Appendix E
Noise Assessment

Glen Innes Wind Farm

Environmental noise assessment - Wind Turbine modification

Reference: 236777
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Revision: 5
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Glen Innes Wind Farm Environmental Noise Assessment

Date 7 March 2014
Reference 236777
Revision 5

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Executive summary

This report provides an environmental noise assessment for the proposed wind turbine modification and a revised layout of the Glen Innes Wind Farm to be located in northern NSW. Previously an *Environmental Noise Impact Assessment* and *Supplementary noise assessment* were carried out in 2008 and 2010 respectively.

The proponent has selected a specific Wind Turbine model to be installed on-site and proposed small changes to the array layout compared to the original *Environmental Noise Impact Assessment* and *Supplementary noise assessment*s. The array comprises of 25 wind turbines with a hub height of 89 m. This report provides an updated noise assessment for the revised array. It outlines the basis for the assessment including:

- Changes in location of the wind turbine sites
- Minor updates to receiver locations
- Selection of a new Wind Turbine model with an increased hub height of 89 m (previous assessments carried out for turbines with a hub height of 80 m)
- Update of the assessment noise criteria (based on original background noise and wind data) due to the changes of the hub height and specification of the Wind Turbine model
- Assessment against the requirements of the *Draft NSW Planning Guidelines: Wind Farms* including:
  - Development of day and night noise criteria
  - Assessment of specific noise characteristics
- Defining an operational strategy to achieve compliance of the revised wind turbine arrangement with applicable design criteria.

Two sets of noise predictions have been carried out for this report implementing the changes to the turbine array and hub height. One set was carried out implementing ISO 9613 input conditions into to the noise model algorithm as per the original environmental noise assessment as well as a more conservative set of modelling inputs as developed in the UK in 2009. It has been shown that based on the original ISO 9613 noise model results that the wind farm can be operated to achieve compliance at all non wind farmer receiver locations for overall noise criteria as well as day and night specific criteria. Noise predictions using the updated conservative modelling inputs showed exceedances of the applicable overall noise criteria at two non wind farmer locations. Exceedances were predicted at the same two non wind farmer locations when assessed against night time noise criteria.

An operational strategy was developed utilising lower noise operating modes of some turbines to show compliance with the overall noise criteria at all locations as well as an operational strategy to satisfy the night time noise criteria. However the implementation of the lower noise operating modes using real-time wind and stability data would only be required during conditions that are favourable for noise propagation towards the sensitive receivers such as downwind or during the occurrence of stable atmospheric conditions.

Overall the predicted noise impacts are lower than those in the *Supplementary noise assessment* due to the specification of a lower noise wind turbine.

Nevertheless, due to the approximation in model predictions, compliance testing will need to be undertaken following installation of the wind farm and if necessary the wind farm operation adjusted to satisfy compliance with applicable noise criteria.

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1 Introduction

1.1 Project scope

This report provides an environmental noise assessment for the proposed wind turbine modification and a revised layout of the Glen Innes Wind Farm to be located in northern NSW. This report is aimed to supplement the previous *Environmental Noise Impact Assessment* and *Supplementary noise assessment* which were carried out in 2008 and 2010 respectively.

On October 2009, the Minister approved the construction and operation of the Glen Innes Wind Farm. The approved project comprised up to 26 wind turbine generators (WTGs), one electrical substation and associated infrastructure including installation of access tracks and underground cables between turbine sites. The Project Approval referenced the October 2008 Environmental Assessment that included a comprehensive noise assessment.

The proponent has selected a specific Wind Turbine model to be installed on-site and proposed small changes to the array layout compared to the original *Environmental Noise Impact Assessment* and *Supplementary noise assessment*s. The current array comprises of 25 wind turbines with a hub height of 89 m. This report provides an updated noise assessment for the revised array. It outlines the basis for the assessment including:

- Changes in location of the wind turbine sites
- Minor updates to receiver locations
- Selection of a new Wind Turbine model with an increased hub height of 89 m (previous assessments carried out for turbines with a hub height of 80 m)
- Update of the assessment noise criteria (based on original background noise and wind data) due to the changes of the hub height and specification of the Wind Turbine model
- Assessment against the requirements of the *Draft NSW Planning Guidelines: Wind Farms*
- Defining an operational strategy to achieve compliance of the revised wind turbine arrangement with applicable design criteria.

Two sets of noise predictions have been carried out for this report. One set was carried out implementing original input conditions into to the noise model algorithm as per the original environmental noise assessment. A second set of predicted noise levels was calculated based on more conservative modelling inputs as developed in the UK in 2009 as per the supplementary noise assessment.

1.2 References

- *Acoustic Noise Emission of the ECO 110*, DST-0449 Rev.00, Alstom, 25 February 2011
- *Development of a wind farm noise propagation prediction model*, Bass, J.H., Bullmore, A.J. and Sloth, E. (1996), Contract JOR3-CT95-0051
- *Draft NSW Planning Guidelines: Wind Farms,* NSW Department of Planning & Infrastructure, December 2011
- *ECO 122 – General description*, DST-0484 Rev.02, Alstom, 29 September 2011
- *Environmental Noise Impact Assessment Glen Innes Wind Farm*, Connell Wagner, 26 June 2008, Revision 6
- *Environmental Noise Guidelines: Wind Farms*, SA EPA, February 2003
- Fact Sheet No. 258 "Occupational and community noise", WHO, February 2001
- *IEC 61400-11 "Wind turbine generator systems – Part 11: Acoustic noise measurement techniques"*, Edition 2.1, 11/2006
- *ISO 9613-2 "Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation"*, 15 December 1996
- *NSW Industrial Noise Policy*, NSW EPA, January 2000
- *Prediction and Assessment of wind turbine noise - Agreement about relevant factors for noise assessment from wind energy projects*, Acoustics Bulletin March/April 2009, *Institute of Acoustics 2009*
- *Sound Power Level for the ECO 122*, DST-0495 Rev.00, Alstom, 16 September 2011
- *Supplementary noise assessment, Glen Innes Wind Farm*, Aurecon, 8 June 2010, Revision 3
- *Technical Note: A theoretical variation of the wind profile power-law exponent as a function of surface roughness and stability*, Irwin JS, Atmospheric Environment Vol. 13, pp 191-194, Pergamon Press Ltd 1979

2 Project overview

2.1 Wind turbine

2.1.1 Technical specification

The Alstom ECO 122 – 2.7 MW IEC III-A Low Wind condition turbine has been chosen for this wind farm. The selection is based on the preferred power yield and technical specification to best suit the wind environment at the proposed development site as identified by the proponent. Key aspects of the manufacturer's specification for the wind turbine used for this assessment are shown in Table 1. The noise curves of the turbine during each operation mode and wind condition along with spectral noise data are shown in Section 4.1.

Table 1 Alstom project wind turbine specifications

Manufacturer	Alstom
Model	ECO 122 – 2.7 MW
Wind Turbine Class	III-A
Number of Blades	3
Rotor Diameter	122 m
Hub Height	89 m
Cut-in wind speed	3 m/s*
Rated wind speed	9.5 m/s*
Cut-out wind speed	25 m/s*
Rated rotor speed	12.25 rpm
Rotor speed range	6.97 – 12.25 rpm

Note * - wind speeds at 10 m above ground not hub height levels

2.1.2 Wind turbine locations

The wind turbine sites are located along the Waterloo Range. Their position relative to the noise receivers is shown in Figure 1 below. Table 2 outlines the coordinates of each of the proposed wind turbine sites for the revised array. The updated array is compared to the previous array as outlined in the *Supplementary noise assessment* in June 2010

Table 2 Wind turbine locations

Turbine	Easting	Northings	Base elevation (m)	89 m Hub Height (m)	Comment
1	364943	6710288	1178	1267	Turbine sites as per approved array
2	364981	6709924	1180	1269	
3	364926	6709583	1180	1269	
4	365131	6709251	1170	1259	
5	365343	6708692	1170	1259	
6	365850	6708179	1191	1280	
7	366162	6707735	1220	1309	
8	366146	6707285	1208	1297	
9	366063	6707025	1220	1309	
10B	365955	6706247	1170	1259	
11	365319	6705820	1170	1259	
11B	365675	6705575	1180	1269	
12B	365980	6705375	1194	1283	
12C	366250	6704900	1194	1283	
13	366026	6704440	1210	1299	Relocated
13B	365775	6704165	1180	1269	
14B	366100	6704675	1200	1289	Turbine sites as per approved array
15	366585	6703630	1214	1303	
16B	366608	6703210	1253	1342	Relocated
16C	366601	6703405	1251	1340	
17	366712	6702887	1210	1299	Turbine sites as per approved array
19	367335	6702318	1260	1349	
20B	367524	6705460	1222	1311	Relocated
21B	367774	6705217	1230	1319	
22B	367651	6704952	1230	1319	

Note - Coordinates are for Map Grid of Australia (MGA) Zone 56

2.2 Noise receivers

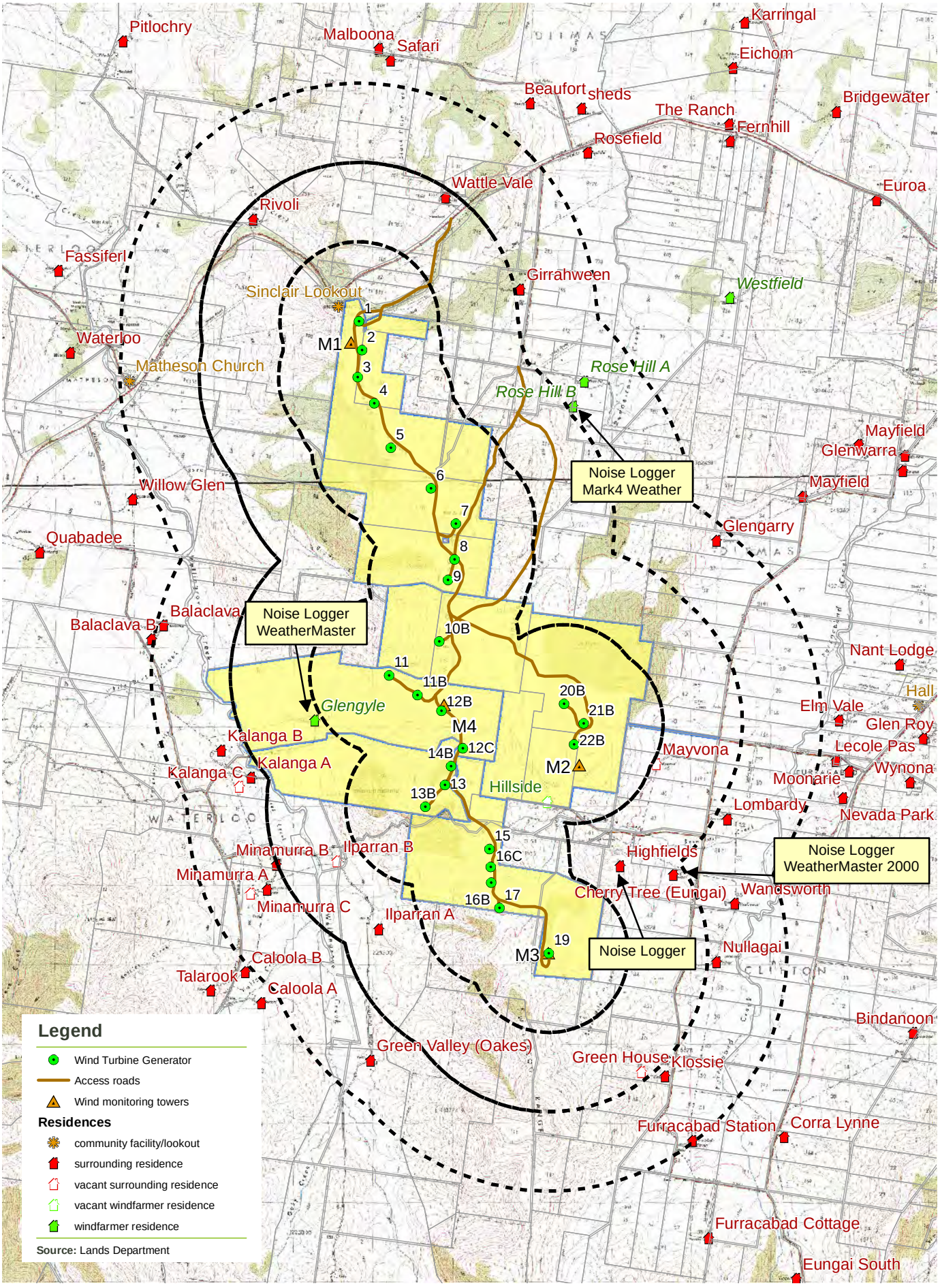
The wind farm site and surrounding areas are zoned Rural 1(a) under the Glen Innes Severn Local Environmental Plan (LEP). There are 29 noise sensitive receivers that are within a 3 km radius from the nearest wind turbines. The 29 noise sensitive receivers are shown in Table 3 and on Figure 1. The residences are distinguished as “wind farmer” residences (located on properties on which the wind turbines are to be located) or neighbouring residences sometimes referred to as relevant receivers. The four vacant neighbouring residences (outlined in Table 3) are currently unoccupied and have been throughout the development process. Sinclair Lookout is also shown in Figure 1 to the north

west of Turbine No. 1. It provides a public access point close to the wind farm site that receives a low level of short term visits.

Table 3 Noise Receivers within 3 km of the wind turbines

Receiver	Type of receiver	Easting	Northing
Balaclava A	neighbouring residence	362484	6706451
Elm Vale	neighbouring residence	368903	6703304
Cherry Tree (Eungai)	neighbouring residence	370996	6705255
Girrahween	neighbouring residence	366978	6710689
Glengarry	neighbouring residence	369447	6707518
Glengyle	wind farmer residence	364384	6705252
Green House	neighbouring residence	368502	6700820
Highfields	neighbouring residence	368235	6703415
Hillside	vacant wind farmer residence	367316	6704226
Ilparran A	neighbouring residence	365191	6702621
Ilparran B	vacant neighbouring residence	364665	6703476
Kalanga A	neighbouring residence	363584	6704532
Kalanga B	neighbouring residence	363211	6704876
Kalanga C	vacant neighbouring residence	363435	6704417
Klossie	neighbouring residence	368800	6700765
Lombardy	neighbouring residence	369589	6704005
Matheson Church	community facility	362050	6709530
Mayvona	vacant neighbouring residence	368693	6704706
Minamurra A	neighbouring residence	363787	6703120
Minamurra B	neighbouring residence	363900	6703434
Minamurra C	vacant neighbouring residence	363576	6703070
Moonarie	neighbouring residence	371122	6704607
Nullagai	neighbouring residence	369447	6702207
Green Valley (Oakes)	neighbouring residence	365090	6700966
Rivoli	neighbouring residence	363609	6711568
Rose Hill A	wind farmer residence	367786	6709527
Rose Hill B	wind farmer residence	367642	6709213
Wandsworth	neighbouring residence	369683	6702942
Wattle Vale	neighbouring residence	366037	6711845

Note - Coordinates are for Map Grid of Australia (MGA) Zone 56



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Projection: MGA

Glen Innes Wind Farm **Environmental Noise Assessment**

FIGURE 1: Location of residence and monitoring locations

3 Noise amenity criteria

3.1 Non wind farmer residences

3.1.1 Overall regression analysis

The original noise amenity criteria were based on the regression analysis of the collected noise and wind data as outlined in the 2008 *Environmental Noise Impact Assessment Glen Innes Wind Farm* report in accordance with the EPA(SA) *Environmental Noise Guidelines: Wind Farms, 2003*. An update of the regression analysis was carried out to take into account the change of the wind turbine hub height (from 80 m to 89 m) as well as the change in the cut-in and rated wind speeds for the newly specified Alstom ECO 122 Wind Turbine. The wind speed at the hub height of 89 m was calculated using the Wind profile power law (as shown in *Atmospheric Environment Vol. 13*) from wind data collected on site at 80 m and 40 m above ground level.

