Macarthur Wind Farm
Noise Compliance Assessment
October to December 2015

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Revision Table

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A	18 January 2016	For Issue
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Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	Units of the A-weighted sound level.
L_{eq}	The energy averaged equivalent noise level over a measurement period.
L_{95}	Noise level exceeded for 95 % of the measurement time as required under NZS 6808:1998. The L_{95} is used to assess wind farm noise, as it is less likely to be adversely affected by extraneous noise than other noise descriptors.
Sound power level (L_W)	The total sound energy emitted by a source, expressed in dB and referenced to a level of 10^{-12} W.

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1 Introduction

This report presents the results of a noise compliance assessment conducted for the Macarthur Wind Farm based on measurements conducted at seven locations around the site between October and December 2015. The compliance assessment has been conducted to measure and assess the noise levels from the wind farm in relation to the requirements of the Macarthur Wind Farm Planning Permit (PL-SP/05/0283, amended 7 April 2011) and New Zealand Standard NZS 6808:1998 *Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators* (NZS 6808:1998).

The Planning Permit requires compliance with the noise criteria to be demonstrated through two rounds of noise monitoring conducted 10 to 12 months after the first. Two rounds of compliance monitoring had been previously conducted by AECOM Australia in February and March 2013 and in January and February 2014. Both of these assessments deemed the Macarthur Wind Farm compliant with the requirements of the Planning Permit.

Due to concerns around the number of monitoring locations used for these earlier compliance monitoring assessments, which was a result of the refusal of some property owners to allow monitoring on their property, it was agreed that an additional round of compliance monitoring would be undertaken, and alternative locations selected for relevant monitoring locations where permission to carry out monitoring was not obtained.

This report presents the results of compliance monitoring and a wind farm noise assessment for seven locations around the Macarthur Wind Farm, based on monitoring conducted between 22 October and 21 December 2015.

2 Site description

The Macarthur Wind Farm is located approximately 16 km east of Macarthur in southwest Victoria. The wind farm is located on three properties that are predominantly used for sheep and cattle grazing, and covers an area of approximately 5500 hectares. The land around the wind farm is generally flat open grassland, with only minor undulations and changes in height.

The wind farm is comprised of 140 Vestas V112 3MW wind turbine generators (WTGs) spread in a grid-like manner across the site. To provide meteorological data for the wind farm operations, six meteorological masts are installed around the site. The locations of the WTGs and the masts are shown on Figure 1 on the following page.

The Vestas V112 3MW WTGs have a hub height of 84 m and a rotor diameter of 112 m. They cut-in when the wind speed at the hub exceeds 3 m/s and cut-out if the wind speed at the hub exceeds 25 m/s. The WTGs reach their maximum sound power level (noise output) when the hub height wind speed at the WTG reaches 10 m/s. Relevant details of the WTGs installed at the site, including sound power information, is provided in Appendix A. The WTGs installed at Macarthur Wind Farm operate in Noise Mode 0, which is a full power mode of operation.

The Macarthur Wind Farm has approximately 30 residential dwellings neighbouring it that have a predicted wind farm noise level of 35 dB(A) or greater for a hub height wind speed of 10 m/s, including host landowner properties. To provide a representative sample of measurement locations around the site, compliance monitoring has been undertaken at the locations summarised in Table 1.

Table 1 Compliance monitoring locations

Location ID	Address
P22A	221 Eastwoods Road, Macarthur, VIC 3286
Q15A alternative location[1]	Grazing land on the western side of Eckersleys Road, approximately 650 m southwest of Q15A, which is located at 457 Eckersleys Road, Gerrigerrup, VIC 3289
R26B	1045 Kangertong Road, Hawkesdale, VIC 3287
V16A	926 Gerrigerrup Minhamite Road, Gerrigerrup, VIC 3289
W26A	568 Kangertong Road, Hawkesdale, VIC
X21A alternative location[1]	Grazing land on the northern side of Greens Lane, approximately 400 m west-northwest of X21A, which is located at 2123 Greens Lane, Hawkesdale, VIC 3287
Y21A	2295 Greens Lane, Hawkesdale, VIC 3287

(1) Permission was not granted by the property owners to carry out compliance noise monitoring at Q15A or X21A and therefore compliance noise monitoring was carried out at an alternative representative site for each of these residences.

