometrical spreading, topography, ground absorption, air absorption and weather conditions. The CONCAWE model is endorsed in the SA Guidelines and is widely accepted as an appropriate noise propagation model.

The predictions have been based on the following input conditions:

- weather category 6 (night with no clouds);
- 10°C temperature
- 80% relative humidity;
- 100% acoustically soft ground;
- wind direction from all WTGs to all residences;
- barrier attenuation of no greater than 2 dB; and,
- 1.5m receiver height.

The SA Guidelines provide a default prediction method which incorporates hard ground in the noise propagation model unless justification is provided for using another input. The CONCAWE propagation model separates ground attenuation into the categories of hard ground and ground with finite acoustic impedance. CONCAWE states that hard ground should be used for surfaces such as concrete or water and all other surfaces including grass or soil should be considered as finite acoustic impedance. The ground between the wind farm and residences is not concrete or water, and therefore a finite acoustic impedance (corresponding to grass or rough pasture within the CONCAWE model) has been used.

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

Noise Predictions

The noise level at the residences in the vicinity of the wind farm from turbines has been predicted for wind speeds from cut in to rated power. The environmental noise criteria and predicted noise level are provided in Table 6 as follows.

Table 6: Comparison of Prediction Noise Levels with Noise Criteria.

Residence ID	Representative Monitoring Location	Predicted Noise Level and Criterion (dB(A)) at Hub Height (80m) Integer Wind Speeds																											
		5 m/s		6 m/s		7 m/s		8 m/s		9 m/s		10 m/s		11 m/s		12 m/s		13 m/s		14 m/s		15 m/s		16 m/s		17 m/s		18 m/s	
		Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction
Non-Project Dwellings																													
R01	R02	35	30	35	32	36	35	37	37	39	39	41	40	43	40	46	39	50	39	53	39	58	39	63	39	68	39	74	39
R06	R06	35	25	35	27	35	30	35	32	35	34	37	35	38	35	40	34	42	34	43	33	44	33	46	33	46	33	47	33
R07	R06	35	24	35	26	35	29	35	31	35	33	37	34	38	34	40	33	42	33	43	33	44	33	46	33	46	33	47	33
R08	R06	35	23	35	25	35	27	35	30	35	31	37	33	38	32	40	32	42	32	43	31	44	31	46	31	46	31	47	31
R09	R06	35	22	35	24	35	27	35	29	35	31	37	32	38	32	40	31	42	31	43	31	44	31	46	31	46	31	47	31
R10	R06	35	21	35	23	35	26	35	28	35	30	37	31	38	31	40	30	42	30	43	29	44	29	46	29	46	29	47	29
R11	R13	35	28	35	30	35	32	35	35	37	37	39	38	41	38	44	37	47	37	50	36	54	36	58	36	63	36	68	36
R17	R19	36	25	36	27	36	30	37	32	38	34	39	35	40	35	42	34	44	34	46	34	49	34	52	34	56	34	61	34
R19	R19	36	27	36	29	36	32	37	34	38	36	39	37	40	37	42	36	44	36	46	36	49	36	52	36	56	36	61	36
R20	R19	36	25	36	27	36	30	37	32	38	34	39	35	40	35	42	34	44	34	46	34	49	34	52	34	56	34	61	34
R22	R19	36	25	36	27	36	30	37	32	38	34	39	35	40	35	42	34	44	34	46	33	49	33	52	33	56	33	61	33
R26	R25	35	24	35	26	35	29	35	31	35	33	35	34	35	34	35	33	37	33	40	33	44	33	48	33	53	33	59	33
R29	R25	35	23	35	26	35	28	35	31	35	32	35	34	35	33	35	32	37	32	40	32	44	32	48	32	53	32	59	32
R38	R36	35	25	35	27	35	30	35	32	35	34	35	35	35	35	35	34	35	34	38	34	41	34	44	34	47	34	51	34
R40	R44	35	21	35	23	35	26	35	28	35	30	35	31	37	31	40	30	42	30	45	30	48	30	50	30	53	30	56	30
R45	R46	35	26	35	28	35	30	35	33	35	35	37	36	40	36	42	35	46	35	49	34	54	34	58	34	64	34	69	34
R47	R49	35	26	35	28	35	31	35	33	35	35	36	36	38	36	40	35	41	35	43	35	45	35	47	35	49	35	51	35
R48	R49	35	24	35	26	35	29	35	31	35	33	36	34	38	34	40	33	41	33	43	33	45	33	47	33	49	33	51	33
R50	R51	35	25	35	27	35	30	35	32	35	34	37	35	39	35	41	34	43	34	45	34	47	34	49	34	51	34	52	34
R53	R51	35	23	35	25	35	28	35	30	35	32	37	33	39	33	41	32	43	32	45	31	47	31	49	31	51	31	52	31
R56	R56	35	27	35	29	35	31	35	34	36	35	38	37	40	36	41	36	43	36	45	35	47	35	49	35	51	35	52	35
R63	R60	36	21	37	24	38	26	39	29	41	30	42	32	44	31	45	30	47	30	47	30	48	30	47	30	46	30	44	30
R65	R44	35	25	35	27	35	30	35	32	35	34	35	35	37	35	40	34	42	34	45	34	48	34	50	34	53	34	56	34
R170	R46	35	24	35	26	35	28	35	31	35	33	37	34	40	33	42	33	46	33	49	32	54	32	58	32	64	32	69	32
R324	R51	35	23	35	25	35	27	35	30	35	32	37	33	39	33	41	32	43	32	45	31	47	31	49	31	51	31	52	31

Residence ID	Representative Monitoring Location	Predicted Noise Level and Criterion (dB(A)) at Hub Height (80m) Integer Wind Speeds																									
		5 m/s		6 m/s		7 m/s		8 m/s		9 m/s		10 m/s		11 m/s		12 m/s		13 m/s		14 m/s		15 m/s		16 m/s		17 m/s		18 m/s	
		Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction
Project Dwellings																											
R02*	R02	45	35	45	37	45	39	45	42	45	44	45	45	45	45	46	44	50	44	53	44	58	44	63	44	68	44	74	44
R14*	R14	45	34	45	36	45	38	45	41	45	43	45	44	45	44	45	43	45	43	47	42	50	42	54	42	58	42	62	42
R16*	R14	45	34	45	36	45	38	45	41	45	43	45	44	45	44	45	43	45	43	47	42	50	42	54	42	58	42	62	42
R25*	R25	45	28	45	30	45	33	45	35	45	37	45	38	45	38	45	37	45	37	45	37	45	37	48	37	53	37	59	37
R30*	R30	45	35	45	37	45	39	45	42	45	44	45	45	45	45	45	44	45	44	45	43	46	43	49	43	52	43	55	43
R31*	R32	45	31	45	33	45	35	45	38	45	40	45	41	45	41	45	40	45	40	47	39	49	39	51	39	53	39	56	39
R34*	R34	45	32	45	35	45	37	45	40	45	41	45	42	45	42	46	41	48	41	50	41	52	41	54	41	55	41	56	41
R36*	R36	45	26	45	29	45	31	45	34	45	35	45	37	45	36	45	35	45	35	45	35	45	35	45	35	47	35	51	35
R41*	R41	45	33	45	36	45	38	45	41	45	42	45	44	45	43	45	43	45	43	45	42	45	42	45	42	45	42	45	42
R42*	R41	45	25	45	27	45	29	45	32	45	34	45	35	45	35	45	34	45	34	45	33	45	33	45	33	45	33	45	33
R44*	R44	45	26	45	28	45	31	45	33	45	35	45	36	45	36	45	35	45	35	45	34	48	34	50	34	53	34	56	34
R46*	R46	45	32	45	35	45	37	45	40	45	41	45	43	45	42	45	42	46	42	49	41	54	41	58	41	64	41	69	41
R49*	R49	45	28	45	30	45	33	45	35	45	37	45	38	45	38	45	37	45	37	45	37	45	37	47	37	49	37	51	37
R51*	R51	45	26	45	29	45	31	45	34	45	35	45	37	45	36	45	35	45	35	45	35	47	35	49	35	51	35	52	35
R52*	R52	45	22	45	24	45	27	45	29	45	31	45	32	45	32	45	31	45	31	46	30	49	30	53	30	56	30	60	30
R59*	R60	45	24	45	26	45	29	45	31	45	33	45	34	45	34	45	33	47	33	47	33	48	33	47	33	46	33	45	33
R60*	R60	45	24	45	26	45	29	45	31	45	33	45	34	45	34	45	33	47	33	47	33	48	33	47	33	46	33	45	33
R61*	R60	45	22	45	25	45	27	45	30	45	31	45	33	45	32	45	31	47	31	47	31	48	31	47	31	46	31	45	31
R64*	R36	45	25	45	27	45	30	45	32	45	34	45	35	45	35	45	34	45	34	45	34	45	34	45	34	47	34	51	34
R128*	R13	45	30	45	33	45	35	45	38	45	39	45	40	45	40	45	39	47	39	50	39	54	39	58	39	63	39	68	39