The results of the background noise monitoring and the regression line for the correlation of background noise levels and wind speed at all are sites are shown in the figures below. The line of best fit for the data set is determined, as required by the EPA(SA) wind farm guidelines using a linear, quadratic or cubic polynomial. The polynomial with the highest correlation coefficient, R^2, is used to obtain the line of best fit. The noise data for the assessment excludes all measurement periods where rainfall or wind speeds in excess of 5 m/s at the microphone occurred as outlined in the 2008 *Environmental Noise Impact Assessment Glen Innes Wind Farm* report. All four sites satisfied the requirement of a minimum 2000 valid noise samples to carry out the regression analysis.

The figures also show the applicable noise criteria calculated in accordance with the 2003 EPA(SA) wind farm guidelines. Further details regarding the background noise survey, site descriptions and criteria calculation can be found in the 2008 *Environmental Noise Impact Assessment Glen Innes Wind Farm* report.

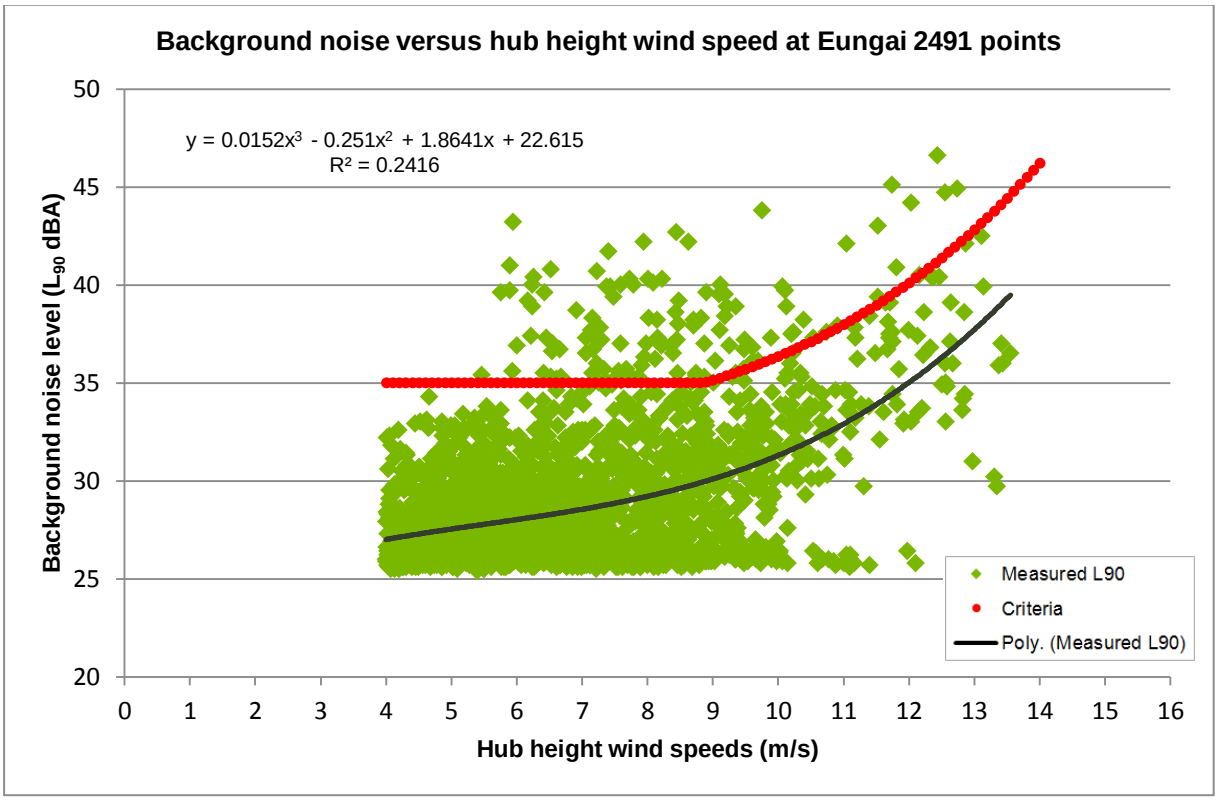


Figure 2 Regression analysis – Cherry Tree (Eungai)

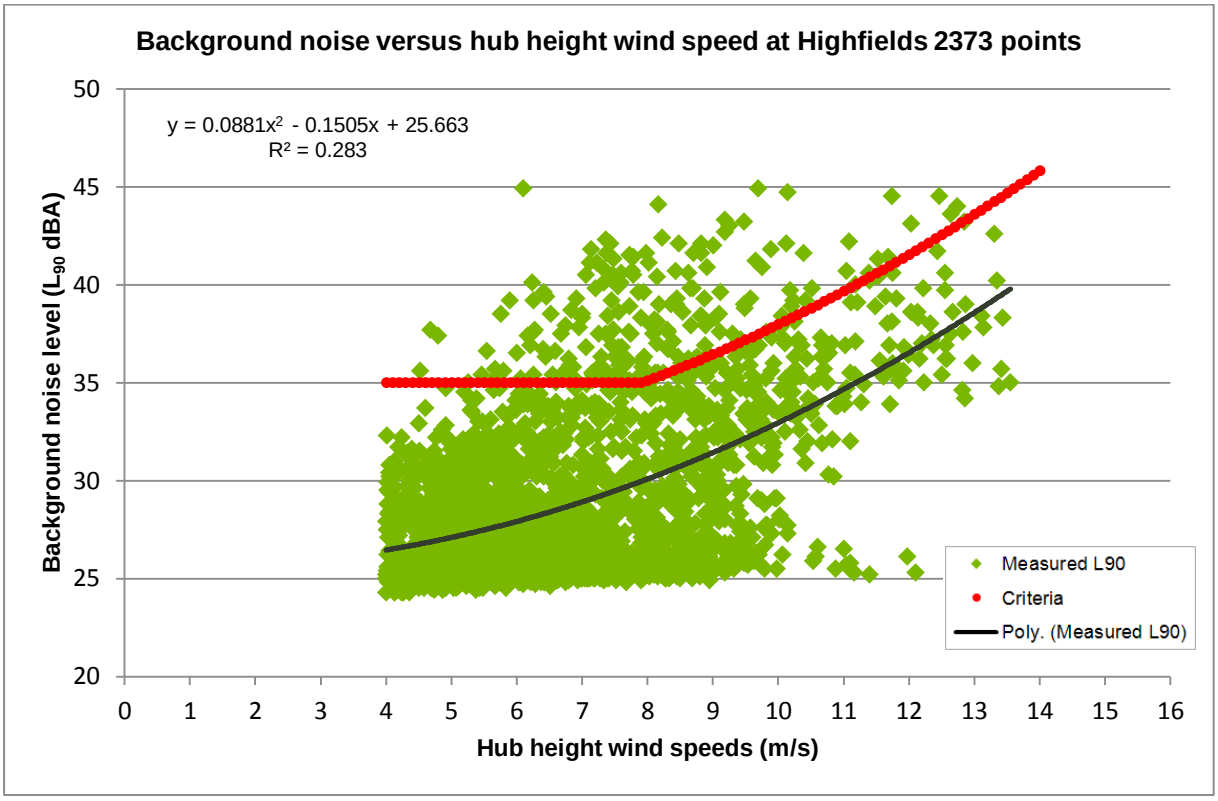


Figure 3 Regression analysis – Highfields

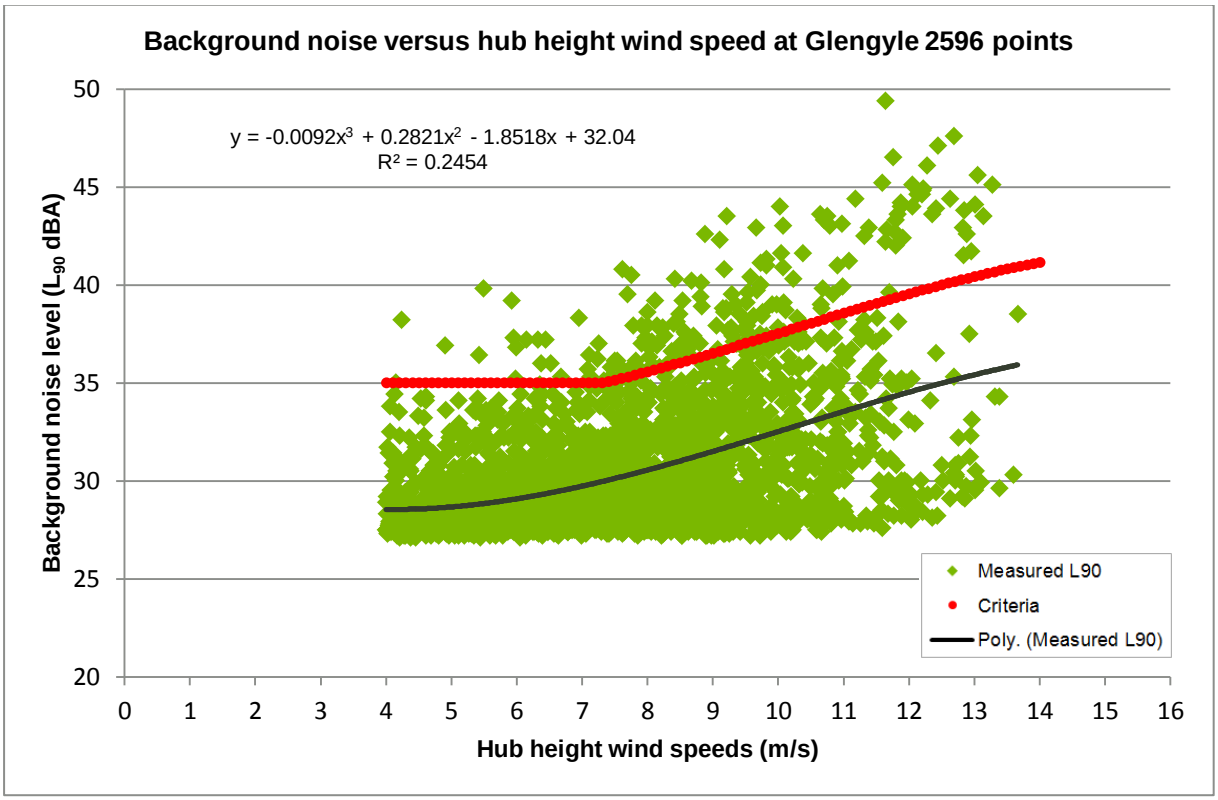


Figure 4 Regression analysis – Glengyle

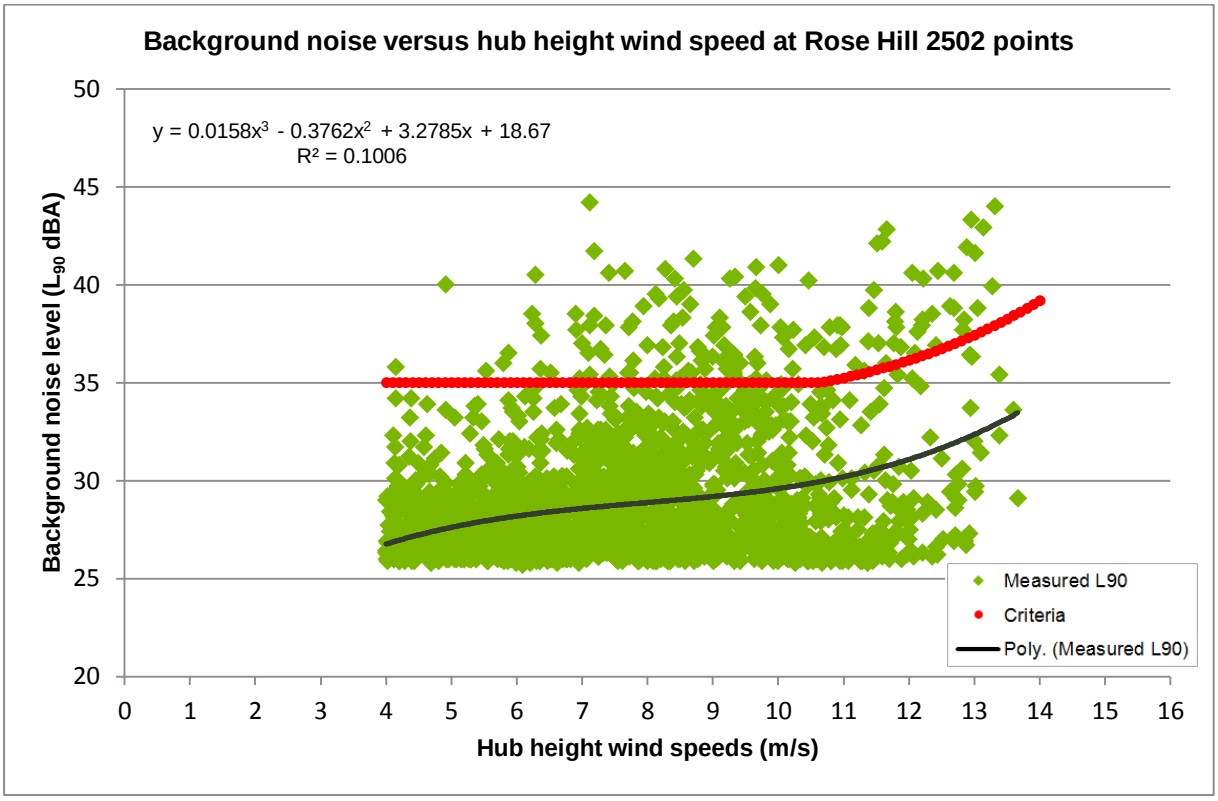


Figure 5 Regression analysis – Rose Hill B

3.1.2 Day and night time specific regression analysis

Draft NSW Planning Guidelines: Wind Farms outline the requirement to establish criteria separately for daytime and night time hours using regression analysis of background noise and wind data collected during these specific times. By separating the regression analysis into the two time periods, the *Draft NSW Planning Guidelines: Wind Farms* are aiming to identify changes in the background noise environment during the different periods of the day. This approach also intends to take into account the different meteorological conditions especially atmospheric stability which is more prevalent during night time hours. The times of day are defined as follows:

- Daytime – 7 am to 10 pm
- Night time – 10 pm to 7 am

No guidance is provided on the minimum required number of regression points for the analysis. The figures below show the applicable daytime and night time regression analysis and respective noise criteria for each site in accordance with the *Draft NSW Planning Guidelines: Wind Farms*.