The compliance monitoring locations are shown in relation to the wind farm site on Figure 1.

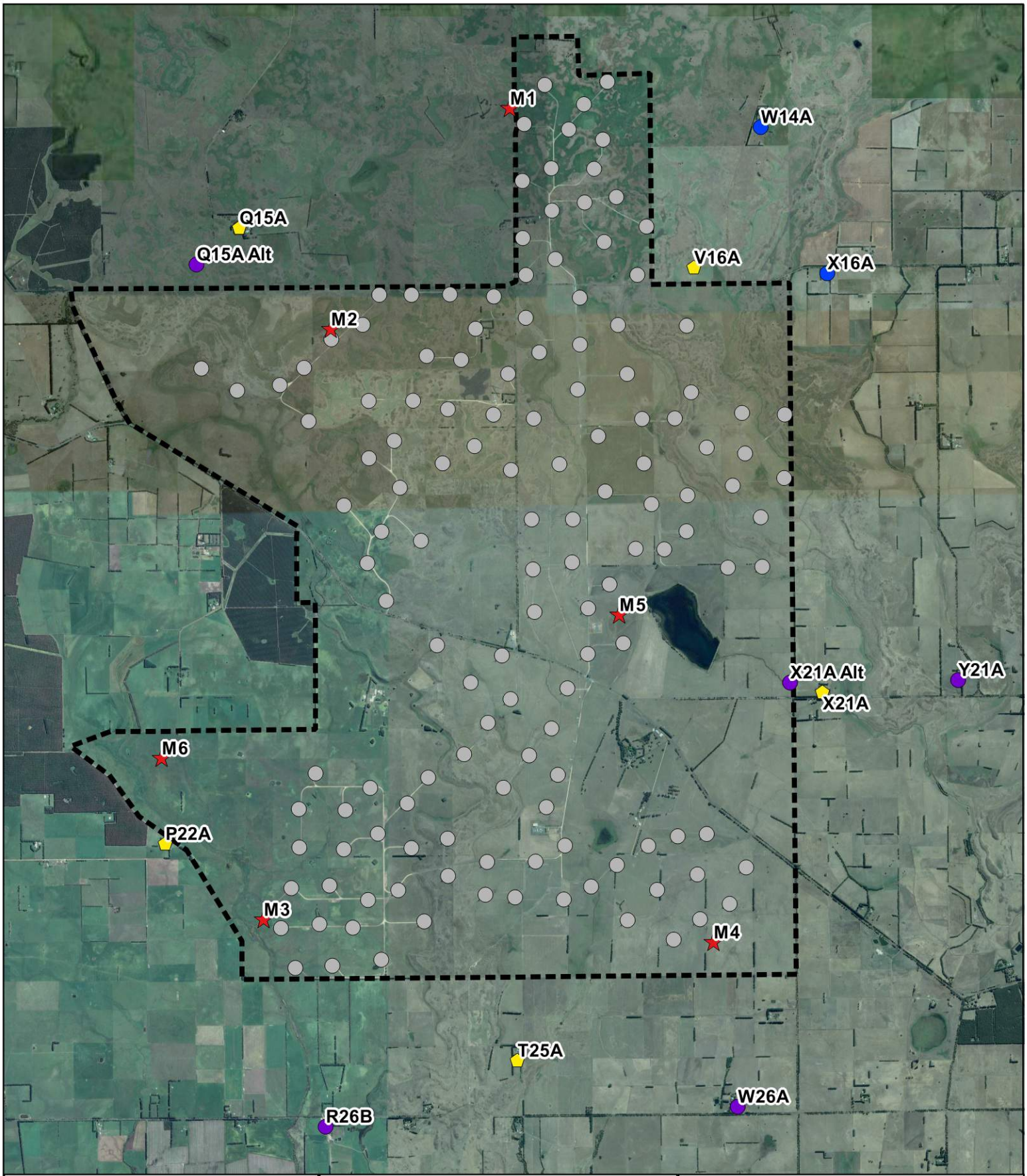

FIGURE 1: Macarthur Wind Farm Site Map

Legend

- WTG
- Meteorological Mast
- Wind Farm Boundary
- Reference Location
- Additional Monitoring Location
- Other Residential Location

0 1000 2000 3000 m

Datum WGS 84, Projection UTM ZONE 54S

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3 Noise assessment criteria

3.1 Planning Permit PL-SP/05/0283

The relevant noise assessment criteria for the Macarthur Wind Farm have been determined based on the Planning Permit issued for the site (PL-SP/05/0283, amended 7 April 2011). Conditions 16 to 33 of the Planning Permit define the noise-related requirements for the operation of the Wind Farm, and these conditions are included in Appendix B of this report.