Based on the predictions, the noise from the 109 Vestas V112 - 3.0 MW turbines will comply with the criteria established in accordance with the

- SA Guidelines at all residences without an agreement; and,
- WHO Guidelines at all residences with an agreement.

Appendix D provides the predicted noise level contour at 10 m/s, the integer wind speed associated with the highest predicted noise level.

Collector Substation Noise

Layout and Details

The noise from the proposed electrical collector substations at the wind farm has been considered for assessment against the INP. Up to 3 collector substations will be constructed on the wind farm site. Depending on the operating voltage of the wind farm power lines, it is also possible that a 330/132kV transformer will also be required as part of the 330kV connection substation located at the southern end of the wind farm site. Table 7 below shows the location, capacity and number of transformers proposed at each location.

Table 7: Transformer Locations.

Substation	Easting	Northing	Transformer Capacity
Northern collector substation (Option A)	678800	6176375	1 X 180MVA
Alternate Northern collector substation (Option B)	679465	6174998	1 x 180MVA
Central collector substation	680563	6168466	1 X 170MVA
Southern collector substation	683900	6151775	1 X 80MVA
Connection substation	684053	6150769	2 X 210MVA

The sound power level of the transformer has been derived from the Australian/New Zealand Standard AS/NS60076.10:2009[5]. The total sound power and octave band sound power levels assumed for the collector substations are provided in Table 8 on the following page.

[5] Australian/New Zealand Standard AS/NZS60076.10:2009, *Power transformers - Determination of sound levels (IEC 60076-10, Ed. 1(2001) MOD).*

Table 8: Transformer Sound Power Levels.

Transformer Capacity	Sound Power Level (dB(A)) for each Octave Band Centre Frequency							Total dB(A)
	63Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
180 MVA	77	85	92	95	87	84	77	98
170 MVA	76	84	92	94	87	84	77	97
80 MVA	72	80	87	90	82	79	72	93
210 MVA	78	86	93	96	88	85	78	99

Noise Predictions

The noise level at residences in the vicinity of the collector substations has been predicted. Where the noise level is predicted to be greater than 20dB(A), the predictions have been compared against the conservative criterion of 30 dB(A) developed under the INP and provided in Table 9 below. Predictions are provided for both northern substation location options. It is noted that the noise level at all other locations is predicted to be 20dB(A) or less.

Table 9: Comparison of Prediction Noise Levels with Environmental Noise Criterion.

Residence ID	Criterion dB(A)	Predicted Noise Level dB(A)
With Northern Collector Substation Option A		
R31*	30	25
R60*	30	21
R59*	30	21
With Northern Collector Substation Option B		
R60*	30	21
R59*	30	21

Both options assessed above include the possible transformers at the connection substation. Based on the predictions, the criterion of 30 dB(A) will be achieved at all locations and as such will not adversely impact on the amenity of residences in the locality of the collector substations.

Other Considerations

The DGRs also require information relating to a range of other considerations as provided below.

Modulation

Amplitude modulation (which is the cyclic variation in the emitted noise level) is a fundamental characteristic of wind turbine noise and is therefore a characteristic which is taken into account in the objective criteria specifically developed for wind farms. A higher than usual level of amplitude modulation has been reported at a small number of wind farm sites in other countries. Due to its limited occurrence, a methodology for the objective assessment of "excessive" amplitude modulation is not well defined. If excessive modulation is found to be a feature of the noise from the Rye Park wind farm, measures should be taken to correct the noise characteristic.

Van Den Berg effect

The Van Den Berg effect is a term that is used to describe "excessive" amplitude modulation as discussed above. The term has also been applied to a meteorological condition that produces a high wind shear whereby low wind speeds are experienced at ground level at the wind farm site with high wind speeds at hub height. Where the noise criteria are derived from background noise levels correlated with wind speeds measured close to ground level, there is the potential that the noise criteria could be exceeded in such a meteorological condition. The potential is removed in this assessment by using the wind speed at the hub height for background noise correlations and noise predictions.

Notwithstanding this, the meteorological conditions required for the Van Den Berg effect typically occur during nights where there is little to no cloud cover and low wind speeds. The Van Den Berg effect has been observed on a flat site in Europe under these specific conditions.

In two matters before the NSW Land and Environment Court (Gullen Range Wind Farm NSW LEC 41288 of 2008 and Taralga Wind Farm NSW LEC 11216 of 2007), it has been determined by the relevant meteorological experts that the required meteorological conditions to trigger the effect were not a feature of the environment. In Gullen Range (NSW LEC 41288 of 2008), the meteorological analysis prepared by Dr Chris Purton concluded that suitable conditions for this effect were not a feature because of the elevated ridgeline location of the wind farm (Purton, evidence NSW LEC 41288 of 2008).

Based on the above, a specific assessment of the likelihood of the Van Den Berg effect occurring at the Rye Park Wind Farm site has not been made.

Low Frequency Noise

Noise sources that produce low frequency content (such as a freight train locomotive or diesel engine) have dominant noise content in the frequency range between 20 and 200 Hz. Low frequency noise is often described as a “rumble”.

Aerodynamic noise from a wind turbine is not dominant in the low frequency range. The main content of aerodynamic noise generated by a wind turbine is often in the area known generically as the mid-frequencies, being between 200 and 1000Hz. For example, this is evident in the octave band sound power levels for the turbine provided in Table 5.

Noise reduces over distance due to a range of factors including atmospheric absorption. The mid and high frequencies are subject to a greater rate of atmospheric absorption compared to the low frequencies and therefore over large distances, whilst the absolute level of noise in all frequencies reduces, the relative level of low frequency noise compared to the mid and high frequency content increases. For example, when standing alongside a road corridor, the mid and high frequency noise from the tyre and road interaction is dominant, particularly if the road surface is wet. However, at large distances from a road corridor in a rural environment, the remaining audible content is the low frequency noise of the engine and exhaust.