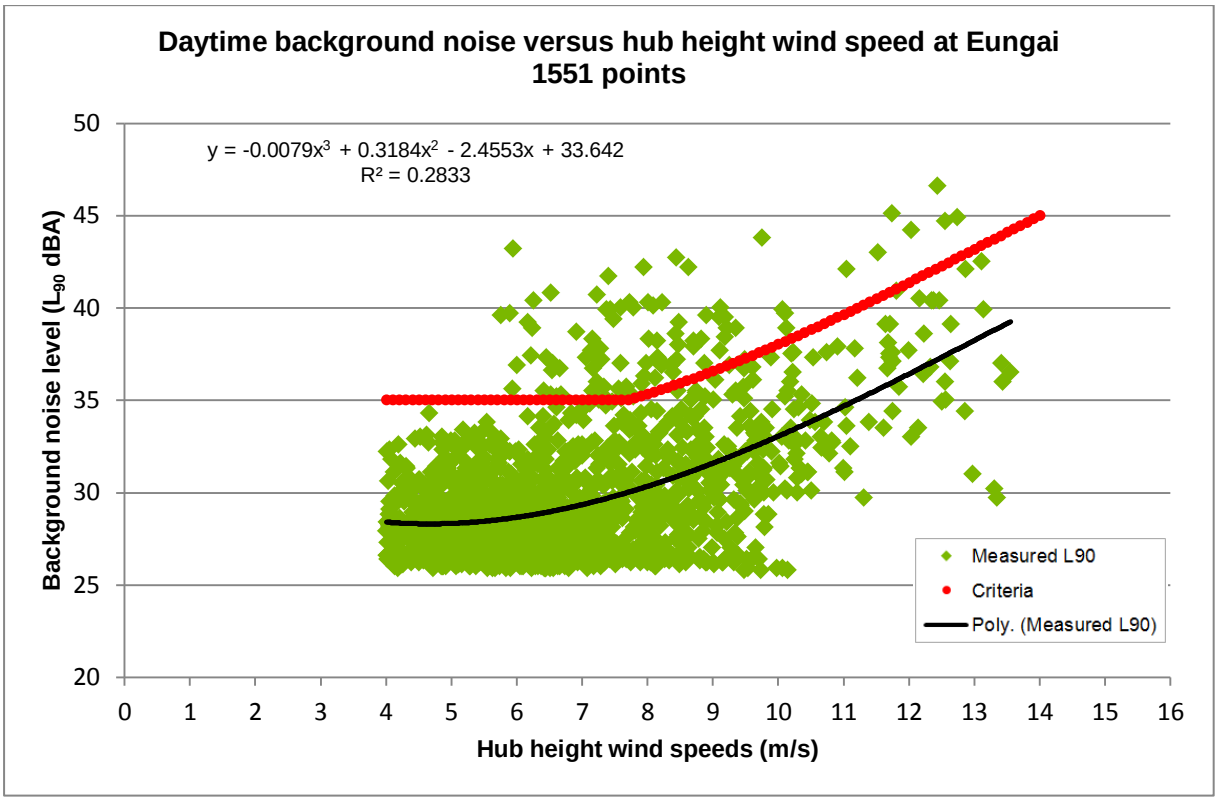


Figure 6 Daytime regression analysis – Cherry Tree (Eungai)

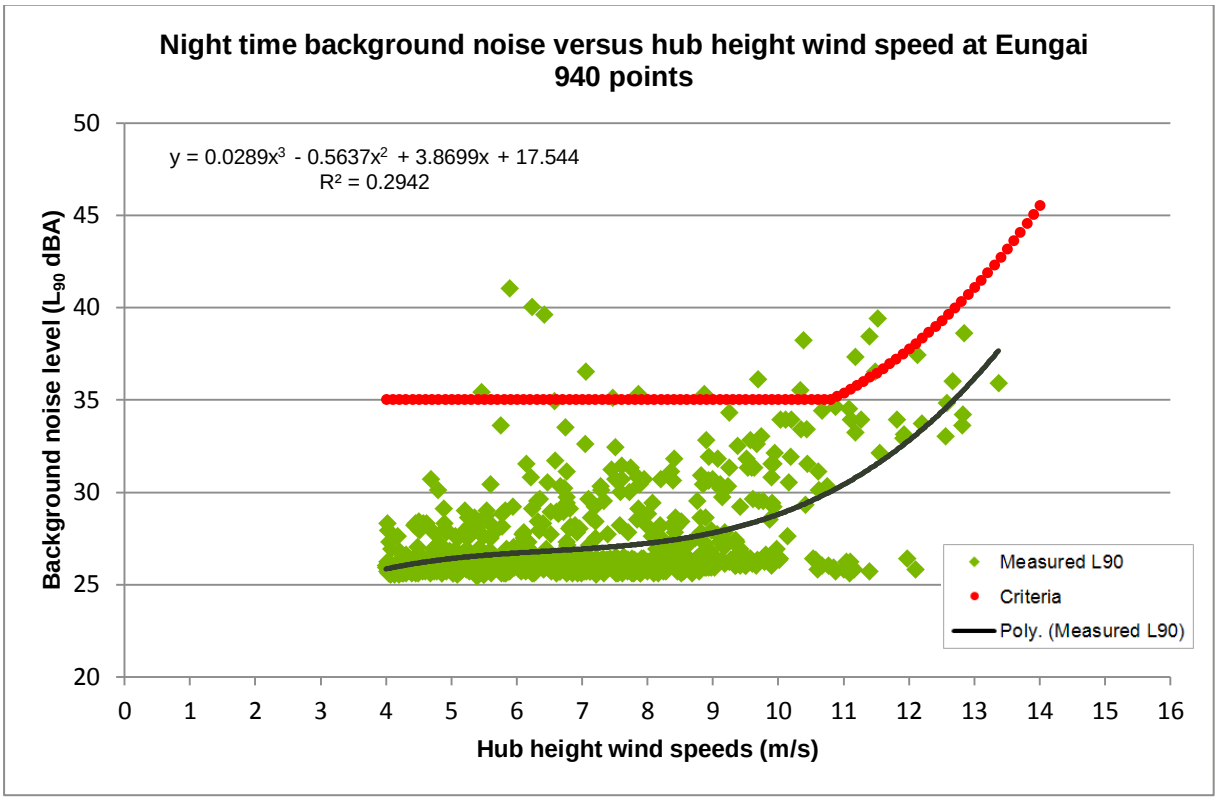


Figure 7 Night time regression analysis – Cherry Tree (Eungai)