Condition 16 of the Planning Permit requires that:

> The operation of the wind energy facility must comply with the New Zealand Standard 'Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators' (NZS 6808:1998) (the 'Standard'), at any dwelling existing in the vicinity of the wind energy facility as at 7 February 2006. In determining compliance with the Standard, the following shall apply:
>
> a) The sound level from the operating wind energy facility, measured outdoors within 10 metres of a dwelling at any relevant nominated wind speed, shall not exceed the background level (L95) by more than 5 dBA or a level of 40 dBA L95, whichever is the greater. This 'background sound level' shall be determined by the method specified in NZS 6808:1998. Compliance shall be determined separately for all time data and for night time data. Night time is defined as 10pm to 7am.
>
> b) If [the] sound has a special audible characteristic the measured sound level of the source shall have a 5 dB penalty applied. The EMP must provide detail on how special audible characteristics are to be determined and the penalty is to be applied.

Condition 22 of the Planning Permit requires that post-construction noise compliance monitoring be carried out at the six reference locations where background noise levels were originally measured prior to the Planning Permit Application. The Condition notes that monitoring can only be carried out subject to the approval of the property owners for each reference location. The six reference locations are detailed in Table 2, with their locations shown on Figure 1.

Table 2 Reference locations

Location ID	Address
P22A	221 Eastwoods Road, Macarthur, VIC 3286
Q15A	457 Eckersleys Road, Gerrigerrup, VIC 3289
T20A	1743 Macarthur Hawkesdale Road, Macarthur, VIC 3286
T25A	842 Kangertong Road, Hawkesdale, VIC 3287
V16A	926 Gerrigerrup Minhamite Road, Gerrigerrup, VIC 3289
X21A	2123 Greens Lane, Hawkesdale, VIC 3287

With regards to the six reference locations, it is noted that:

- The dwelling at T20A no longer exists and the land is understood to be subject to a restrictive covenant preventing development or construction of any dwelling in the future. The change in status of this particular land has been brought about through a change in ownership from Sharp to Officer (wind farm host landowner) since the Planning Permit was issued for Macarthur Wind Farm. Therefore, no noise compliance monitoring has been undertaken at T20A.
- The dwelling at V16A has been decommissioned and the land is understood to be subject to a restrictive covenant preventing development or construction of any dwelling in the future. The change in status of this particular land has been brought about through a change in ownership from McKenry to Robertson (wind farm host landowner) since the Planning Permit was issued for Macarthur Wind Farm. Despite this, noise measurements have been conducted at this location as part of this compliance noise assessment, with the measurement results presented for information only.

In addition to the above, the property owners of Q15A, T25A and X21A did not provide permission for compliance noise monitoring to be conducted at their properties and therefore compliance noise monitoring was not able to be conducted at these three reference locations. Instead, alternative and representative locations were identified and agreed with Moyne Shire Council prior to this round of noise monitoring, as detailed in Table 3. These alternative locations are shown on Figure 1.