Low frequency sound produced by wind farms is not unique in overall level or content. Low frequency sound can be easily measured and heard at a range of locations at levels well in excess than in the vicinity of a wind farm. Compliance with the SA Guidelines will therefore inherently provide an adequate level of protection of amenity in the surrounding area from low frequency noise impacts.

Notwithstanding, predictions of the C-weighted noise level (the C-weighting is used to indicate the low frequency content) at residences have been made based on the worst-case (highest noise level) sound power level spectra for the turbines.

Based on the predictions, the low frequency noise from the wind farm will be no greater than 60 dB(C) at all non-associated residences. These levels are below low frequency noise limits considered by the NSW authorities for recent developments and for the Draft NSW Guidelines.

Infrasound

Infrasound is generally defined as noise at frequencies less than 20 Hz. The generation of infrasound was detected on early turbine designs, which incorporated the blades 'downwind' of the tower structure. The mechanism for the generation was that the blade passed through the wake caused by the presence of the tower.

Modern turbines locate the blades upwind of the tower and it is found that turbines of contemporary design produce much lower levels of infrasound.

Infrasound is often described as inaudible, however, sound below 20 Hz will be audible provided that the sound level is sufficiently high. The thresholds of hearing for infrasound have been determined in a range of studies. In addition, it has been found that the non-audible perception of infrasound through felt vibrations in various parts of the body only occurs at levels well above the threshold of hearing.

Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics. The A-weighting network (dB(A)) is the most common, and it is applied to simulate the human response for sound in the most common frequency range. The A-weighting network is used by the SA Guidelines. The G-weighting network has been standardised to determine the human perception and annoyance due to noise that lies within the infrasound frequency range.

A common audibility threshold from the range of studies is an infrasound noise level of 85 dB(G) or greater. This is used by the Queensland Department of Environment and Resource Management's (DERM's) draft Guideline for the assessment of low frequency noise as the acceptable level of infrasound in the environment from a noise source to protect against the potential onset of annoyance and is consistent with other approaches, including the UK Department for Environment, Food and Rural Affairs (DEFRA).

Whilst the aerodynamic noise from rotating turbine blades produces energy in the infrasound range, a large range of measurements of infrasound noise emissions from modern upwind turbines indicates that at distances of 200 metres, infrasound is in the order of 25 dB below the recognised perception threshold of 85 dB(G). The level of Infrasound will further reduce at greater distances from the turbines, therefore the infrasound at dwellings is expected to be even lower as the separation distances between wind farms and dwellings is in excess of 200m.

It is noted that there are natural sources of infrasound including wind and breaking waves, and of man-made sources such as industrial processes, vehicle movements and air conditioning and ventilation systems that make infrasound at a similar or greater level than what has been measured at distances of 200m from a modern wind turbine.

A South Australian Government study by the Environment Protection Authority into infrasound (*Infrasound levels near windfarms and in other environments*, January 2013) provided findings for both G and un-weighted measurement data at very low frequencies that were consistent with a wide range of national and international peer reviewed studies, including:

- the measured levels of infrasound from wind farms are well below the threshold of perception; and
- the measured infrasound levels around wind farms are no higher than levels measured at other locations where people live, work and sleep; and
- the characteristics of noise produced by wind farms are not unique and are common in everyday life.

It is for the above reasons that infrasound from wind farms is not required to be assessed in contemporary standards and guidelines used by Australian and International authorities.

Corona and Aeolian Noise

Corona and Aeolian noise can be generated from the transmission lines. Corona noise is electrically-induced and occurs under specific conditions when the transmission lines are operational, whereas Aeolian noise is wind-induced and occurs under specific conditions regardless of the transmission lines are operational or not.

Corona noise is infrequent and typically occurs in specific conditions of rain or high humidity when the air adjacent to a conductor of high voltage lines is ionised and becomes a conductor of electricity. The noise that is produced is typically a low level of hissing that is rarely a problem at distances greater than 50 to 100m from the transmission lines.

Aeolian noise is infrequent and only occurs at times when there is a specific wind speed and direction to generate the mechanism of air passing over thin structures. The Aeolian noise generally only occurs on rare occasions and at times when there are high wind speeds and high background noise levels. There are mitigation measures available to reduce Aeolian noise if necessary.

Contingency Strategy

The DGRs require that a contingency strategy exists in the event of commissioned turbine noise exceeding the noise predictions. It is noted that modern turbines typically have multiple operating modes which produce lower noise levels.

Therefore, in the event of commissioned turbine noise exceeding the criteria, opportunities exist to reduce the noise of the turbines using lower noise modes that can be implemented under certain operating conditions. Notwithstanding, the predictions are based on conservative (higher noise level) modelling assumptions as a means of reducing the potential for commissioned turbine noise levels exceeding the predictions.

CONSTRUCTION NOISE

The equipment and activities on site will vary throughout the project, depending on various stages of construction. The predicted noise from construction activity is presented as a worst case (highest noise level) scenario, where it is assumed all equipment is present, and operating simultaneously on site for each stage of construction.

The weather conditions used for the predictions are the most conducive for the propagation of noise, comprising an overcast day with a breeze from the construction activity to the receiver. Other weather conditions would result in lower noise levels than those predicted for day-time construction.

WTG Installation

The separation distance of the closest non-associated dwelling to a proposed WTG is approximately 900m. A separation distance greater than 900m will result in lower noise levels than that presented below in Table 10. The required separation distance in order to achieve the 40 dB(A) criterion, which is 10 dB(A) above the RBL, is provided in Table 10 also.

Table 10: Predicted construction noise levels.

Phase	Main Plant and Equipment	Predicted Noise Level at 900m	Separation to Achieve 40 dB(A) Criterion
Site Set-Up and Civil Works	Generator Transport truck Excavator Low loader	46 dB(A)	1650m
Road and Hard Stand Construction	Mobile crushing and screening plant Dozer Roller Low loader Tipper truck Excavator Scraper Transport truck	52 dB(A)	2400m
Excavation and foundation construction	Excavator Front end loader Concrete batching plant Mobile crushing and screening plant Truck-mounted concrete pump Concrete mixer truck Mobile crane Transport truck Tipper truck	52 dB(A)	2400m
Electrical Installation	Rock trencher Concrete mixer truck Low loader Tipper truck Mobile crane	52 dB(A)	2400m
Turbine Delivery and Erection	Extendable trailer truck Low loader Mobile crane	47 dB(A)	1800m

Based on the predicted noise levels, it is expected that construction noise from the WTG installation will be greater than 40 dB(A) at a distance of 900m. The predicted noise levels are significantly less than the 75 dB(A) upper limit provided in the ICN Guideline.

Based on the above, it is possible that a dwelling located between 900m and up to 2400m from a WTG may be defined as “noise affected” but not “highly noise affected” by the ICN Guideline.

Access Roads

Access to the WTG sites will be via a specifically constructed road network. The separation distance of the closest non-associated dwelling to a designated access road is approximately 250m. The noise from typical road construction activity, such as as described in Table 10 has been predicted to be 63 dB(A) at 250m.

Based on the above, it is possible that a dwelling located between 900m and up to 2400m from an access road may be defined as “noise affected” but not “highly noise affected” by the ICN Guideline.

Batching Plant

Two fixed batching plants have been proposed for the construction phase, at the locations in Table 11.

Table 11: Predicted construction noise levels.

	Coordinates (UTM WGS84 H55)	
	Easting	**Northing**
Batching Plant 1	678977	6182581
Batching Plant 2	683855	6150596

The closest non-associated dwelling to a proposed batching yard is approximately 1200m away. The noise from typical batching plant machinery, such as cement trucks, loaders, and delivery trucks has been predicted to be 33 dB(A) at 1200m.