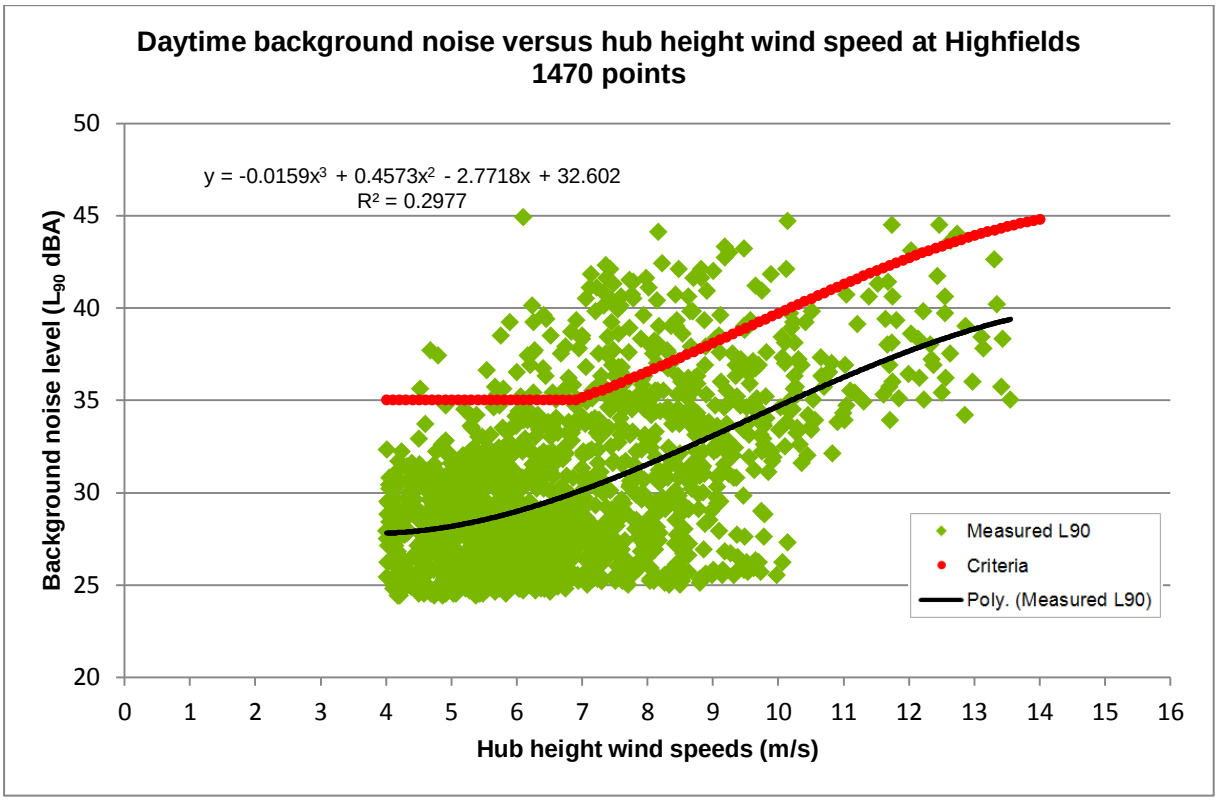


Figure 8 Daytime regression analysis – Highfields

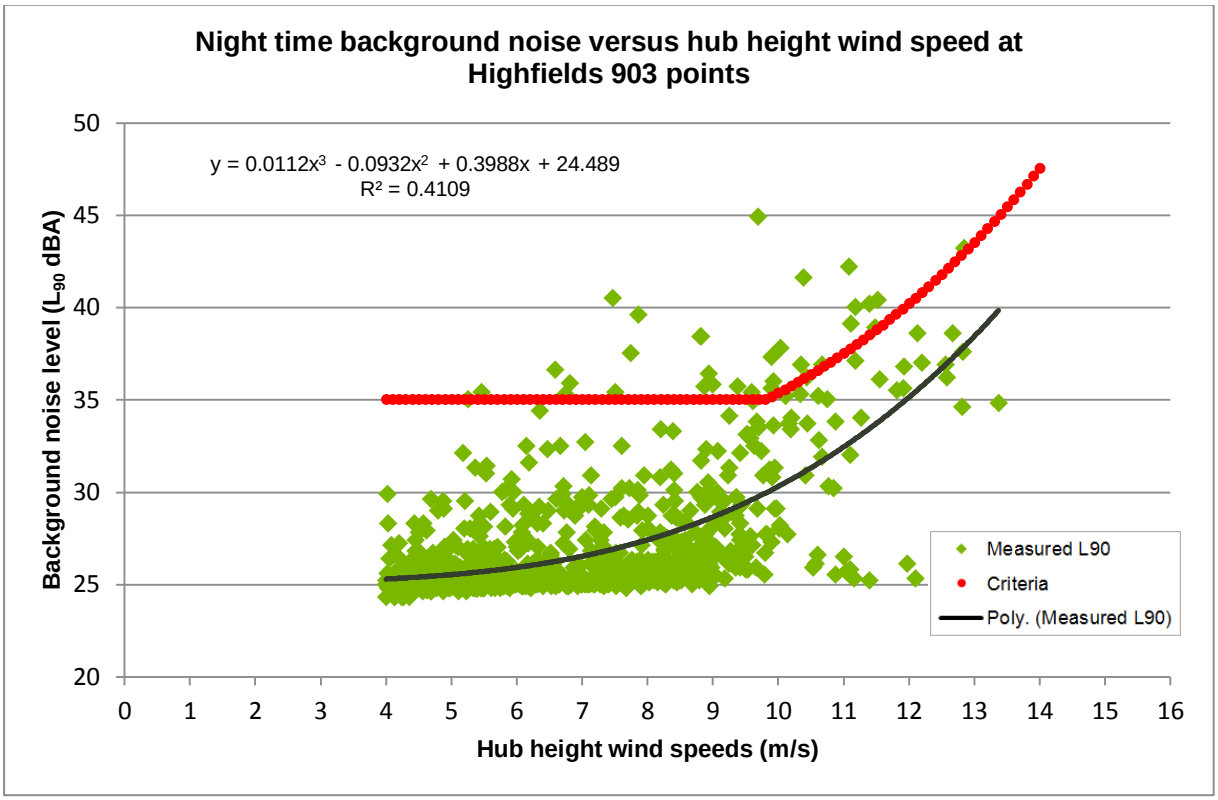


Figure 9 Night time regression analysis – Highfields

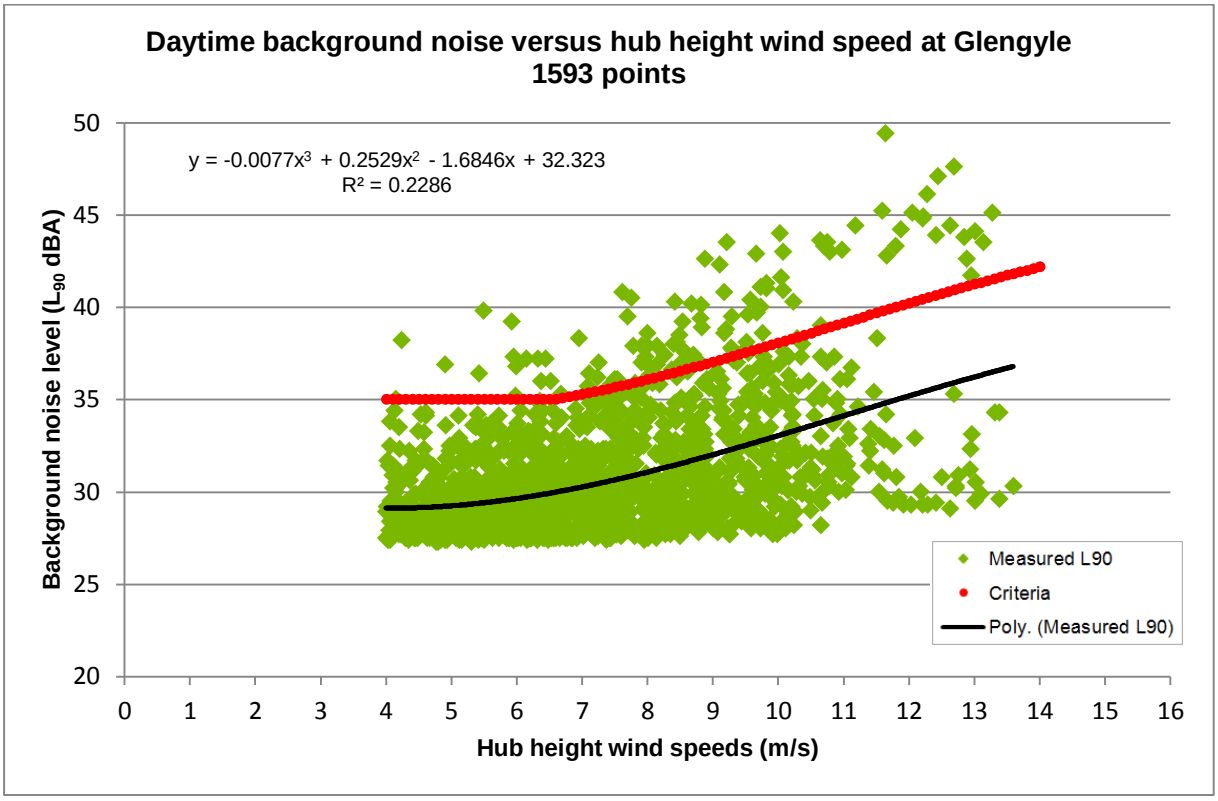


Figure 10 Daytime regression analysis – Glengyle

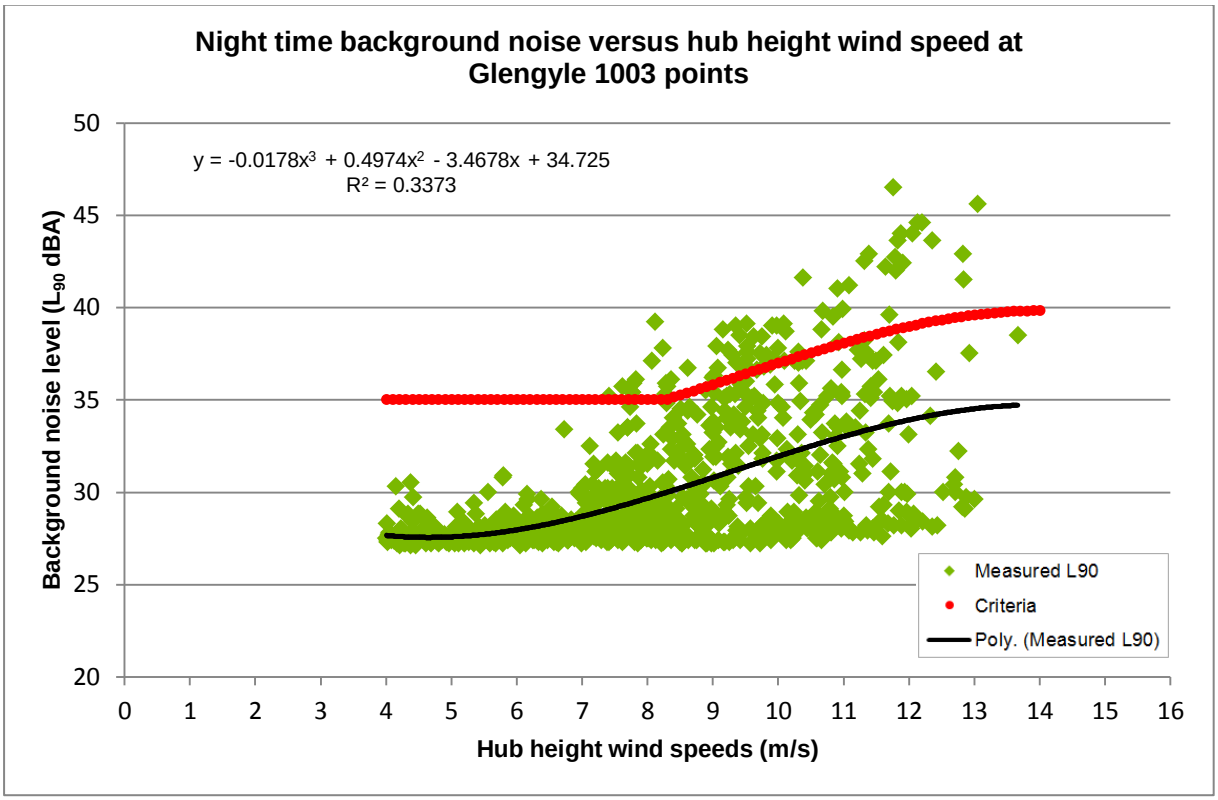


Figure 11 Night time regression analysis – Glengyle

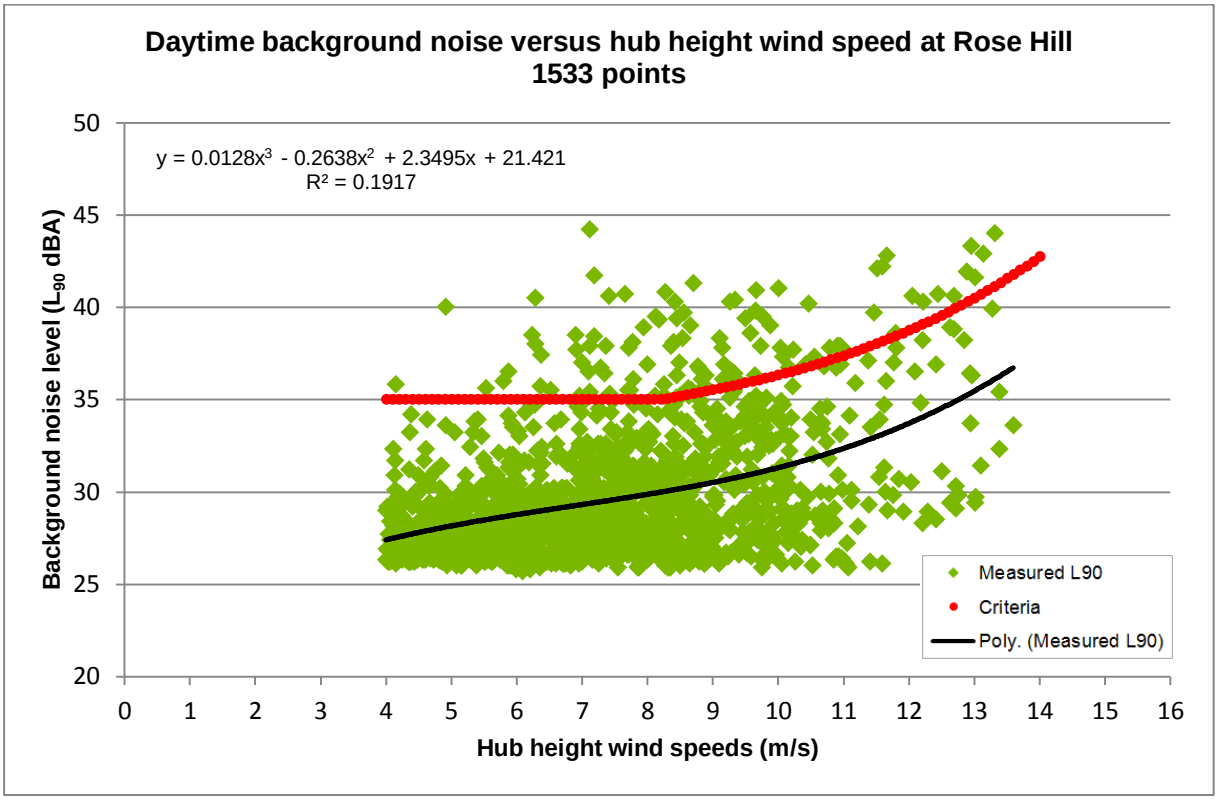


Figure 12 Daytime regression analysis – Rose Hill B

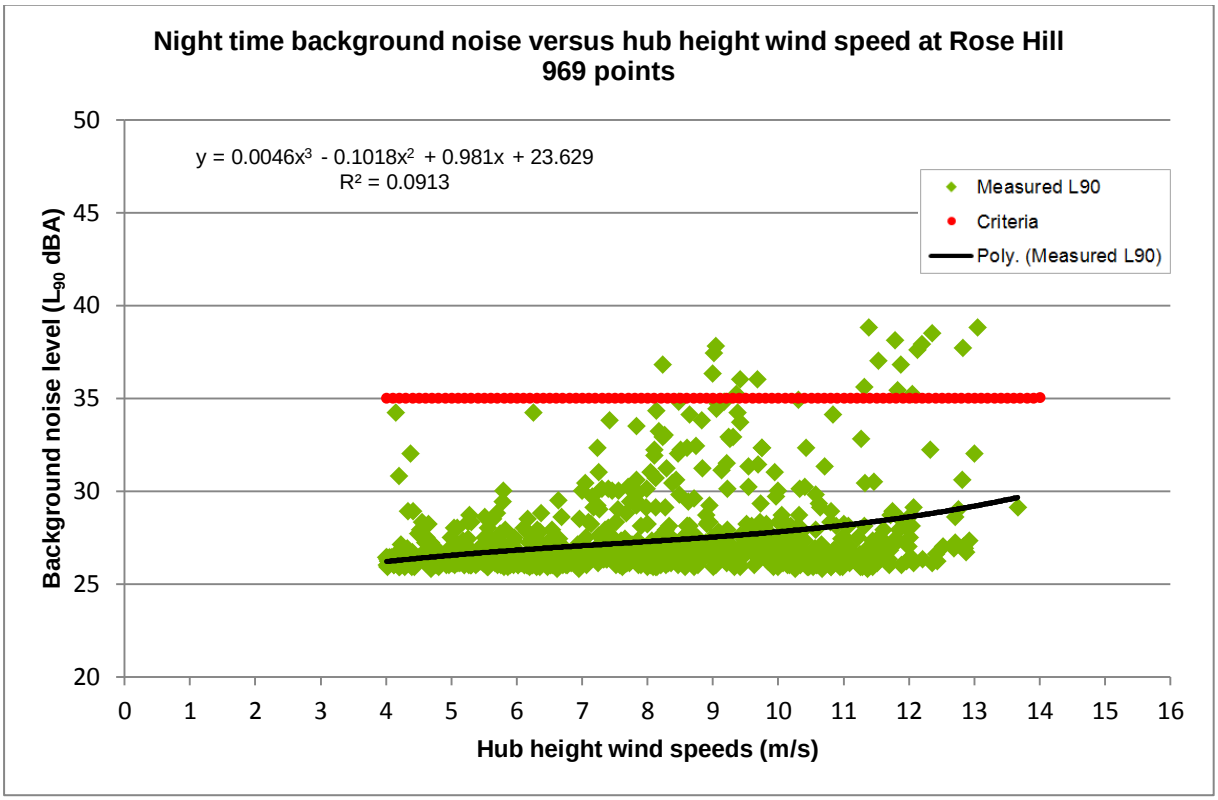


Figure 13 Regression analysis – Rose Hill B

3.1.3 Assessment criteria

The applicable criteria derived in accordance with the 2003 SA EPA Guidelines (for residences where background monitoring occurred) referenced to hub height integer wind speeds are shown in Table 4 below. Noise criteria based on daytime and night time regression analysis in accordance with *Draft NSW Planning Guidelines: Wind Farms* are also shown for each location.

Table 4 Noise Criteria for residences where background monitoring was undertaken

Base location	Criteria Type	Criterion $L_{Aeq,10min}$ (dBA) for each Hub Height Wind Speed (m/s)										
		4	5	6	7	8	9	10	11	12	13	14
Cherry Tree (Eungai)	Overall	35	35	35	35	35	35	36	38	40	43	46
	Day	35	35	35	35	35	37	38	40	41	43	45
	Night	35	35	35	35	35	35	35	35	38	41	46
Highfields	Overall	35	35	35	35	35	36	38	40	42	44	46
	Day	35	35	35	35	37	38	40	41	43	44	45
	Night	35	35	35	35	35	35	35	38	40	44	48
Glengyle	Overall	35	35	35	35	36	37	38	39	40	40	41
	Day	35	35	35	35	36	37	38	39	40	41	42
	Night	35	35	35	35	35	36	37	38	39	40	40

Base location	Criteria Type	Criterion $L_{Aeq,10min}$ (dBA) for each Hub Height Wind Speed (m/s)										
		4	5	6	7	8	9	10	11	12	13	14
Rose Hill B	Overall	35	35	35	35	35	35	35	35	36	37	39
	Day	35	35	35	35	35	36	36	37	39	41	43
	Night	35	35	35	35	35	35	35	35	35	35	35

The criteria developed for the four background noise monitoring sites can be applied for the assessment of other neighbouring properties which are expected to have similar background noise characteristics; these are outlined in Table 5.

Table 5 Correspondence of background noise sites and those with similar noise amenity criteria

Background Monitoring Site	Sites considered to have similar background noise environment
Cherry Tree (Eungai)	Elm Vale, Klossie, Green House, Lombardy, Mayvona, Moonarie, Nullagai, Wandsworth
Glengyle	Balaclava A, Ilparran A, Ilparran B, Kalanga A, Kalanga B, Kalanga C, Minamurra A, Minamurra B, Minamurra C, Green Valley (Oakes), Rivoli (on western side of Range and similar to Glengyle location)
Rose Hill B	Girrahween, Glengarry, Matheson Church,
Highfields	Wattle Vale (also close to Gwydir Highway (about 100m) so may have a higher background noise environment). Highfields is surrounded by large trees and appears to have high background levels

3.2 Wind farmer residences

As indicated above wind farmer residences are those located on properties where the turbines are to be installed. The wind farmer residences are not subject to the same noise amenity criteria as non-wind farmer residences. Higher noise levels are regarded as acceptable at wind farmer residences due to the landowners having a choice in the location of turbines on their property and as beneficiaries of lease agreements in respect of the wind farm development. However, noise amenity criteria are still relevant but involving higher noise levels than for non-wind farmer residences.

The noise amenity criteria shown in Table 6, relate to the wind farmer residences (Glengyle, Hillside, Rosehill A & B), and are based on the WHO Community Noise Guidelines. Meeting these guidelines will ensure that the amenity value of these residences is not unreasonably interfered with.

Table 6 Noise amenity criteria for wind farmer residences (based on WHO Community Noise Guidelines)

Specific Environment	Critical health effect(s)	L_{Aeq} (dBA)	Time base (hours)	L_{Amax} (dBA)
Outdoor living area	Serious annoyance, daytime and evening	55	16	-
Dwelling Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms (with window open)	Sleep disturbance, night-time	45	8	60

3.3 NSW Industrial noise policy

The one or two transformers located at the proposed substation will be the only significant noise sources to fall under the criteria outlined by the NSW EPA Industrial Noise Policy. The criteria will be driven by the intrusiveness criteria by the night-time rating background noise level at the Rose Hill B measurement location. The criterion is as follows:

- $L_{Aeq,15min}$ (transformer) ≤ 34 dBA at noise sensitive receiver

The nearest residences to the substation site are Rivoli, Wattle Vale and Girrahween all of which are located at about 2 km from the substation site. Due to the distances between the substation and the respective residences and consideration of existing noise from the Gwydir Highway and woodland areas and the residence settings, the noise impact of the transformer(s) at the three residence locations is assessed as being acceptable.

Sinclair Lookout is located close to the northern end of the wind farm and about 500 metres from the proposed substation site. The lookout is at the top of the unsealed Sinclair Lookout Road and comprises a turning circle within a small clearing on the partly cleared ridge. The view from the lookout is to the west over Wellingrove Valley. The Office of Environment and Heritage (formerly DECCW) has suggested that the impact at the lookout should be assessed against passive recreation amenity criteria where a L_{Aeq} level of 50 is the recommended acceptable level and a L_{Aeq} level of 55 is the recommended maximum level when the area is being used.

The lookout does not appear to have frequent visitation and has no facilities that would encourage long term visits. It is also a fairly exposed site and at times of strong winds would be likely to discourage lengthy stays and potentially result in a higher ambient noise level than for other more sheltered locations. As such any noise impact for visitors to the lookout would be likely to be of a short term nature and once the wind farm is operating any audible noise from the wind turbine at the lookout could potentially form part of the experience of viewing the wind farm at a relatively close distance.