Table 3 Alternative locations where permission was not obtained from landowners

Location ID	Alternative location
Q15A	An alternative location was selected on the grazing land located on the opposite (western) side of Eckersleys Road. The alternative location is approximately 650 m southwest of the dwelling at Q15A and in a similar direction from the wind farm. The predicted wind farm noise level at the alternative location is identical to that at Q15A such that it is considered a representative location for noise monitoring.
T25A	T25A is located to the south of Macarthur Wind Farm and therefore two alternative locations, where background noise monitoring had previously been undertaken, were selected to the south of the site. These locations are R26B and W26A. T25A is approximately 1.9 km from the nearest WTG, as is R26B. W26A is approximately 2.1 km from the nearest WTG. The predicted wind farm noise level at T25A is 2 to 3 dB higher than that predicted at R26B and W26A, however, in the absence of permission from the property owner of T25A, these locations were considered appropriate alternatives as they are representative of the next nearest residences to the wind farm to the south.
X21A	X21A is located to the east of Macarthur Wind Farm, approximately 1.6 km from the nearest WTG. Initially, monitoring was conducted at Y21A, which is a residence further to the east of the wind farm and approximately 2.6 km from the nearest WTG as this was the nearest residence to the east for which permission to monitor could be obtained. As Y21A was significantly further from the wind farm than X21A, however, an alternative location was setup later during the monitoring period on grazing land approximately 400 m west-northwest of the dwelling at X21A. This location was 1.4 km from the nearest WTG with a predicted wind farm noise level that is 1 dB higher than that at X21A, and is therefore considered a conservative alternative site.

3.2 Specific noise criteria for measurement locations

In accordance with NZS 6808:1998, background noise levels measured prior to operation of the wind farm have been used to determine noise criteria for each of the compliance monitoring sites.

Background noise levels were originally measured for the purpose of determining site-specific noise criteria at each of the Planning Permit reference locations by Hayes McKenzie[1] in December 2004. In considering the background noise monitoring and resultant criteria determined by Hayes McKenzie, the Planning Panel Report for the Macarthur Wind Farm (May 2006) identified two shortcomings with the noise data:

- The Panel deemed that the data gathered at T20A was unreliable and that additional monitoring should be conducted at this location. This recommendation is no longer relevant as the dwelling at T20A no longer exists and the land is understood to be subject to a restrictive covenant preventing development or construction of any dwelling in the future.
- The Panel noted that the original background noise levels determined by Hayes McKenzie had been referenced to wind speeds measured by a single meteorological mast, with an anemometer installed at a height of 80 m. As only a single mast was used, which may not be representative of wind speeds across the entire site, it was recommended that a correlation be performed to relate the wind speeds measured during the Hayes McKenzie monitoring to the locations and heights of the anemometers of the permanent meteorological masts that were to be installed at Macarthur Wind Farm.

Considering the above Planning Panel Report recommendations and a desire to establish noise criteria for locations in addition to the six reference locations, a decision was made to complete updated background noise measurements at 25 locations around the site, with wind speeds referenced to the six permanent meteorological masts. These background noise measurements were performed by AECOM Australia during the period from August 2010 to January 2011 and the results and measurement process are documented in the *Macarthur Wind Farm Background Noise Monitoring* report.[2] With regards to the locations assessed in this report, these measurements defined criteria for P22A, Q15A, R26B and X21A.

The background noise measurements in 2010 and 2011 did not include the dwellings at W26A and Y21A. Limited background noise data is available for these two sites based on pre-wind farm commissioning measurements undertaken at the two locations

For each site, specific wind farm noise criteria have been determined based on the measured background noise levels in accordance with NZS 6808:1998. The wind farm noise criteria for each location for all time data (i.e. day and night periods combined) are shown in Table 4 and the criteria for night time (10 pm to 7 am) data are shown in Table 5.

Note that no criteria are shown for V16A as the dwelling has been decommissioned and the land is understood to be subject to a restrictive covenant preventing development or construction of any dwelling in the future.

[1] Hayes McKenzie APW, *Macarthur Wind Farm – Noise Impact Assessment*, Report No. 03.545-01 Final, dated May 2005.

[2] AECOM Australia, *Macarthur Wind Farm – Background Noise Monitoring*, Report No. 60157134-A11C01RP-03, dated 26 April 2013.

Table 4 Wind farm noise criteria for all time data

Hub height wind speed	Wind farm noise criteria in dB(A) for all time data					
m/s	P22A	Q15A	R26B	W26A	X21A	Y21A
0	40	40	40	40	40	40
1	40	40	40	40	40	40
2	40	40	40	40	40	40
3	40	40	40	40	40	40
4	40	40	40	40	40	40
5	40	40	40	40	40	40
6	40	40	40	40	40	40
7	40	40	40	40	40	40
8	40	41	40	40	40	40
9	41	42	41	40	41	40
10	44	43	42	41	42	41
11	46	44	44	43	44	43
12	49	45	45	44	45	44
13	51	46	47	46	47	45
14	53	48	48	47	49	46
15	55	49	50	49	51	48
16	57	51	51	50	53	49
17	–	53	52	52	55	50
18	–	–	54	53	–	51
19	–	–	55	55	–	53
20	–	–	56	56	–	–
21	–	–	58	–	–	–
22	–	–	58	–	–	–
23	–	–	59	–	–	–
24	–	–	60	–	–	–
25	–	–	60	–	–	–