Noise Mitigation

Where residences are classed as “noise affected” by the ICN Guideline, the developer is required to apply all feasible and reasonable work practices, and to inform the residents of the proposed construction work.

“Feasible and reasonable” noise control strategies to minimise noise during construction may include engineering measures such as the construction of temporary acoustic barriers, the use of proprietary enclosures around machines, the use of silencers, the substitution of alternative construction processes and the fitting of broadband reversing signals. It may also

include administrative measures such as inspections, scheduling and providing training to establish a noise minimisation culture for the works.

The following mitigation measures are recommended to be implemented for the construction works and provide the framework for the development of a Construction Management Plan by the construction team once the final construction methods, timing, locations and equipment have been determined.

Scheduling

Construction works, including heavy vehicle movements into and out of the site, restricted to the hours between 7am and 6pm Monday to Friday, and between 8am and 1pm on Saturdays. Works carried out outside of the hours should only entail:

- works that do not cause noise emissions to be audible at any nearby residences not located on the site; or
- the delivery of materials as requested by Police or other authorities for safety reasons; or
- emergency work to avoid the loss of lives, property, and/or to prevent environmental harm.

If any other works are required outside of the specified hours, they will only be carried out with the prior consent of the relevant New South Wales authority.

Location of Fixed Noise Sources

Locate fixed noise sources such as crushing and screening plant, generators and compressors at the maximum practicable distance to the nearest dwellings, and where practicable, use existing landforms to block line of sight between the fixed noise source and the dwelling.

Provide Acoustic Screens around Fixed Noise Sources

Provide acoustic screens or mounding for fixed crushing and screening plant, and concrete batching plant wherever these noise sources are located within 2400m of a non-associated

dwelling and do not have direct line of sight blocked to that dwelling, in accordance with the following requirements:

- Locate the screen as close as practicable to the noise source;
- Construct from mounding using excavated soil from the site or a material with a minimum surface density of 10 kg/m^2, such as 1.2mm thick sheet steel or 9mm thick compressed fibre cement sheeting, or use purpose built transportable sound barriers such as the Peace “Sound Barriers”;
- Construct to a minimum height that blocks direct line of sight between the noise source and any receiver within 2400m;
- Construct such that there are no air gaps or openings at joints;
- Extend such that the length is at least 5 times greater than its height or so that it is bent around the noise source;

In addition, the site topography, and other shielding features (e.g. large stationary machines, mounds of topsoil and piles of materials) should be used for increased shielding when locating fixed noise sources within the 2400m distance.

Enclose Generators and Compressors

Provide proprietary acoustic enclosures for site compressors and generators located within 2400m of a non-associated dwelling.

Alternative Processes

Investigate and implement alternative processes where feasible and reasonable, such as hydraulic or chemical splitters as an alternative to impact rock breaking, or the use of broadband reversing alarms in lieu of the high pitched devices. A broadband reversing alarm emits a unique sound which addresses the annoyance from the high pitched devices. The fitting of a broadband alarm should be subject to an appropriate risk assessment, with the construction team being responsible for ensuring the alarms are installed and operated in accordance with all relevant occupational, health and safety legislative requirements.

Site Management

- Select and locate centralised site activities and material stores as far from noise-sensitive receivers as possible;
- Care should be taken not to drop materials such as rock, to cause peak noise events, including materials from a height into a truck. Site personnel should be directed as part of a training regime to place material rather than drop it;
- Plant known to emit noise strongly in one direction, such as the exhaust outlet of an attenuated generator set, shall be orientated so that the noise is directed away from noise sensitive areas if practicable;
- Machines that are used intermittently shall be shut down in the intervening periods between works or throttled down to a minimum;
- Implement worksite induction training, educating staff.

Equipment and Vehicle Management

- Ensure equipment has Original Equipment Manufacturer (OEM) mufflers (or better) installed;
- Ensure equipment is well maintained and fitted with adequately maintained silencers which meet the OEM design specifications. This inspection should be part of a monitoring regime;
- Ensure silencers and enclosures are intact, rotating parts are balanced, loose bolts are tightened, frictional noise is reduced through lubrication and cutting noise reduced by keeping equipment sharp. These items should be part of a monitoring regime;
- Use only necessary power to complete the task;
- Inspect, as part of a monitoring regime, plant and equipment to determine if it is noisier than other similar machines, and replace or rectify as required.

Community Consultation

Implement the following noise and vibration elements into the overall community consultation process. The aim of the consultation is to ensure adequate community awareness and notice of expected construction noise.

The minimum elements should include:

- Regular Community Information newsletters, providing details of the construction plan and duration of the construction phases;
- A site notice board in a community location providing copies of the newsletters, updated construction program details, and contact details of relevant project team members;
- A feedback mechanism for the community to submit questions to the construction team, and for the construction team to respond;
- Regular updates on the construction activities to local authorities to assist in complaint management if necessary;
- Contact details of the project manager and/or site "Environmental Representative".

In addition, prior to any construction activity occurring within 2400m of a dwelling without a commercial agreement, or significant construction traffic periods or impacts on local road conditions:

- Contact the local community potentially affected by the proposed works and inform them of the proposed work, the location of the work, the day(s) and date(s) of the work and the hours involved[6];
- This contact shall be made a reasonable time before the proposed commencement of the work; and
- Contact details of the project manager and / or site "Environmental Representative" should be provided.

The above measures should be incorporated and implemented through a Construction Noise Management Plan for the site. The Plan should be developed by the construction team once the actual construction activities have been determined.

[6] It is preferable to overestimate the hours of work, rather than extending the work hours for longer than anticipated.

Construction Traffic

Construction activity will incorporate passenger vehicle and heavy vehicle movements to and from the site along local roads in the vicinity of the wind farm. These vehicles will include semi-trailers, low loaders, haulage trucks, mobile cranes, water tankers, four-wheel-drive vehicles and passenger vehicles.

The day-time criterion provided by the ECRTN is an equivalent ($L_{Aeq,\ 1hour}$) noise level of 55 dB(A) during any given hour. It is predicted that a distance of 10m from the road side the criterion can be achieved for 10 passenger vehicle movements and 3 heavy vehicle movements in one hour. The number of vehicle movements can double for every doubling of distance from the roadside and continue to achieve the 55 dB(A) criterion. That is, 20 passenger vehicles and 6 heavy vehicle movements could be accommodated in an hour at a dwelling that is 20m from the roadside. It is noted that care should be taken to avoid excessive acceleration of trucks and the use of truck engine brakes in close proximity to dwellings.

In accordance with the general principles of dealing with temporary construction noise impacts as compared to permanent operational noise, where the ECRTN is exceeded, the following mitigation measures should be employed to reduce construction traffic noise:

- Communicate with the affected community in accordance with the provisions above;
- Establish and maintain a route into the site so that heavy vehicles do not enter noise sensitive areas for access where practicable;
- Incorporate information regarding the route to all drivers prior to accessing the site and the need to minimise impacts through driver operation at certain locations;
- Schedule construction traffic deliveries such that it is as evenly dispersed as practicable;
- Restrict construction to the day-time operating hours for the construction site, subject to the scheduling caveats in the Construction Noise Management Plan.

Construction Vibration

It is expected that the main sources of vibration will be the rock trenching equipment and roller operation during the road and hard stand construction. The level of vibration at a distance will be subject to the energy input of the equipment and the local ground conditions. Typically, the distances required to achieve the construction vibration criteria provided in the Technical Guideline are in the order of 20m. At a distance of 100m, vibration from these activities is unlikely to be detectable to humans.