4 Noise level predictions

4.1 Wind turbine noise emissions

4.1.1 Overall noise emissions

As outlined in Section 2.1, the Alstom ECO 122 – 2.7 MW has been specified as a preferred wind turbine to be installed for the Glen Innes Wind Farm development with a hub height of 89 m. Due to the limited data available for this turbine the following assumptions have been made:

- The spectral noise emissions have been assumed to be as per the similar Alstom ECO 110 – 3.0 MW wind turbine. The spectral data has been scaled to equate the total Sound Power Level of the ECO 122 as per the *Sound Power Level for the ECO 122*,

Table 7 and Figure 14 show the sound power levels emitted from the wind turbine for integer hub height wind speeds. Figure 15 shows the spectral sound power level for wind turbine. Mode 0 is the standard operating condition of the wind turbine where the maximum noise emissions occur and maximum power is generated.

Table 7 Alstom ECO 122 - 2.7 MW sound power levels for Mode 0

Wind speed (m/s) at Hub Height (89 m)	Sound Power Level (dBA)
4	91.5
5	93.3
6	97.3
7	100.6
8	103.5
9	105.7
10	106.0
11	105.6
12	105.3
13	105.2
14	105.2

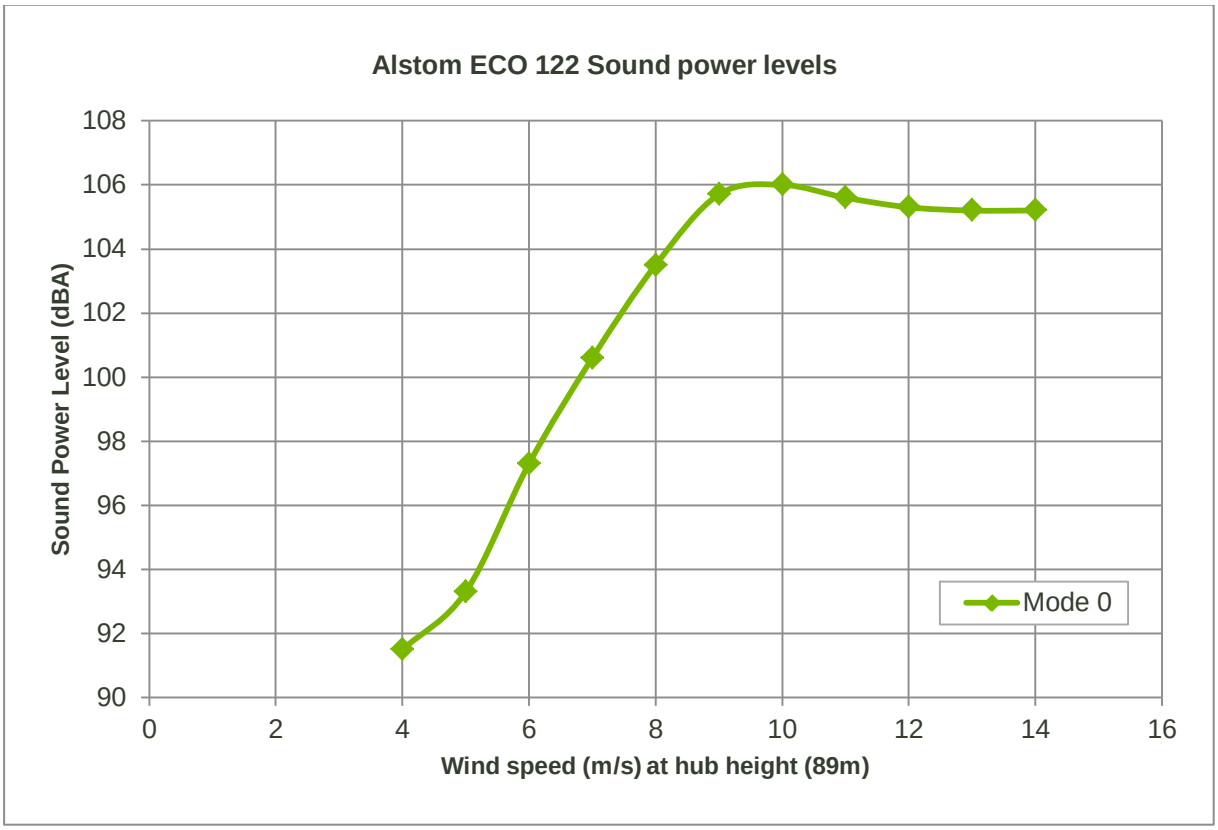


Figure 14 Alstom ECO 122 sound power levels between cut-in and rated hub height wind speeds

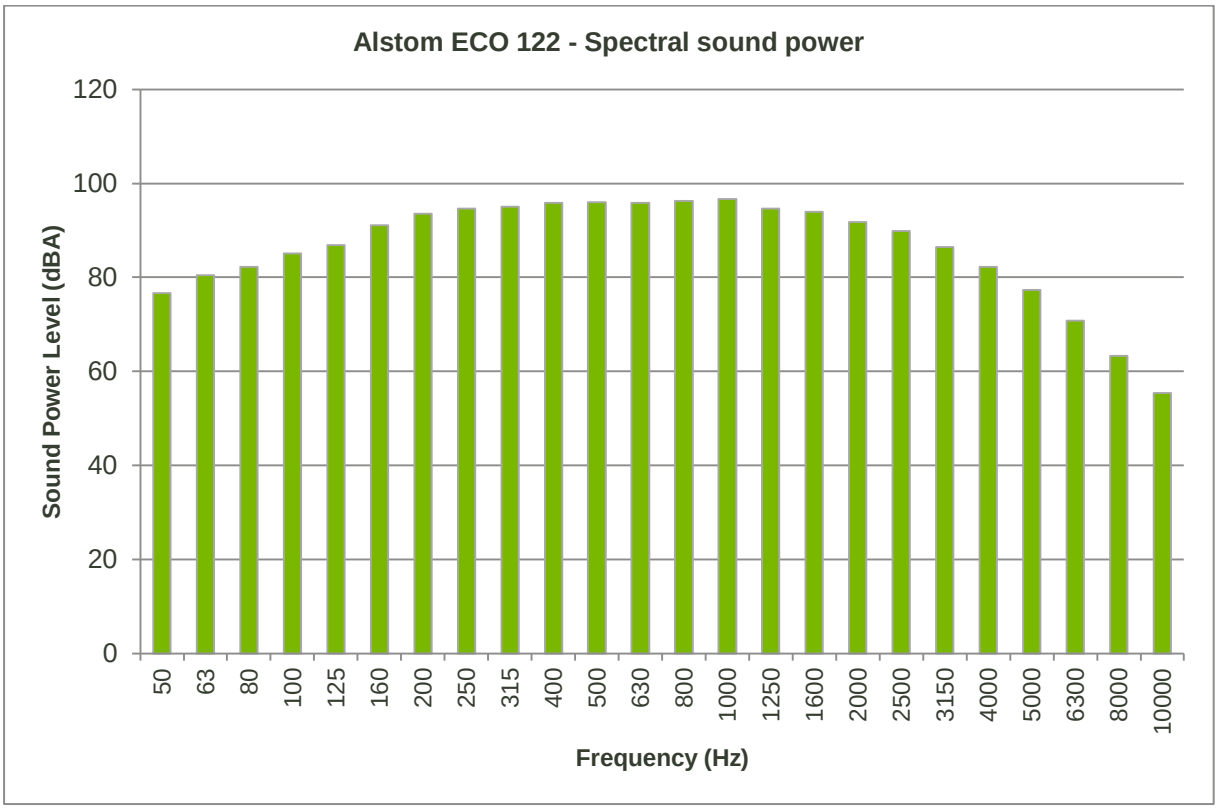


Figure 15 Alstom ECO 122 Spectral sound power levels at a hub height wind speed of 10 m/s

4.1.2 Tonality

The tonal audibility data $\Delta L_{A,k}$ calculated for the Alstom ECO 110 – 3.0 in accordance with IEC 61400-11 is shown in Table 8 below. Based on this data it can be shown that wind turbine satisfies the tonal analysis and no penalty has to be applied. Due to the similarities in construction of the Alstom ECO 110 and ECO 122 wind turbines, it is expected the ECO 122 turbine to have similar tonal characteristics.

Table 8 Audible tonality assessment to IEC 61400-11

Wind speed (m/s) at Hub Height (89 m)	Tonal audibility $\Delta L_{A,k}$ (dBA)
8.5	-5.51
9.9	-8.57
11.3	-4.66
12.7	-5.08
14.1	-4.52

4.2 Original model inputs and predicted noise levels – ECO 122 wind turbines

The wind farm noise emissions are based on the Alstom ECO 122 2.7 MW wind turbine generators with the noise emissions peaking at a hub height wind speed of 10 m/s. The noise predictions were carried out using the SoundPLAN developed model for the original assessment incorporating the change in the hub height and adjustments in locations of some wind turbines and receiver locations. Inputs into the SoundPLAN model have been entered as follows:

- Positions of sources, receivers and ground contours were input from electronic data created for this project with features specified in the MGA coordinate system
- Meteorological inputs used by ISO 9613-2
  - Relative humidity – 80 %
  - Ambient temperature – 20°C
  - Atmospheric pressure – 1 atm
  - Ground absorption rating as, G = 1

These inputs are consistent with the original modelled results and ensure consistent results when comparing the changes between the original and supplementary assessments and comply with the 2003 SA EPA Wind Farm Noise Guidelines.

It is noted that the predicted noise levels determined using the ISO 9613 algorithm have been validated to agree to within 2 dBA of noise levels measured under practical “worst case” conditions at distances of up to 1,000 m from a noise source [Bass et al (1996)].

Noise levels due to the operation of the wind farm utilising the revised layout are shown in Table 9 below for each integer wind speed (at hub height) without taking into account atmospheric stability (outside of the ISO 9613-2 modelling algorithm). Worst-case sound powers emitted by the wind farm when all wind turbine generators are operated in Mode 0 (associated with maximum turbine noise levels) have been used in the calculation with an adjustment being made depending on the wind speed. The predicted noise impacts are lower than the *Supplementary noise assessment* due to the use of quieter wind turbines.

The predicted noise levels satisfy both the overall noise criteria as well as day night specific assessment criteria outlined in Section 3.1.3.

Table 9 Predicted Noise Levels at each receiver for wind turbines in Mode 0 operation

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	5	6	7	8	9	10	11	12	13	14
Balaclava A	9	11	15	18	21	23	23	23	23	22	22
Elm Vale	5	7	11	14	17	20	20	19	19	19	19
Eungai	13	15	19	22	25	27	28	27	27	27	27
Girrahween	11	13	17	20	23	25	25	25	25	24	24
Glengarry	8	10	14	17	20	22	23	22	22	22	22
Glengyle	18	19	23	27	30	32	32	32	31	31	31
Green house	9	11	15	18	21	23	23	23	23	23	23
Highfields	17	18	22	26	29	31	31	31	30	30	30
Hillside	22	24	28	31	34	37	37	36	36	36	36
Ilparran A	16	18	22	25	28	30	31	30	30	30	30
Ilparran B	16	18	22	25	28	30	31	30	30	30	30
Kalanga A	12	14	18	22	24	27	27	27	26	26	26
Kalanga B	11	13	17	20	23	25	26	25	25	25	25
Kalanga C	12	14	18	21	24	26	26	26	26	25	25
Klossie	7	9	13	17	19	22	22	22	21	21	21
Lombardy	11	13	17	20	23	25	26	25	25	25	25
Matheson Church	7	9	13	17	19	22	22	22	21	21	21
Mayvona	18	20	24	27	30	32	32	32	32	32	32
Minamurra A	11	13	17	20	23	25	26	25	25	25	25
Minamurra B	12	14	18	21	24	26	27	26	26	26	26
Minamurra C	10	12	16	20	22	25	25	25	24	24	24
Moonarie	5	7	11	14	17	19	19	19	19	18	18
Nullagai	8	10	14	17	20	23	23	22	22	22	22
Oakes	9	11	15	18	21	23	24	23	23	23	23
Rivoli	10	11	15	19	22	24	24	24	23	23	23
Rose Hill A	11	13	17	20	23	25	25	25	25	24	24
Rose Hill B	11	13	17	20	23	25	26	25	25	25	25
Wandsworth	10	11	15	19	22	24	24	24	23	23	23
Wattle Vale	10	12	16	19	22	24	24	24	24	24	24

4.3 Updated model inputs and predicted noise levels – ECO 122 wind turbines

A group of acoustic consultants in the UK has developed a set of conditions as part of noise prediction calculations in accordance with the ISO 9613-2 algorithm which are outlined in *Prediction and assessment of wind turbine noise – Agreement about relevant factors for noise assessment from wind energy projects, Acoustic Bulletin March/April 2009, Institute of Acoustics 2009.* The aim of these conditions is to enhance the quality and to provide consistent results for wind farm noise assessment across the acoustic community. These model input conditions provide a more conservative approach to the noise predictions when compared to the original methodology. The updated model input conditions are summarised below:

- Positions of sources, receivers and ground contours were input from electronic data created for this project with features specified in the MGA coordinate system
- Meteorological inputs used by ISO 9613-2
  - Relative humidity – 70 %
  - Ambient temperature – 10°C
  - Atmospheric pressure – 1 atm
  - Ground absorption rating as, G = 0.5
  - Receivers at a height of 4 m above ground
  - Barrier attenuation calculation within ISO 9613-2 not included in calculation

Under the updated model input conditions increased noise levels are predicted at the neighbouring residences, with exceedances predicted at Highfields and Mayvona. The results are summarised in Table 10 below with respective noise contours shown in Appendix A.

The biggest increase in the predicted noise levels relates to the change in the ground absorption effect, with the ground no longer providing up to 2 dB attenuation, instead it generates up to a 2 dB addition to the noise level due to the reflection effects.

The predicted noise impacts are lower than the *Supplementary noise assessment* due to the use of quieter wind turbines however some exceedances are still predicted using this methodology.