Table 5 Wind farm noise criteria for night time data

Hub height wind speed	Wind farm noise criteria in dB(A) for night time data (10 pm – 7 am)					
m/s	P22A	Q15A	R26B	W26A	X21A	Y21A
0	40	40	40	40	40	40
1	40	40	40	40	40	40
2	40	40	40	40	40	40
3	40	40	40	40	40	40
4	40	40	40	40	40	40
5	40	40	40	40	40	40
6	40	40	40	40	40	40
7	40	40	40	40	40	40
8	40	40	40	40	40	40
9	40	40	40	40	40	40
10	40	41	40	40	40	40
11	42	42	41	40	40	40
12	45	43	43	41	42	40
13	48	45	44	43	44	41
14	51	46	46	45	46	42
15	54	47	47	47	47	43
16	57	48	48	49	49	44
17	–	49	49	–	50	–
18	–	–	50	–	–	–
19	–	–	50	–	–	–
20	–	–	–	–	–	–
21	–	–	–	–	–	–
22	–	–	–	–	–	–
23	–	–	–	–	–	–
24	–	–	–	–	–	–
25	–	–	–	–	–	–

4 Monitoring procedure

4.1 Monitoring dates and positions

At each of the seven monitoring locations, a noise logger was installed at an appropriate location to continuously measure A-weighted noise levels in 10-minute intervals.

Table 6 summarises the dates for which continuous monitoring was undertaken for each location and the position of the noise monitor at each location. The approximate distance to the dwelling and the nearest WTG are also presented. Photographs of each monitoring location are shown in Appendix C.

It is noted that, with the exception of P22A, it was not possible to position the monitors within 10 m of the dwelling as required by Condition 16. This was because:

- It was not possible to find an appropriate location within 10 m of the house that had a clear view of the wind farm, was away from extraneous noise sources and significant vegetation, and was in a position that did not inconvenience the residents.
- It was desirable to maintain the same locations at which pre-operation background noise monitoring was conducted at locations R26B, W26A and Y21A.
- Permission was not obtained for monitoring on the land of Q15A and X21A. The alternative monitoring positions for these locations were established on neighbouring land.

In all cases, the monitor was positioned at a site either closer to or the same distance from the wind farm and therefore are considered appropriate representative locations.

All monitoring positions were also at least 5 m away from vertical reflecting surfaces in accordance with NZS 6808:1998, with the microphone installed at a height of approximately 1.5 m above ground level.

Table 6 Compliance monitoring periods and positions

Location ID	Monitoring period	Coordinates of logger UTM WGS84 Zone 54S		Approximate distance to		Monitoring position notes
		Easting	Northing	Dwelling	Nearest WTG	
P22A	2:50 pm on 22 October to 10:10 am on 11 December	599499	5786224	8 m	1.5 km	Positioned on the wind farm side of the residence at the same place that both previous background noise monitoring was undertaken and that previous rounds of compliance monitoring was undertaken.
Q15A alternative location	4:50 pm on 22 October to 9:30 am on 11 December	599950	5793010	660 m (to Q15A)	1.2 km	Positioned in open grazing land with no significant surrounding vegetation (e.g. no trees or bushes). Position selected such that predicted wind farm noise level at the measurement position was the same as that at the dwelling of Q15A.
R26B	12:10 am on 23 October to 10:40 am on 11 December	601343	5782890	24 m	1.9 km	Positioned on the side of driveway to the northwest of the residence. The wind farm noise levels at this location are considered representative of those at the dwelling. Monitoring position was consistent with the positioned used during previous background noise monitoring at R26B. Some of the vegetation in the immediate vicinity of the noise logger appeared to have grown since the previous background noise monitoring.