Based on the separation distances between the construction activities and the nearest dwellings being in excess of 100m, vibration levels are expected to easily achieve the criteria.

If construction activities producing high levels of vibration occur within 100m of a dwelling, it is recommended that a monitoring regime is implemented during these times to ensure compliance with the Technical Guideline.

CONCLUSION

An environmental noise and vibration assessment has been made of the construction and operation of the proposed Rye Park Wind Farm. The assessment considers the current layout comprising 109 wind turbine generators.

The assessment considered the Director General's requirements (DGRs) for noise and vibration and compared the proposal against the following:

- Wind Turbines – the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines* (2003);
- Collector Substations - *NSW Industrial Noise Policy* (EPA 2000);
- Site Establishment and Construction - *Interim Construction Noise Guideline* (DECC 2009);
- Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW EPA, 1999); and,
- Vibration – *Assessing Vibration: A Technical Guideline* (DECC, 2006).

Based on predictions, the noise from the proposed turbine layout will achieve the environmental noise criteria established in accordance with the SA Guidelines and the WHO Guidelines at all dwellings.

Construction activity is addressed through the establishment of a construction noise and vibration framework, developed to achieve the relevant DGRs for the adequate control of noise and vibration from general construction activity, transport and potential blasting activity.

Notwithstanding the conclusions of this report, the assessment of operational noise from the proposed Rye Park Wind Farm will be repeated during the procurement stage to demonstrate that the final turbine selection and final layout following "micro-siting" will achieve compliance with the project criteria prior to construction.

Based on the above, the construction and operation of the proposed Rye Park Wind Farm achieves the Director General's requirements.

APPENDIX A: COORDINATES OF RYE PARK NOISE SOURCES

Wind Turbines

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
1	676629	6186672
2	676471	6186291
3	676320	6185897
4	676320	6185509
5	677805	6185279
6	676377	6185158
7	677490	6184967
9	677384	6184591
11	677266	6184203
12	677322	6183750
16	677936	6182318
17	681368	6182678
18	678502	6182471
20	681054	6182312
21	678588	6181965
22	679549	6181989
25	679389	6181591
26	678511	6181575
28	678484	6181184
29	678385	6180840
30	679009	6180754
31	680367	6180463
32	678570	6180428
34	678899	6180032
35	679581	6180032
36	680242	6180109
37	678987	6179642
38	679645	6179648
39	680098	6179394
41	680008	6179119
42	680994	6179015
43	679027	6179114
44	678960	6178706
45	678438	6178498
47	678190	6178066
48	681515	6177825
49	681955	6177678
50	681372	6177446
51	681355	6177078
52	681625	6176824
53	681153	6176713
56	681509	6176441
58	682400	6176161

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
61	680965	6176347
62	680830	6175999
63	682309	6175645
64	683431	6175508
65	684812	6175374
66	682384	6175319
67	680267	6175231
68	684506	6175044
69	682302	6174979
71	682195	6173075
72	682099	6172655
73	681120	6172346
74	681358	6172003
75	681388	6171634
76	680446	6171508
77	681464	6171283
78	680782	6171250
79	680673	6170767
80	682014	6170267
82	682004	6169806
83	681810	6169398
84	681373	6167591
85	681917	6167300
86	681730	6166773
87	681536	6166404
90	681137	6165157
93	681045	6164377
94	680716	6163813
95	681550	6163639
96	682288	6163400
97	682410	6162959
98	682319	6162534
99	682358	6162122
101	682364	6161546
102	686233	6156685
103	685997	6156377
104	686150	6156084
119	683654	6152722
120	684987	6152789
122	683572	6152343
124	685103	6152217
125	684396	6152175
127	684307	6151723

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
128	683138	6151393
129	684402	6151298
130	683127	6151016
131	683001	6150684
133	678003	6181399
134	677946	6181062
135	679301	6180383
136	680809	6181821
137	680652	6181414
138	680607	6181022
139	680934	6177688
140	680771	6177337
141	680488	6175710
142	684592	6152523
143	681415	6167988
144	678465	6177749
145	686104	6154215
146	684178	6174388
147	684451	6173978
148	684474	6173545
149	683804	6173875
150	682052	6170803
151	677325	6185689

Collector Substations

Sub-station Number	Coordinates (UTM WGS84 H44)	
	Easting	Northing
Northern Option A	678800	6176375
Northern Option B	679465	6174998
Central	680563	6168466
Southern	683900	6151775
Connection	684053	6150769

APPENDIX B: RESIDENTIAL STATUS

ID	Coordinates (UTM WGS84 H55)	
	Easting	Northing
Non-Associated Residences		
R01	677,418	6,187,127
R06	681,484	6,184,020
R07	681,917	6,183,967
R08	682,339	6,183,864
R09	682,517	6,183,838
R10	682,842	6,183,767
R11	679,650	6,183,618
R17	676,127	6,181,740
R19	676,412	6,181,665
R20	676,130	6,181,544
R22	676,095	6,181,037
R26	676,523	6,178,178
R29	676,434	6,177,903
R38	679,623	6,173,620
R40	678,605	6,171,136
R45	682,847	6,165,279
R47	680,155	6,162,689
R48	679,834	6,162,662
R50	680,701	6,161,784
R53	680,877	6,160,875
R56	686,567	6,153,140
R63	683,875	6,148,991
R65	676,668	6,179,644
R170	683,284	6,165,017
R324	680,449	6,161,468