Table 10 Predicted Noise Levels at each receiver using updated ISO 9613 inputs

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	5	6	7	8	9	10	11	12	13	14
Balaclava A	15	17	21	24	27	30	30	29	29	29	29
Elm Vale	12	14	18	21	24	26	26	26	26	26	26
Eungai	20	22	26	29	32	34	34	34	34	33	33
Girrahween	17	19	23	26	29	32	32	31	31	31	31
Glengarry	15	17	21	24	27	29	29	29	29	29	29
Glengyle	24	25	29	33	36	38	38	38	37	37	37
Green house	15	17	21	24	27	29	30	29	29	29	29
Highfields	23	25	29	32	35^{ON}	37^{ON}	37^{N}	37	37	37	37
Hillside	28	30	34	37	40	42	43	42	42	42	42
Ilparran A	22	24	28	31	34	36^{N}	37^{N}	36	36	36	36

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	5	6	7	8	9	10	11	12	13	14
Ilparran B	22	24	28	31	34	36[N]	37[N]	36	36	36	36
Kalanga A	19	21	25	28	31	33	33	33	33	33	33
Kalanga B	18	20	24	27	30	32	32	32	32	31	31
Kalanga C	18	20	24	27	30	33	33	32	32	32	32
Klossie	14	16	20	23	26	28	29	28	28	28	28
Lombardy	18	20	24	27	30	32	32	32	32	32	32
Matheson Church	14	16	20	23	26	28	28	28	28	28	28
Mayvona	24	25	29	33	36[ODN]	38[ODN]	38[ODN]	38[ON]	37	37	37
Minamurra A	18	20	24	27	30	32	32	32	32	32	32
Minamurra B	19	21	25	28	31	33	33	33	33	32	32
Minamurra C	17	19	23	26	29	31	32	31	31	31	31
Moonarie	11	13	17	20	23	26	26	25	25	25	25
Nullagai	15	17	21	24	27	29	30	29	29	29	29
Oakes	16	18	22	25	28	30	30	30	30	30	30
Rivoli	16	18	22	25	28	30	31	30	30	30	30
Rose Hill A	17	19	23	27	29	32	32	32	31	31	31
Rose Hill B	18	20	24	27	30	32	32	32	32	32	32
Wandsworth	16	18	22	25	28	30	31	30	30	30	30
Wattle Vale	16	18	22	25	28	30	31	30	30	30	30

Note: Highlighted noise levels equal or exceed the design (noise amenity) criteria: [O] – overall criteria, [D] – daytime criteria, [N] – night time criteria

4.4 Limitations of the ISO 9613-2 noise model

It should be noted that the ISO 9613 standard predicts noise levels under meteorological conditions favourable to propagation of sound from the wind turbines towards the sensitive receivers. Conditions favourable to propagation are defined as “downwind propagation” (wind speed between approximately 1 m/s and 5 m/s) or “propagation under a well-developed moderate ground based temperature inversion, such as commonly occurs at night”. This means that the predicted noise levels by ISO 9613 assume simultaneous downwind conditions between the turbines and all of the receivers irrespective of their position relative to each other (ie simultaneous worst case in all directions). Therefore, the ISO 9613 model is unsuitable for modelling noise during unfavourable wind conditions for noise propagation ie upwind from source to receiver.

For Glen Innes, the vast majority of the wind comes from the east or south-south-east. Specifically, the night time wind direction is a consistent easterly wind, and only during the daytime does it potentially switch to a westerly. Therefore the predicted exceedances at the Highfields and Mayvona receivers are unlikely to occur throughout the year given their location east of the proposed wind turbines.

4.5 Special noise characteristics

Special noise characteristics include low frequency noise and tonal noise emissions. *Draft NSW Planning Guidelines: Wind Farms* require the assessment of these special noise characteristics.

4.5.1 Low frequency noise

The *Draft NSW Planning Guidelines: Wind Farms* outline low frequency noise criteria of 65 dBC for daytime and 60 dBC for night time. Should the wind turbine noise emissions exceed these noise levels a more detailed assessment is required. Table 11 provides the worst case C-weighted noise emissions. All of the noise levels satisfy the daytime criteria of 65 dBC and night time criteria of 60 dBC, therefore no further investigation is required.

Table 11 Low frequency noise emissions at a hub height wind speed of 10 m/s

Receiver	Sound pressure level (dBC)	Receiver	Sound pressure level (dBC)
Balaclava A	43	Lombardy	44
Elm Vale	40	Matheson Church	42
Eungai	45	Mayvona	47
Girrahween	42	Minamurra A	44
Glengarry	38	Minamurra B	44
Glengyle	47	Minamurra C	44
Green house	41	Moonarie	39
Highfields	45	Nullagai	37
Hillside	50	Oakes	42
Ilparran A	47	Rivoli	39
Ilparran B	47	Rose Hill A	42
Kalanga A	45	Rose Hill B	40
Kalanga B	44	Wandsworth	43
Kalanga C	44	Wattle Vale	41
Klossie	38		

4.5.2 Tonality

The *Draft NSW Planning Guidelines: Wind Farms* outlines criteria for audible tones from the operation of wind turbines at the sensitive receiver. These are based on the definition outlined in *NSW Industrial Noise Policy* and are defined as follows:

- Level of one-third octave band exceeds the level of the adjacent bands on both sides by:
  - 5 dB or more if the centre frequency of the band containing the tone is above 400 Hz
  - 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz
  - 15 dB or more if the centre frequency of the band containing the tone is below 160 Hz

If any of the above conditions be satisfied, a 5 dBA penalty should be applied to the overall noise prediction.

The one-third octave band noise levels from the wind turbines at each sensitive receiver were assessed and no presence of tonality was identified in the predicted noise results.

4.5.3 Amplitude Modulation

Amplitude modulation refers to the aerodynamic noise from the turbine blades at the blade pass frequency (typically at approximately 1 Hz). This is related to the rotational speed of the turbine. When the noise emission from the wind turbines has modulation of greater than 4 dBA at the blade pass frequency, a 5 dBA penalty should be applied to the overall predicted noise levels.

Currently there are no methods to predict whether excessive amplitude modulation would occur. The assessment is limited to measurements of an operational wind farm.

5 Assessment and recommendations

5.1 Exceedance

5.1.1 Overall noise criteria

The predicted noise levels using the original ISO 9613 model inputs did not show any exceedances of overall noise criteria for integer hub height wind at the updated location of the turbines and Alstom ECO 122 wind turbines operating at maximum noise emission levels.

The predicted noise levels using the updated conservative model inputs showed some exceedances of the noise criteria. It should be noted that the predicted exceedances at Highfields and Mayvona would only occur during the rare times when a westerly wind occurs at the Glen Innes site. During typical wind conditions of east or south-south-east these exceedances would not occur.

Table 12 Details of instances where predicted noise exceeds the overall amenity criteria based on updated model inputs

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	5	6	7	8	9	10	11	12	13	14
Highfields											
Predicted noise	23	25	29	32	35	37	37	37	37	37	37
Criteria	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*42*	*44*	*46*
Exceedance	-12	-10	-6	-3	0	1	-1	-3	-5	-7	-9
Mayvona											
Predicted noise	24	25	29	33	36	38	38	38	37	37	37
Criteria	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*43*	*46*
Exceedance	-11	-10	-6	-2	1	3	2	0	-3	-6	-9

Note: Highlighted noise levels equal or exceed the overall design (noise amenity) criteria

5.1.2 Day and night noise criteria

The predicted noise levels using the original ISO 9613 model inputs did not show any exceedances of the daytime and night time noise criteria for integer hub height wind at the updated location of the turbines and Alstom ECO 122 wind turbines operating at maximum noise emission levels.

The predicted noise levels using the updated conservative model inputs showed some exceedances of the noise criteria. These are summarised in Table 13 below. The predicted exceedances at

Highfields and Mayvona would only occur during the rare times when a westerly wind occurs at the Glen Innes site especially during the night time. Typical night time wind conditions consist of an easterly wind during which these exceedances would not occur.

Table 13 Details of instances where predicted noise exceeds the amenity criteria based on updated model inputs

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Highfields											
Predicted noise	23	25	29	32	35^{N}	37^{N}	37^{N}	37	37	37	37
Night Criteria	*35*	*35*	*35*	*35*	*35*	*35*	*35*	*38*	*40*	*44*	*48*
Exceedance	-12	-10	-6	-3	0	2	2	-1	-3	-7	-11
Mayvona											
Predicted noise	24	25	29	33	36^{DN}	38^{DN}	38^{DN}	38^{N}	37	37	37
Day Criteria	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*43*	*46*
Exceedance	-11	-10	-6	-2	1	1	0	-2	-4	-6	-8
Night Criteria	*35*	*35*	*35*	*35*	*35*	*35*	*35*	*35*	*38*	*41*	*46*
Exceedance	-11	-10	-6	-2	1	3	3	3	-1	-4	-9
Ilparran A & B											
Predicted noise	22	24	28	31	34	36^{N}	37^{N}	36	36	36	36
Night Criteria	*35*	*35*	*35*	*35*	*35*	*36*	*37*	*38*	*39*	*40*	*40*
Exceedance	-13	-11	-7	-4	-1	0	0	-2	-3	-4	-4

Note: ^{D} – noise levels equal or exceed the daytime criteria, ^{N} – noise levels equal or exceed the night time criteria

5.2 Operational strategy

To control noise emissions from the wind turbine(s) and ensure compliance, their operating mode can be changed. This in turn lowers the emitted noise; however it also reduces the power generated by that turbine. This section shows the required operational mode strategy to satisfy the noise criteria (Section 3.1.3) for the updated conservative modelling inputs. Selection of turbine operating mode (and hence turbine noise levels) can be implemented by using the wind farm SCADA control system based on real-time measurements of wind speed and turbine operation. The SCADA system can be programmed to respond to specific data inputs by adjusting the modes of operation for the critical turbines based on control logic to ensure compliance at relevant receiver locations.

Two operating modes have been specified to satisfy the noise criteria. These are outline as follows:

- Mode 1 – Maximum sound Power output of L_w 104 dBA at hub height wind speeds 8 – 11 m/s
- Mode 2 – Maximum sound Power output of L_w 100 dBA at hub height wind speeds 7 – 11 m/s

However the implementation of the lower noise operating modes would only be required during conditions that are favourable for noise propagation such as downwind or during the occurrence of stable atmospheric conditions. Downwind conditions for the worst affected receivers of Highfields and Mayvona consisting of a westerly wind are rare for the Glen Innes site.

5.2.1 Overall noise criteria

Table 14 outlines the required operating modes of individual turbines to satisfy the noise criteria at all non wind farmer residences. Table 15 shows the predicted noise levels at all receivers after applying the reduced operating modes to satisfy the noise criteria at all non wind farmer residences. Appendix A shows the applicable noise contour. It should be noted that Mayvona neighbouring residence is currently unoccupied and has been unoccupied throughout the development process.

Table 14 Operating modes of individual turbines to satisfy overall noise criteria

Receiver	Required Operating modes of wind turbines						
	15	16B	16C	19	20B	21B	22B
Highfields	1	1	1	1	-	-	1
Mayvona	-	-	-	-	1	2	2
Satisfy all	**1**	**1**	**1**	**1**	**1**	**2**	**2**

Note: All remaining wind turbines to operate at standard Mode 0.

Table 15 Predicted noise levels applying operation modes (summarised in Table 14) to satisfy criteria at all receivers using updated ISO 9613 inputs

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	5	6	7	8	9	10	11	12	13	14
Balaclava A	15	17	21	24	27	30	30	29	29	29	29
Elm Vale	9	11	15	19	21	24	24	24	23	23	23
Eungai	18	20	24	27	30	33	33	32	32	32	32
Girrahween	17	19	23	26	29	32	32	31	31	31	31
Glengarry	14	16	20	23	26	28	28	28	28	28	28
Glengyle	24	25	29	33	36	38	38	38	37	37	37
Green house	14	16	20	23	26	28	28	28	28	28	28
Highfields	22	23	27	31	34	36	36	36	35	35	35
Hillside	27	28	32	36	39	41	41	41	40	40	40
Ilparran A	22	24	28	31	34	36	36	36	36	36	36
Ilparran B	22	24	28	31	34	36	36	36	36	36	36
Kalanga A	19	21	25	28	31	33	33	33	33	32	32
Kalanga B	18	19	23	27	30	32	32	32	31	31	31
Kalanga C	18	20	24	27	30	32	33	32	32	32	32
Klossie	13	15	19	22	25	27	27	27	27	27	27
Lombardy	16	18	22	25	28	30	31	30	30	30	30
Matheson Church	14	16	20	23	26	28	28	28	28	28	28
Mayvona	21	22	26	30	33	35	35	35	34	34	34
Minamurra A	17	19	23	27	29	32	32	32	31	31	31

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	5	6	7	8	9	10	11	12	13	14
Minamurra B	18	20	24	28	30	33	33	33	32	32	32
Minamurra C	17	18	22	26	29	31	31	31	30	30	30
Moonarie	9	11	15	18	21	23	24	23	23	23	23
Nullagai	14	16	20	23	26	28	28	28	28	28	28
Oakes	15	17	21	24	27	29	30	29	29	29	29
Rivoli	16	18	22	25	28	30	31	30	30	30	30
Rose Hill A	17	19	23	26	29	31	32	31	31	31	31
Rose Hill B	18	20	24	27	30	32	32	32	32	31	31
Wandsworth	15	17	21	24	27	29	29	29	29	29	29
Wattle Vale	16	18	22	25	28	30	31	30	30	30	30

Note: Highlighted noise levels equal design (noise amenity) criteria

5.2.2 Night noise criteria

Table 16 outlines the required operating modes of individual turbines to satisfy the noise criteria at all non wind farmer residences for night time noise criteria. Table 17 shows the predicted noise levels at all receivers after applying the reduced operating modes to satisfy the noise criteria at all non-wind farmer residences. Appendix A shows the applicable noise contour. It should be noted that Mayvona neighbouring residence is currently unoccupied and has been unoccupied throughout the development process.

Table 16 Operating modes of individual turbines to satisfy night time noise criteria at all receivers

Receiver	Required Operating modes of wind turbines						
	15	16B	16C	19	20B	21B	22B
Satisfy all	-	2	1	2	1	2	2

Note: All remaining wind turbines to operate at standard Mode 0.

Table 17 Predicted noise levels applying operation modes (summarised in Table 16) to satisfy criteria at all receivers using updated ISO 9613 inputs

Receiver	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
	4	5	6	7	8	9	10	11	12	13	14
Balaclava A	15	17	21	24	27	30	30	29	29	29	29
Elm Vale	9	11	15	18	21	23	23	23	23	23	23
Eungai	17	19	23	27	29	32	32	32	31	31	31
Girrahween	17	19	23	26	29	32	32	31	31	31	31
Glengarry	14	16	20	23	26	28	28	28	28	28	28
Glengyle	24	25	29	33	36	38	38	38	37	37	37
Green house	12	14	18	21	24	27	27	26	26	26	26
Highfields	21	23	27	30	33	35	35	35	35	34	34
Hillside	26	28	32	35	38	40	41	40	40	40	40
Ilparran A	21	23	27	30	33	35	36	35	35	35	35
Ilparran B	22	23	27	31	34	36	36	36	35	35	35
Kalanga A	19	20	24	28	31	33	33	33	32	32	32
Kalanga B	17	19	23	27	29	32	32	32	31	31	31
Kalanga C	18	20	24	27	30	32	32	32	32	32	32
Klossie	11	13	17	20	23	26	26	25	25	25	25
Lombardy	16	17	21	25	28	30	30	30	29	29	29
Matheson Church	14	16	20	23	26	28	28	28	28	28	28
Mayvona	20	22	26	29	32	35	35	34	34	34	34
Minamurra A	17	19	23	26	29	31	32	31	31	31	31
Minamurra B	18	20	24	27	30	32	33	32	32	32	32
Minamurra C	16	18	22	25	28	31	31	30	30	30	30
Moonarie	8	10	14	17	20	22	23	22	22	22	22
Nullagai	13	14	18	22	25	27	27	27	26	26	26
Oakes	14	16	20	24	26	29	29	29	28	28	28
Rivoli	16	18	22	25	28	30	31	30	30	30	30
Rose Hill A	17	19	23	26	29	31	32	31	31	31	31
Rose Hill B	18	20	24	27	30	32	32	32	32	31	31
Wandsworth	14	16	20	23	26	28	28	28	28	28	28
Wattle Vale	16	18	22	25	28	30	31	30	30	30	30

Note: Highlighted noise levels equal night time criteria

5.2.3 Comparison between existing approval and modification application predicted levels for non-associated residences

Table 18 shows the comparison between the predicted noise levels for the non-associated residences (non-wind farmer residences) provided in the *Supplementary Noise assessment (2010)* which supported the original development application (Approval) against the predicted noise levels for the modification application (Modification). Predicted noise levels in the Supplementary Noise assessment at each receiver were modelled with wind turbines 21B and 22B in Mode 3 operation and rest of the turbine in Mode 0 operation. Predicted noise levels in the modification application at each receiver were modelled with various modes of operation (15 at Mode 1, 16B at Mode 1, 16C at Mode 1, 19 at Mode 1, 20B at Mode 1, 21B at Mode 2 and 22B at Mode 2).