Location ID	Monitoring period	Coordinates of logger UTM WGS84 Zone 54S		Approximate distance to		Monitoring position notes
		Easting	Northing	Dwelling	Nearest WTG	
V16A	11:10 am on 23 October to 9:00 am on 11 December	605805	5792902	24 m	0.7 km	Positioned to the south of the now-decommissioned residence in the same location as the previous post-construction monitoring conducted at V16A. The wind farm noise levels at this location are considered representative of the noise level at the decommissioned residence.
W26A	7:50 pm on 22 October to 11:00 am on 11 December	606189	5783062	27 m	2.1 km	Positioned to the east of the residence off of the driveway and away from the vegetation around the house. The wind farm noise levels at this location are considered representative of the noise level at the residence. The location was not consistent with the previous background noise monitoring position as the exact location of the background noise monitor could not be identified.
X21A alternative location	12:10 pm on 3 December to 10:20 am on 21 December	606869	5788022	400 m (to X21A)	1.4 km	Positioned in open grazing land, approximately 400 m west of the dwelling at X21A. No significant vegetation in the immediate vicinity although a creek was located approximately 25 m to the north. Position was selected such that predicted wind farm noise level at the measurement position was higher than that at X21A, with the noise level predicted to be 1.1 dB higher at the measurement location than at the dwelling.

Location ID	Monitoring period	Coordinates of logger UTM WGS84 Zone 54S		Approximate distance to		Monitoring position notes
		Easting	Northing	Dwelling	Nearest WTG	
Y21A	7:00 pm on 22 October to 10:40 am on 21 December	608846	5788025	29 m	2.6 km	Positioned to the southwest of the residence in the clearing. The wind farm noise levels at this location are considered representative of the noise level at the residence. The location of the previous background noise monitoring position was not known, and the noise logger was only able to be placed in the general vicinity of the previous monitoring as indicated by the property owners. Significant vegetation surrounded the monitoring location and was noted to be the dominant source of noise during all visits to the site.

4.2 Equipment

Table 7 summarises the noise monitoring equipment used at each location as well as the sound level calibrator used to perform field calibration checks at the commencement of the monitoring and during every subsequent visit to the monitoring locations. In accordance with Planning Permit Condition 23, all equipment carries a current calibration certificate from a National Association of Testing Authorities (NATA) accredited laboratory, with the certificates included in Appendix D.

Table 7 Noise monitoring equipment

Location	Equipment type	Serial number	Date of last laboratory calibration[1]
P22A	Rion NL-42 sound level meter	946982	17 December 2014
Q15A alternative location	Rion NL-42 sound level meter	245575	7 August 2014
R26B	Rion NL-42 sound level meter	946979	17 December 2014
V16A	Rion NL-42 sound level meter	946978	17 December 2014
W26A	Rion NL-21 sound level meter	888253	24 November 2014
X21A alternative location	Rion NL-22 sound level meter	862918	22 September 2015
Y21A	Rion NL-18 sound level meter (from 22 October to 12 November) Rion NL-22 sound level meter (after 12 November)	460076 862934	8 January 2014 7 August 2014
–	Brüel & Kjær 4231 sound calibrator	2389129	13 April 2015

(1) In accordance with NATA guidelines, laboratory calibration of sound level meters is performed every two years and laboratory calibration of sound level calibrators is performed annually.

All sound level meters used were Class 2 instruments, suitable for wind farm noise monitoring in accordance with NZS 6808:1998. The calibration of the instruments was field checked at the commencement of the monitoring and during every subsequent visit, and no significant drift in calibration (i.e. equal to or greater than 0.5 dB) was observed.

The microphones were positioned at a height of approximately 1.5 m above ground level and fitted with 90 mm diameter windshields to reduce wind-induced noise on the microphone.

4.3 Wind data

Wind speed and direction data for the Macarthur Wind Farm was provided by Vestas in 10-minute intervals for each of the six meteorological masts at the site. The coordinates of the masts are presented in Table 8 and the locations are shown on Figure 1.

Table 8 Meteorological mast locations

Mast	Coordinates of mast UTM WGS84 Zone 54S		Lead mast for
	Easting	Northing	
M1	603659	5794791	Q15A, V16A
M2	601520	5792228	–
M3	600644	5785321	–
M4	605928	5784988	R26B, W26A, X21A, Y21A
M5	604870	5788838	–
M6	599468	5787226	P22A

Note that, based on the locations at which measurements have been undertaken within this report, wind speed and direction data from M2 and M5 was not used as it was not relevant.