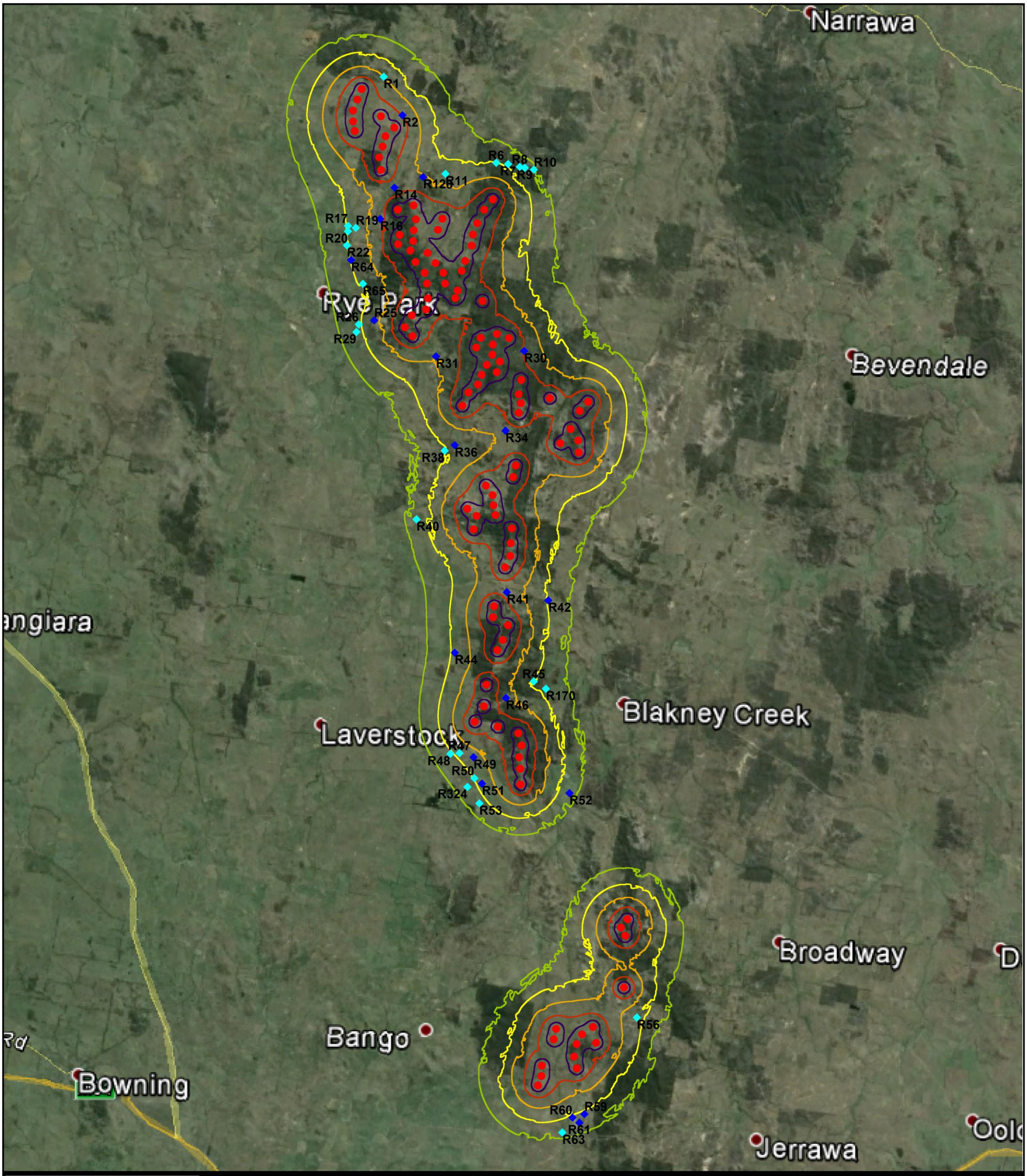
ID	Coordinates (UTM WGS84 H55)	
	Easting	Northing
Associated Residences		
R02*	678,095	6,185,733
R14*	677,807	6,183,115
R16*	677,297	6,181,991
R25*	677,075	6,178,323
R30*	682,495	6,177,218
R31*	679,304	6,177,019
R34*	681,817	6,174,338
R36*	679,988	6,173,811
R41*	681,870	6,168,503
R42*	683,370	6,168,206
R44*	679,986	6,166,322
R46*	681,835	6,164,679
R49*	680,667	6,162,540
R51*	680,970	6,161,588
R52*	684,135	6,161,246
R59*	684,670	6,149,654
R60*	684,244	6,149,529
R61*	684,489	6,149,335
R64*	676,239	6,180,502
R128*	678,848	6,183,498

APPENDIX C: DIRECTOR-GENERAL'S REQUIREMENTS

- **Noise Impacts** - the EA must:
  - → include a comprehensive noise assessment of all phases and components of the project including: turbine operation, the operation of the electrical substation, corona and / or aeolian noise from the transmission line, construction noise (focusing on high noise-generating construction scenarios and works outside of standard construction hours), traffic noise during construction and operation, and vibration generating activities (including blasting) during construction and/ or operation. The assessment must identify noise/ vibration sensitive locations (including approved but not yet developed dwellings), baseline conditions based on monitoring results, the levels and character of noise (e.g. tonality, impulsiveness, low frequency etc) generated by noise sources, noise/ vibration criteria, modelling assumptions and worst case and representative noise/ vibration impacts;
  - → in relation to wind turbine operation, determine the noise impacts under operating meteorological conditions (i.e. wind speeds from cut in to rated power), including impacts under meteorological conditions that exacerbate impacts (including varying atmospheric stability classes and the van den Berg effect for wind turbines). The probability of such occurrences must be quantified;
  - → include monitoring to ensure that there is adequate wind speed/profile data and ambient background noise data that is representative for all sensitive receptors;
  - → provide justification for the nominated average background noise level used in the assessment process, considering any significant difference between daytime and night time background noise levels at background noise levels higher than 30 dB(A);
  - → identify any risks with respect to tonal, low frequency or infra-noise;
  - → clearly outline the noise mitigation, monitoring and management measures that would be applied to the project. This must include an assessment of the feasibility, effectiveness and reliability of proposed measures and any residual impacts after these measures have been incorporated;
  - → if any noise agreements with residents are proposed for areas where noise criteria cannot be met, provide sufficient information to enable a clear understanding of what has been agreed and what criteria have been used to frame any such agreements; and
  - → include a contingency strategy that provides for additional noise attenuation should higher noise levels than those predicted result following commissioning and/or noise agreements with landowners not eventuate.

  The assessment must be undertaken consistent with the following guidelines:
  - → Wind Turbines - the South Australian Environment Protection Authority's *Wind Farms - Environmental Noise Guidelines* (2003);
  - → Substation – *NSW Industrial Noise Policy* (EPA, 2000);
  - → Site Establishment and Construction – *Interim Construction Noise Guidelines* (DECC, 2009);
  - → Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW EPA, 1999); and
  - → Vibration – *Assessing Vibration: A Technical Guideline* (DECC, 2006).

APPENDIX D: PREDICTED NOISE LEVEL CONTOUR AT 10m/s



Rye Park Wind Farm

Environmental Noise

Vestas V112 - 3.0 MW

CONCAWE
Worst-case Meteorological Conditions

0 1 2 4 km

N

Legend

- Wind Turbine
- Non-Associated Dwelling
- Associated Dwelling

Predicted Noise Level (dB(A))

- = 30
- = 35
- = 40
- = 45
- = 50

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Bango Wind Farm
&
Rye Park Wind Farm

Cumulative Environmental Noise Assessment

S4889C2
April 2016

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INTRODUCTION

Sonus has prepared environmental noise assessments for both the Bango Wind Farm for CWP Renewables and the Rye Park Wind Farm for Trustpower. These are detailed in reports “S3958C5” and “S3200C9” respectively. The wind farms are both located north of Yass and east of Boorowa, New South Wales (NSW).

Sonus has now been engaged to conduct a cumulative environmental noise assessment of these two wind farms.

The environmental noise assessment was commissioned to address the Secretary’s Environmental Assessment Requirements (SEARs) relating to operational noise for each project. The SEARs specify that the assessment of operational noise must be conducted in accordance with the South Australian Environment Protection Authority’s Wind Farms – Environmental Noise Guidelines (2009), with modified criteria used in New South Wales.

The assessment of operational noise has been based on a GE 3.4-130 wind turbine selection proposed for the Bango Wind Farm and Vestas V112 - 3.0 MW turbines being proposed for the Rye Park Wind Farm. The proposed locations of the turbines for each of the wind farms are provided in Appendix A, the sound power levels from the proposed turbines are provided in Appendix B and a description of the noise model is provided in Appendix C.

APPROACH

The SEARs for each project require operational noise to be assessed against the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines 2009* (the SA Guidelines) with a baseline criterion of 35 dB(A). That is, the noise from each wind farm should be no greater than:

- 35 dB(A) or
- 5 dB(A) above the background noise level

at each integer hub height wind speed when measured at a sensitive receptor.

In addition to considering the noise from each project, the SEARs require that a cumulative assessment be conducted to determine if the noise from one project, when added to the noise from the second project, would result in the criteria being exceeded.