Table 18 Comparing predicted noise levels at non associated receivers between approval and modification application

Receiver	Application	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
		4	5	6	7	8	9	10	11	12	13	14
Rivoli	Approval	8	14	19	23	26	28	29	30	30	-	-
	Modification	16	18	22	25	28	30	31	30	30	30	30
	Overall criteria	*35*	*35*	*35*	*35*	*36*	*37*	*38*	*39*	*40*	*40*	*41*
Wattle Vale	Approval	9	15	20	24	27	29	30	31	31	-	-
	Modification	16	18	22	25	28	30	31	30	30	30	30
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*42*	*44*	*46*
Girrahween	Approval	10	16	21	25	27	30	31	32	32	-	-
	Modification	17	19	23	26	29	32	32	31	31	31	31
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*37*	*39*
Glengarry	Approval	7	14	19	22	25	27	29	29	30	-	-
	Modification	14	16	20	23	26	28	28	28	28	28	28
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*37*	*39*
Mayvona *	Approval	17	23	28	32	35	37	38	39	39	-	-
	Modification	20	22	26	29	32	35	35	34	34	34	34
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*43*	*46*
Lombardy	Approval	11	18	23	27	29	31	33	34	34	-	-
	Modification	16	17	21	25	28	30	30	30	29	29	29
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*43*	*46*
Highfields	Approval	17	23	29	32	35	37	39	39	40	-	-
	Modification	21	23	27	30	33	35	35	35	35	34	34
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*42*	*44*	*46*
Nullagai	Approval	7	14	19	23	25	27	29	30	30	-	-
	Modification	13	14	18	22	25	27	27	27	26	26	26
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*43*	*46*

Receiver	Application	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
		4	5	6	7	8	9	10	11	12	13	14
Klossie	Approval	7	13	29	22	25	27	29	29	30	-	-
	Modification	11	13	17	20	23	26	26	25	25	25	25
	Overall criteria	*35*	*35*	*35*	*35*	*35*	*35*	*36*	*38*	*40*	*43*	*46*
Eungai	Approval	13	20	25	29	31	33	35	36	36	-	-
	Modification	17	19	23	27	29	32	32	32	31	31	31
	Overall criteria	35	35	35	35	35	35	36	38	40	43	46
Illparran A	Approval	14	20	25	29	32	34	35	36	36	-	-
	Modification	21	23	27	30	33	35	36	35	35	35	35
	Overall criteria	*35*	*35*	*35*	*35*	*36*	*37*	*38*	*39*	*40*	*40*	*41*

Note: Highlighted noise level indicating increased or decreased noise level compared with approval application

As evident from Table 18 above, noise impacts for the modification application in comparison with the approval application for few of the non-associated residences has shown a decrease (pink highlights) for specific wind speeds, while there have also been some increases (orange highlights) for specific wind speeds. Although there have been minor to major changes (both an increase or decrease) in noise level, the noise impacts are below the stipulated overall noise criteria for all the locations and for all the wind speeds.

5.2.4 Comparison between existing approval and modification application predicted levels for associated residences

Table 19 shows the comparison between the predicted noise levels for the associated residences (wind farmer residences) provided in the *Supplementary Noise assessment (2010)* which supported the original development application (Approval) against the predicted noise levels for the modification application (Modification). Predicted noise levels in the Supplementary Noise assessment at each receiver were modelled with wind turbines 21B and 22B in Mode 3 operation and rest of the turbine in Mode 0 operation. Predicted noise levels in the modification application at each receiver were modelled with various modes of operation (15 at Mode 1, 16B at Mode 1, 16C at Mode 1, 19 at Mode 1, 20B at Mode 1, 21B at Mode 2 and 22B at Mode 2).

Also provided below, is a comparison of the predicted noise levels against the World Health Organisation (WHO) Guidelines for Community Noise. The Working Group on Noise from Wind Turbines (Final Report, ETSU for DTI, 1996) recommends the outdoor noise limit of 45dB(A) (after any adjustment for tonality) for landowners having financial involvement in the wind farm.

Table 19 Comparing predicted noise levels at non associated receivers between approval and modification application

Receiver	Application	Predicted $L_{Aeq,10min}$ (dBA) at various hub height wind speeds (m/s)										
		4	5	6	7	8	9	10	11	12	13	14
Hillside	Approval	20	26	31	35	38	40	41	42	42	-	-
	Modification	26	28	32	35	38	40	41	40	40	40	40
Glengyle	Approval	15	21	26	30	33	35	36	37	37	-	-
	Modification	24	25	29	33	36	38	38	38	37	37	37
Rosehill B	Approval	8	15	20	23	26	28	30	30	31	-	-
	Modification	18	20	24	27	30	32	32	32	32	31	31
WHO criteria (Outside bedroom with windows open)		45	45	45	45	45	45	45	45	45	45	45

6 Conclusion

This report outlines the carried out environmental noise assessment for the proposed wind turbine modification and a revised layout of the Glen Innes Wind Farm to be located in northern NSW. Previously an *Environmental Noise Impact Assessment* and *Supplementary noise assessment* were carried out in 2008 and 2010 respectively.

The proponent has selected a specific Wind Turbine model to be installed on-site and proposed small changes to the array layout compared to the previous assessments. The array comprises of 25 wind turbines with a hub height of 89 m. An update of the regression analysis to determine the applicable noise criteria has been carried out based on original background noise and wind data due to the changes of the hub height and specification of the Wind Turbine model. The requirements of the *Draft NSW Planning Guidelines: Wind Farms* were also taken into account which included development of specific day and night time criteria along with assessment of specific noise characteristics.

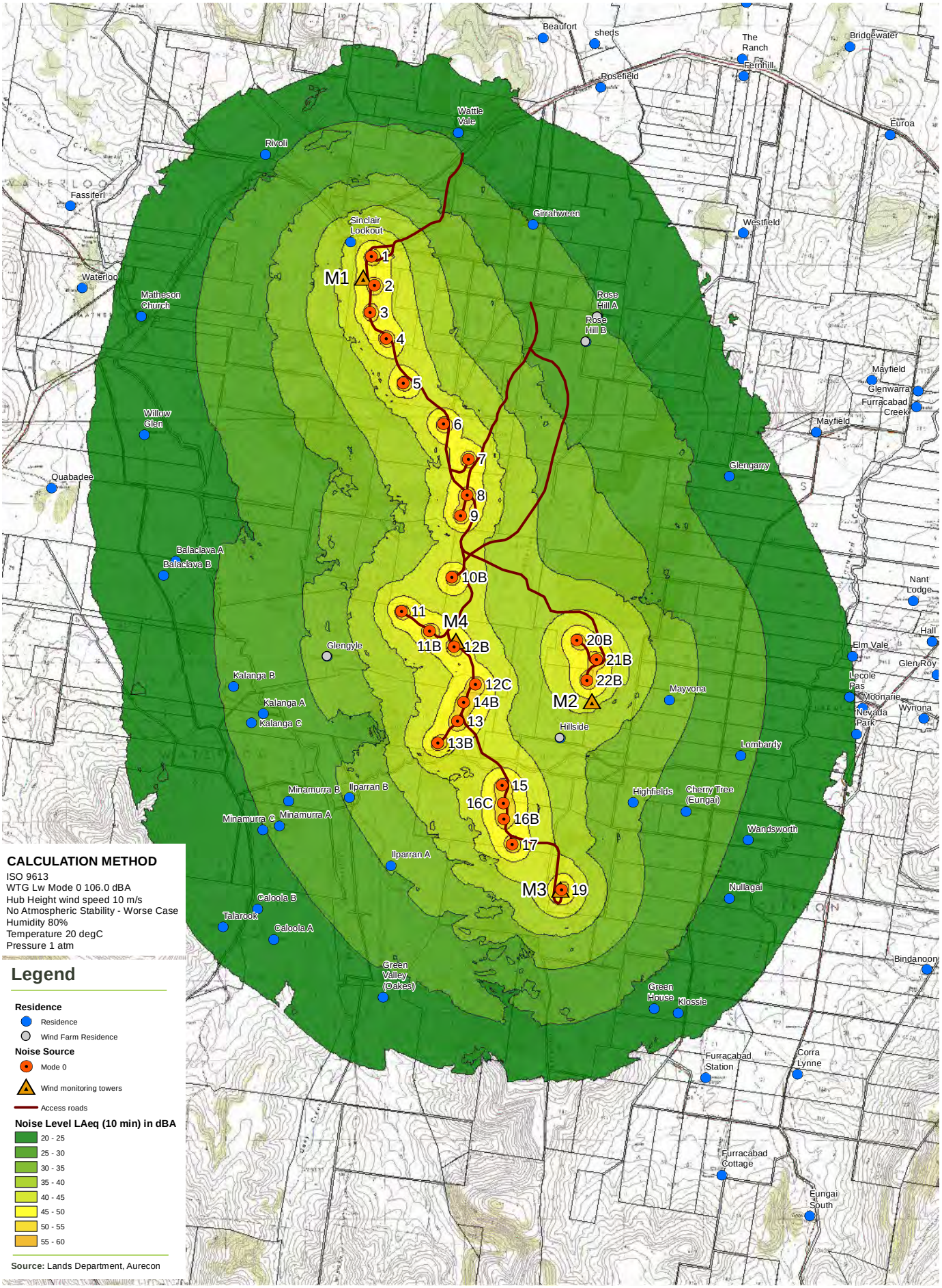
Two sets of noise predictions have been carried out for this report implementing the changes to the turbine array and hub height. One set was carried out implementing ISO 9613 input conditions into to the noise model algorithm as per the original environmental noise assessment as well as a more conservative set of modelling inputs as developed in the UK in 2009. It has been shown that based on the original ISO 9613 noise model results that the wind farm can be operated to achieve compliance at all non wind farmer receiver locations for overall noise criteria as well as day and night specific criteria. Noise predictions using the updated conservative modelling inputs showed exceedances of the applicable overall noise criteria at two non wind farmer locations. Exceedances were predicted at the same two non wind farmer locations when assessed against night time noise criteria.

An operational strategy was developed utilising lower noise operating modes of some turbines to show compliance with the overall noise criteria at all locations as well as an operational strategy to satisfy the night time noise criteria. Table 18 demonstrates that the noise impact for the modification application for a few of the non-associated residences have decreased for specific wind speeds while a few have increased in comparison with the approval application. Although there has been an increase/decrease in noise level for few wind speeds, the noise impacts are below the stipulated overall noise criteria for all the locations and for all the wind speeds. It should be noted that the implementation of the lower noise operating modes using real-time wind and stability data would only be required during conditions that are favourable for noise propagation towards the sensitive receivers such as downwind or during the occurrence of stable atmospheric conditions

Overall the predicted noise impacts are lower than those in the *Supplementary noise assessment* due to the specification of a lower noise wind turbine.

Nevertheless, due to the approximation in model predictions, compliance testing will need to be undertaken following installation of the wind farm and if necessary the wind farm operation adjusted to satisfy compliance with applicable noise criteria.

Appendix A
Predicted noise contours



CALCULATION METHOD

ISO 9613
WTG Lw Mode 0 106.0 dBA
Hub Height wind speed 10 m/s
No Atmospheric Stability - Worse Case
Humidity 80%
Temperature 20 degC
Pressure 1 atm

Legend

Residence
- Residence
- Wind Farm Residence

Noise Source
- Mode 0
- Wind monitoring towers
- Access roads

Noise Level LAeq (10 min) in dBA
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60

Source: Lands Department, Aurecon

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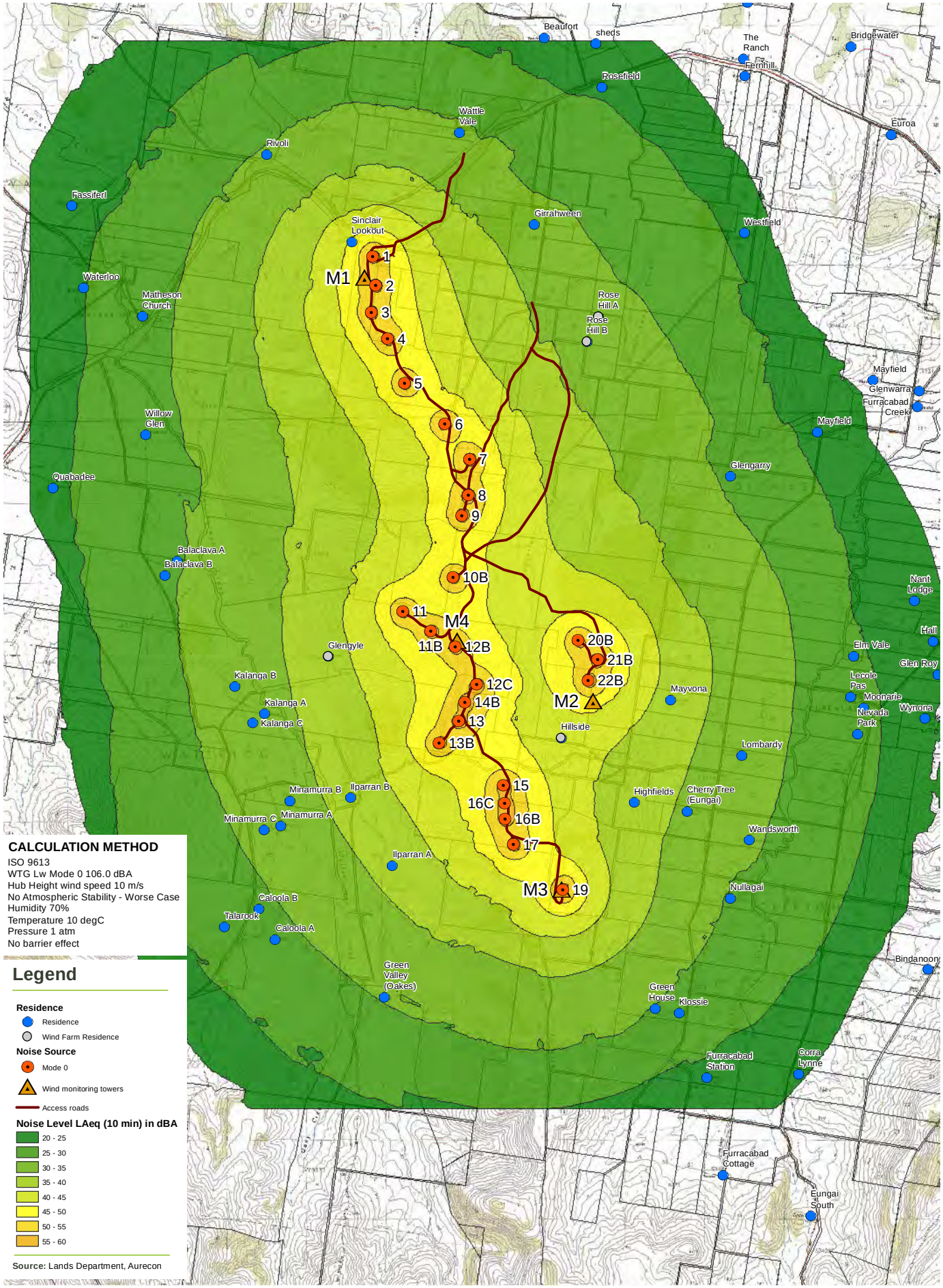
SCALE 1:65,000 @ A4