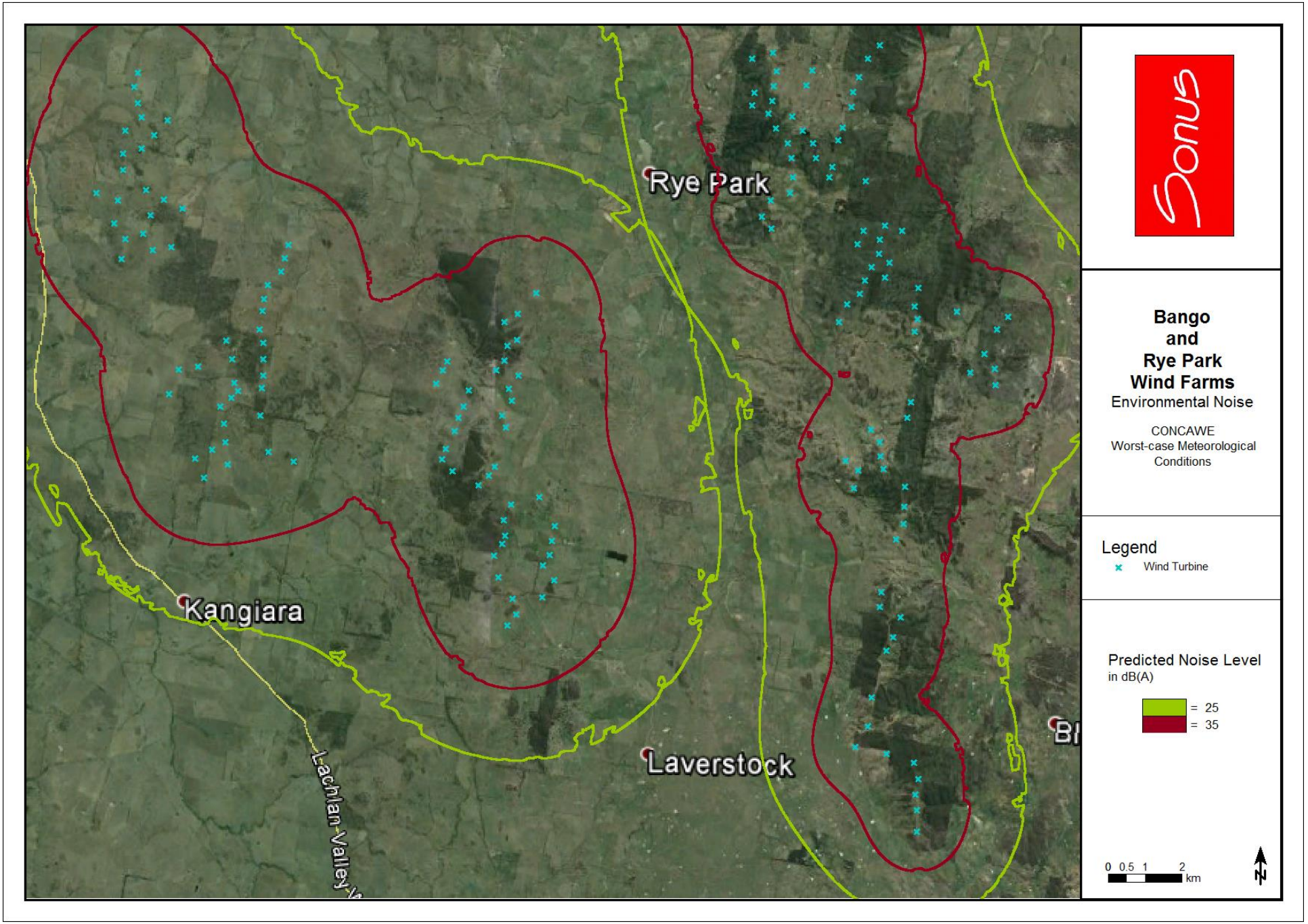
In circumstances where both projects have the same hub height, the cumulative noise can be predicted for each hub height integer wind speed and compared with the criteria developed for each project. However, where the hub heights of the projects are different, the criteria (which are based on the hub height wind speed) for each project would also be different, resulting in a potentially difficult interpretation of compliance.

A conservative approach (resulting in a potential overestimate of cumulative noise levels) is to predict the noise based on the highest sound power level produced by the turbines of each project and assume that a resiodence located between the two wind farms can be downwind from both wind farms at the same time. The conservative cumulative effect can then be considered by determining how much the noise from one project increases the predicted noise from the other, and vice versa. By way of example only, the table below shows the logarithmic addition of the predicted noise from one arbitrary project (at the limit of 35 dB(A)) with the noise from a second arbitrary project:

Example predicted noise level		Cumulative noise level
Project 1	**Project 2**	
35 dB(A)	35 dB(A)	38 dB(A)
35 dB(A)	34 dB(A)	38 dB(A)
35 dB(A)	33 dB(A)	37 dB(A)
35 dB(A)	32 dB(A)	37 dB(A)
35 dB(A)	31 dB(A)	36 dB(A)
35 dB(A)	30 dB(A)	36 dB(A)
35 dB(A)	29 dB(A)	36 dB(A)
35 dB(A)	28 dB(A)	36 dB(A)
35 dB(A)	27 dB(A)	36 dB(A)
35 dB(A)	26 dB(A)	36 dB(A)
35 dB(A)	25 dB(A)	35 dB(A)
35 dB(A)	24 dB(A)	35 dB(A)
35 dB(A)	23 dB(A)	35 dB(A)
35 dB(A)	22 dB(A)	35 dB(A)
35 dB(A)	21 dB(A)	35 dB(A)
35 dB(A)	20 dB(A)	35 dB(A)

The table shows that if the noise from one project is at the limit of 35 dB(A) then a second project must contribute 25 dB(A) or less in order to conservatively maintain the cumulative level at 35 dB(A).

Based on the above, a 35 dB(A) and a 25 dB(A) contour has been produced for each wind farm and overlaid on a single aerial image. Provided the 25 dB(A) contour of one wind farm does not cross over the 35 dB(A) contour of the other wind farm, and each individual wind farm is compliant, then the cumulative noise will also be compliant.


Rye Park
Kangiara
Laverstock
Lachlan Valley
Sonus
Bango
and
Rye Park
Wind Farms
Environmental Noise
CONCAWE
Worst-case Meteorological
Conditions
Legend
Wind Turbine
Predicted Noise Level
in dB(A)
= 25
= 35
0 0.5 1 2
km
N

DISCUSSION

The predicted 35 dB(A) contour from the Bango Wind Farm is shown as a red contour on the western side and the 35 dB(A) contour from the Rye Park Wind Farm is shown as a red contour on the eastern side. The 25 dB(A) contours from each of the wind farms are shown as green contours.

The 25 dB(A) contour from the Rye Park Wind Farm does not cross the 35 dB(A) contour from the Bango Wind Farm and therefore the Rye Park Wind Farm will not add to the predicted noise from the Bango Wind Farm inside the 35 dB(A) contour. Therefore a compliant environmental noise assessment for the Bango Wind Farm will not be modified by the noise from the Rye Park Wind Farm.

The 25 dB(A) contour from the Bango Wind Farm does not cross the 35 dB(A) contour from the Rye Park Wind Farm and therefore the Bango Wind Farm will not add to the predicted noise from the Rye Park Wind Farm inside the 35 dB(A) contour. Therefore the environmental noise assessment for the Rye Park Wind Farm will not be modified by the noise from the Bango Wind Farm.

APPENDIX A: WIND TURBINE COORDINATES

Bango Wind Farm

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
1	670,056	6,172,655
2	671,370	6,174,593
3	669,956	6,172,305
4	665,381	6,176,955
5	671,287	6,174,189
6	670,581	6,170,855
7	671,618	6,174,752
8	671,402	6,173,443
9	672,551	6,169,350
10	669,706	6,171,830
11	671,220	6,172,725
12	671,606	6,167,380
13	669,456	6,173,580
15	662,281	6,173,305
16	672,506	6,168,980
17	665,484	6,177,302
18	661,436	6,181,108
19	672,625	6,168,300
20	671,370	6,167,089
21	661,881	6,180,255
22	665,289	6,176,593
23	671,631	6,175,455
24	671,481	6,173,130
25	664,806	6,173,805
26	671,281	6,175,230
27	664,806	6,174,230
28	672,301	6,167,831
29	664,931	6,176,230
30	672,131	6,176,005
31	671,261	6,169,917
32	670,859	6,171,115

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
33	671,656	6,173,805
34	670,190	6,172,964
35	661,038	6,179,320
37	661,341	6,181,554
38	661,656	6,178,780
39	664,944	6,171,739
41	671,006	6,168,951
42	663,781	6,172,005
43	664,756	6,173,455
44	671,506	6,167,805
45	664,721	6,172,733
47	661,531	6,179,905
48	664,831	6,175,855
49	663,856	6,171,405
50	671,054	6,173,944
51	671,465	6,170,340
52	672,310	6,168,689
53	662,230	6,180,655
54	671,217	6,169,267
55	663,656	6,172,955
56	665,621	6,171,497
57	663,806	6,174,730
58	660,806	6,177,880
59	663,756	6,172,505
61	663,056	6,174,030
62	660,319	6,178,696
63	669,634	6,173,944
64	669,615	6,171,540
65	661,031	6,179,755
66	672,635	6,169,745
68	663,431	6,171,805

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
70	661,106	6,180,380
71	662,631	6,178,280
72	669,756	6,174,180
73	662,976	6,171,569
74	671,031	6,171,355
75	661,781	6,178,105
76	663,956	6,173,205
77	661,537	6,180,733
78	664,021	6,173,610
79	662,139	6,178,525
80	670,331	6,173,405
81	671,328	6,172,413
82	672,228	6,170,535
83	664,781	6,175,530
85	661,572	6,177,598
86	661,437	6,181,941
87	664,704	6,175,039
89	663,206	6,171,055
92	669,892	6,171,233
93	671,295	6,169,503
94	664,131	6,173,380
95	660,889	6,178,505
96	661,100	6,177,474
97	661,000	6,176,924
98	661,845	6,177,173
99	662,336	6,177,256
100	664,803	6,174,672
101	663,965	6,174,234
102	662,538	6,173,952
103	671,131	6,168,379

Rye Park Wind Farm

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
1	676629	6186672
2	676471	6186291
3	676320	6185897
4	676320	6185509
5	677805	6185279
6	676377	6185158
7	677490	6184967
9	677384	6184591
11	677266	6184203
12	677322	6183750
16	677936	6182318
17	681368	6182678
18	678502	6182471
20	681054	6182312
21	678588	6181965
22	679549	6181989
25	679389	6181591
26	678511	6181575
28	678484	6181184
29	678385	6180840
30	679009	6180754
31	680367	6180463
32	678570	6180428
34	678899	6180032
35	679581	6180032
36	680242	6180109
37	678987	6179642
38	679645	6179648
39	680098	6179394
41	680008	6179119
42	680994	6179015
43	679027	6179114
44	678960	6178706
45	678438	6178498
47	678190	6178066
48	681515	6177825
49	681955	6177678

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
50	681372	6177446
51	681355	6177078
52	681625	6176824
53	681153	6176713
56	681509	6176441
58	682400	6176161
61	680965	6176347
62	680830	6175999
63	682309	6175645
64	683431	6175508
65	684812	6175374
66	682384	6175319
67	680267	6175231
68	684506	6175044
69	682302	6174979
71	682195	6173075
72	682099	6172655
73	681120	6172346
74	681358	6172003
75	681388	6171634
76	680446	6171508
77	681464	6171283
78	680782	6171250
79	680673	6170767
80	682014	6170267
82	682004	6169806
83	681810	6169398
84	681373	6167591
85	681917	6167300
86	681730	6166773
87	681536	6166404
90	681137	6165157
93	681045	6164377
94	680716	6163813
95	681550	6163639
96	682288	6163400
97	682410	6162959

Turbine ID	Coordinates (UTM WGS84 H44)	
	Easting	Northing
98	682319	6162534
99	682358	6162122
101	682364	6161546
102	686233	6156685
103	685997	6156377
104	686150	6156084
119	683654	6152722
120	684987	6152789
122	683572	6152343
124	685103	6152217
125	684396	6152175
127	684307	6151723
128	683138	6151393
129	684402	6151298
130	683127	6151016
131	683001	6150684
133	678003	6181399
134	677946	6181062
135	679301	6180383
136	680809	6181821
137	680652	6181414
138	680607	6181022
139	680934	6177688
140	680771	6177337
141	680488	6175710
142	684592	6152523
143	681415	6167988
144	678465	6177749
145	686104	6154215
146	684178	6174388
147	684451	6173978
148	684474	6173545
149	683804	6173875
150	682052	6170803
151	677325	6185689

APPENDIX B: TURBINE SOUND POWER LEVELS

Bango Wind Farm – GE3.4-130 with a hub height of 120m

Hub Height Wind Speed (m/s)	SWL (dB(A)) for each Octave Band Centre Frequency								Total SWL (dB(A))
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
3	78	87	89	89	90	87	78	60	96
4	78	87	89	89	90	87	78	60	96
5	77	87	90	90	90	88	81	62	96
6	80	89	93	92	92	90	83	64	99
7	83	92	96	96	96	93	86	68	102
8	85	94	99	99	98	96	88	70	105
9	87	96	100	101	101	98	90	70	106
10	88	96	100	101	101	98	90	69	107
11	88	96	99	101	101	98	90	69	107
12	88	96	99	101	101	99	89	68	107
13	88	96	99	101	101	98	88	67	107
14 (rated power)	88	96	99	101	101	98	88	66	107

Rye Park Wind Farm - Vestas V112 - 3.0 MW with a hub height of 80m

Hub Height Wind Speed (m/s)	SWL (dB(A)) for each Octave Band Centre Frequency								Total SWL (dB(A))
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
5	74	85	88	91	91	87	81	70	96
6	76	87	91	93	93	89	84	72	98
7	79	90	93	96	95	92	86	75	101
8	81	92	96	98	98	94	89	77	103
9	83	94	97	100	100	96	90	79	105
10	86	95	99	101	100	96	94	86	106
11	89	96	98	100	101	99	94	85	107
12	89	94	97	99	101	101	95	86	107
13	89	94	97	99	101	101	95	86	107
14	89	94	96	98	101	101	97	91	107
15	89	94	96	98	101	101	97	91	107
16	89	94	96	98	101	101	97	91	107
17	89	94	96	98	101	101	97	91	107
18 (rated power)	89	94	96	98	101	101	97	91	107

APPENDIX C: NOISE MODEL

The predictions of environmental noise from the proposed wind farm have been made using the CONCAWE[1] noise propagation model and SoundPLAN noise modelling software. The sound propagation model considers the following influences:

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

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

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

- weather category 6 (night with no clouds and wind from both wind farms to the dwelling under consideration);
- atmospheric conditions at 10°C and 80% relative humidity;
- wind direction from all WTGs to the particular residence under consideration, even in circumstances where WTGs are located in opposite directions from the residence;
- acoustically soft ground to reflect the pastoral nature of the land; and,
- maximum barrier attenuation from topography of 2 dB(A).

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