0 0.5 1 Kilometres

Projection: MGA

Glen Innes Wind Farm

FIGURE A1: Noise Assessment - Mode 0



CALCULATION METHOD

ISO 9613
WTG Lw Mode 0 106.0 dBA
Hub Height wind speed 10 m/s
No Atmospheric Stability - Worse Case
Humidity 70%
Temperature 10 degC
Pressure 1 atm
No barrier effect

Legend

Residence
- Residence
- Wind Farm Residence

Noise Source
- Mode 0
- Wind monitoring towers
- Access roads

Noise Level LAeq (10 min) in dBA
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60

Source: Lands Department, Aurecon

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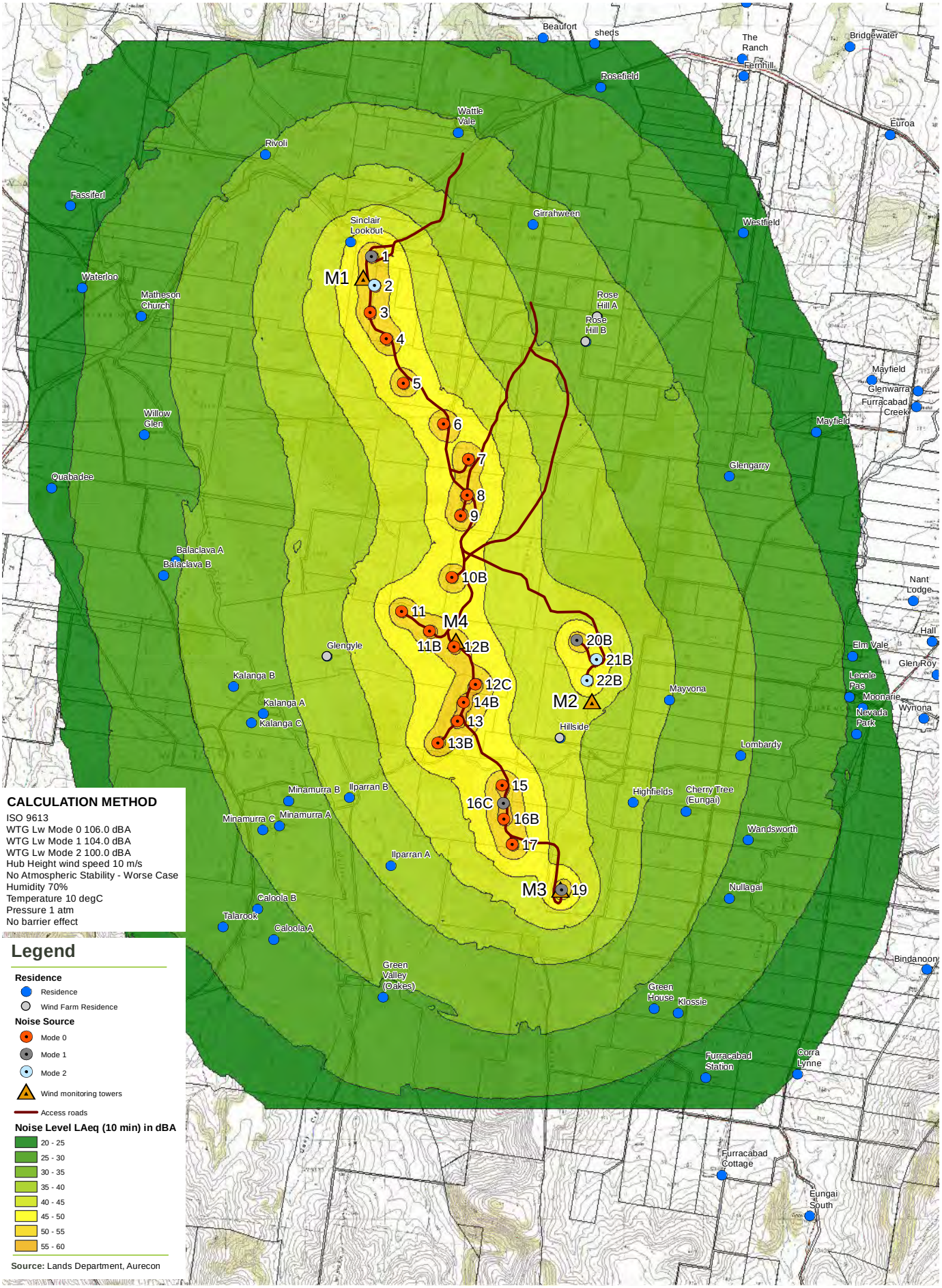
SCALE 1:65,000 @ A4

0 0.5 1 Kilometres

Projection: MGA

Glen Innes Wind Farm

FIGURE A2: Noise Assessment - updated input conditions



CALCULATION METHOD

ISO 9613
WTG Lw Mode 0 106.0 dBA
WTG Lw Mode 1 104.0 dBA
WTG Lw Mode 2 100.0 dBA
Hub Height wind speed 10 m/s
No Atmospheric Stability - Worse Case
Humidity 70%
Temperature 10 degC
Pressure 1 atm
No barrier effect

Legend

Residence
- Residence
- Wind Farm Residence

Noise Source
- Mode 0
- Mode 1
- Mode 2
- Wind monitoring towers
- Access roads

Noise Level LAeq (10 min) in dBA
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60

Source: Lands Department, Aurecon

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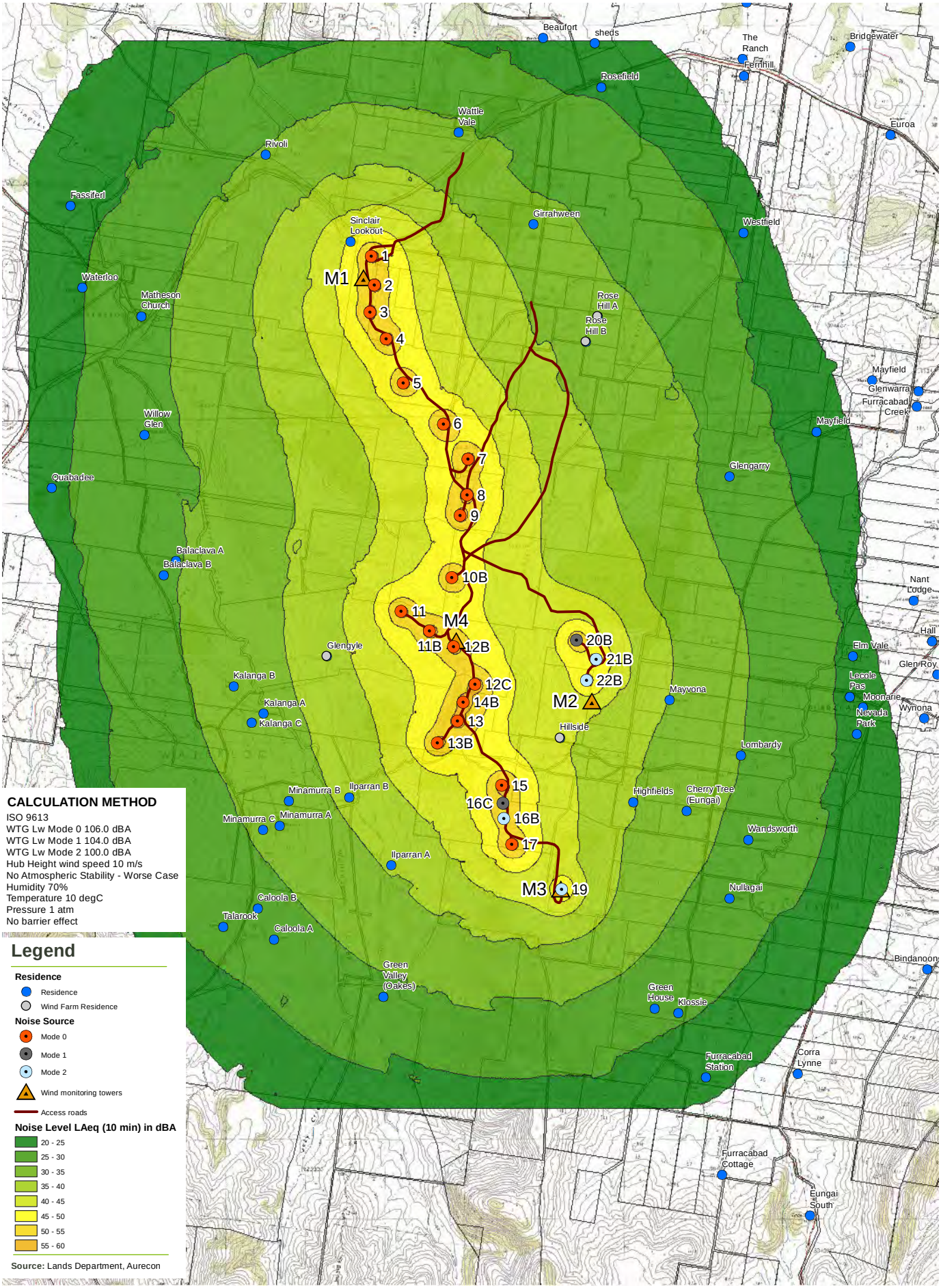
SCALE 1:65,000 @ A4

0 0.5 1 Kilometres

Projection: MGA

Glen Innes Wind Farm

FIGURE A3: Noise Assessment - updated input conditions



CALCULATION METHOD

ISO 9613
WTG Lw Mode 0 106.0 dBA
WTG Lw Mode 1 104.0 dBA
WTG Lw Mode 2 100.0 dBA
Hub Height wind speed 10 m/s
No Atmospheric Stability - Worse Case
Humidity 70%
Temperature 10 degC
Pressure 1 atm
No barrier effect

Legend

Residence
- Residence
- Wind Farm Residence

Noise Source
- Mode 0
- Mode 1
- Mode 2
- Wind monitoring towers
- Access roads

Noise Level LAeq (10 min) in dBA
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60

Source: Lands Department, Aurecon

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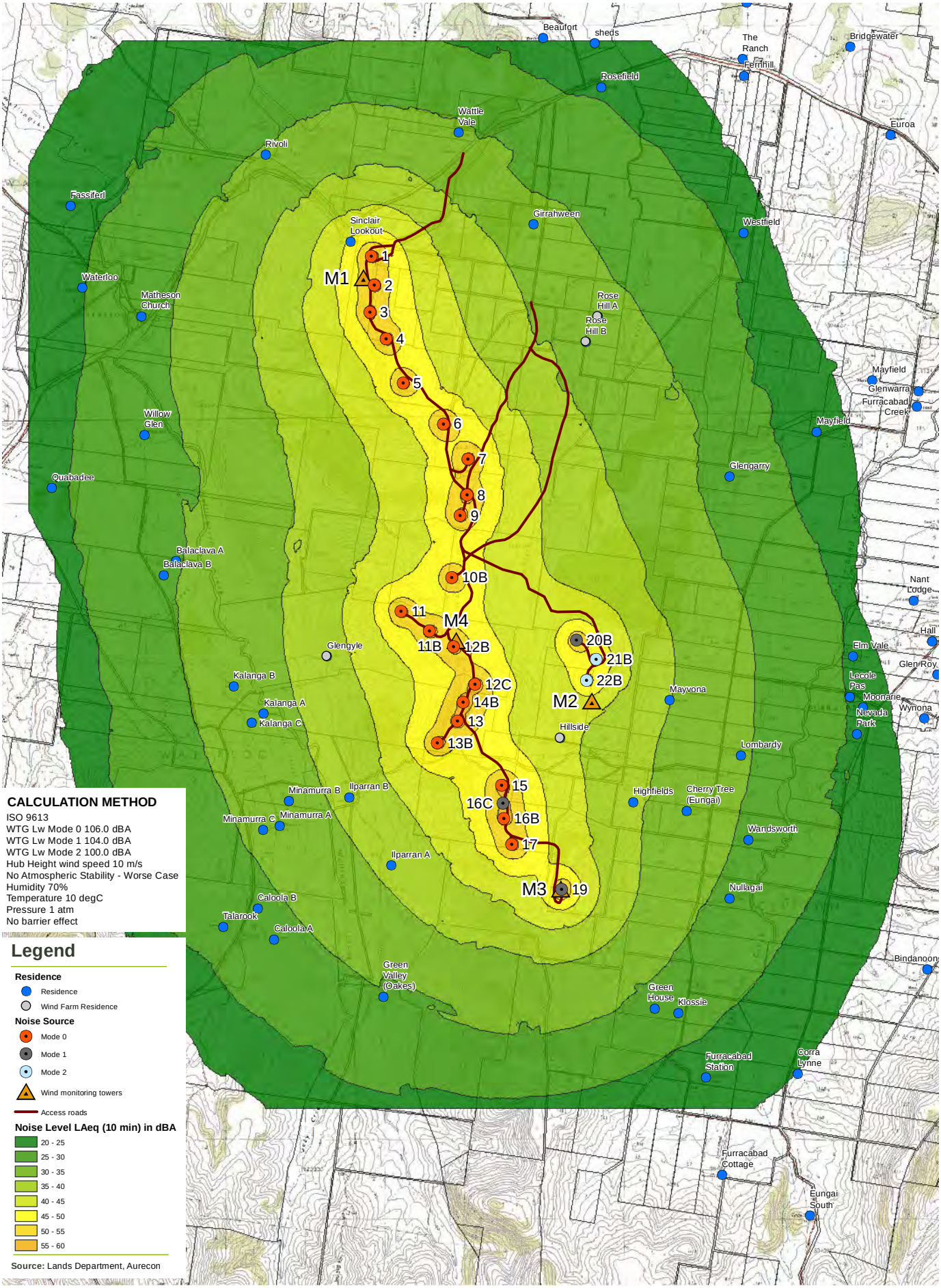
SCALE 1:65,000 @ A4

0 0.5 1Kilometres

Projection: MGA

Glen Innes Wind Farm

FIGURE A4: Night time noise assessment - updated input conditions



CALCULATION METHOD

ISO 9613
WTG Lw Mode 0 106.0 dBA
WTG Lw Mode 1 104.0 dBA
WTG Lw Mode 2 100.0 dBA
Hub Height wind speed 10 m/s
No Atmospheric Stability - Worse Case
Humidity 70%
Temperature 10 degC
Pressure 1 atm
No barrier effect

Legend

Residence
- Residence
- Wind Farm Residence

Noise Source
- Mode 0
- Mode 1
- Mode 2
- Wind monitoring towers
- Access roads

Noise Level LAeq (10 min) in dBA
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60

Source: Lands Department, Aurecon

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SCALE 1:65,000 @ A4

0 0.5 1Kilometres

Projection: MGA

Glen Innes Wind Farm

FIGURE A3: Overall noise assessment - updated input conditions

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