Wind direction data

Wind direction data was taken from the wind direction sensor at a height of 82 m above ground at each meteorological mast. The wind direction data for each monitoring location was taken from the lead mast for that particular location, as shown in Table 8. The lead mast is typically the nearest mast to the location, which provides an accurate indication of wind direction in that area.

Note that, throughout this report, the wind direction represents the direction that the wind is blowing from, with 0º corresponding to a northerly wind, 90º corresponding to an easterly wind and so on.

Wind speed data

Each meteorological mast has two wind speed sensors (Cup 1A and Cup 1B) at 84 m above ground, corresponding to the hub height of the WTGs. Depending on the wind direction, one of the hub height wind speed sensors will potentially be wake-affected by the mast itself and therefore the wind speed data for each mast for each 10-minute period will depend on the wind direction. Table 9 presents the applicable wind direction range for each cup on each of the relevant masts.

Additionally, because of the layout of the wind farm, there will be certain wind direction ranges for which each meteorological mast will be wake-affected by WTGs as they will be downwind of the wind farm. This has the effect of reducing the wind speed measured at the mast compared to the wake-free wind speed that would have prevailed during the background noise monitoring.

Table 9 Applicable wind direction ranges for wind speed measurement cups on relevant masts

Mast	Wind direction at mast for which cup not wake-affected by mast	
	Cup 1A	Cup 1B
M1	0° ≤ WD < 45° and 225° ≤ WD < 360°	45° ≤ WD < 225°
M3	0° ≤ WD < 60° and 240° ≤ WD < 360°	60° ≤ WD < 240°
M4	60° ≤ WD < 240°	0° ≤ WD < 60° and 240° ≤ WD < 360°
M6	0° ≤ WD < 30° and 210° ≤ WD < 360°	30° ≤ WD < 210°

Section 4.5.4 of NZS 6808:1998 states that:

> For the measurement of background levels, the same location should be used for the measurement of windspeed and direction before and after installation. Care must be taken to ensure the measurement of windspeed and direction is not significantly affected by the WTG(s).

Therefore, in accordance with the requirements of the Planning Permit and NZS 6808:1998, it is necessary to process the analysed wind speed data to obtain a measure of the wake-free wind speed. In order to determine the wake-free wind speed data for the compliance noise monitoring, a procedure was developed by the project's wind consultants, DNV GL (previously Garrad Hassan). Their report is attached as Appendix E.

The processes documented in the DNV GL report includes:

- The procedure used to transform wind speed data collected at the now-demolished development masts (Robertson and Officer) to the six installed permanent meteorological masts. While this procedure has not been used in this report, it was used in the AECOM Background Noise Monitoring Report to reference the measured background noise levels to the six permanent meteorological masts. This ensures consistency between the pre- and post-construction monitoring wind speed measurement positions.
- The procedure used to obtain wake-free wind data when the relevant meteorological mast for a particular residential location is in the wake of the nearby WTGs. This procedure is summarised in Section 4 of the DNV GL report.

The procedure to determine wake-free wind data has been developed based on a comparison of data collected simultaneously at each mast over an extended period of time, prior to the operation of the wind farm, and analysed in 30-degree wind bins to provide suitable accuracy. The wake-free mast that provides the best correlation to the wake-affected mast has been selected for the basis of the correlation.

Procedure to obtain wake-free wind data

For each monitoring location, a lead mast is defined as documented in Table 8. Depending on the wind direction, data is either used from the lead mast or used from another mast that will not be wake-affected by the wind farm, with a correlation factor applied to relate the wind speed between the masts. The procedures recommended by DNV GL for each different lead met mast relevant to this assessment are summarised below.

Lead Meteorological Mast M1

For locations where M1 is the lead mast (Q15A and V16A), the applicable wind direction ranges and meteorological masts are shown in Table 10.

Table 10 Mast selection procedure for lead mast M1

Wind direction (M1)	Meteorological mast used for wind speed data
70° ≤ WD < 218°	M4
0° ≤ WD < 20° and 218° ≤ WD < 360°	M1
20° ≤ WD < 70°	M6

For periods where data from M4 or M6 was used as data collected at M1 was potentially wake-affected, the correlation factors summarised in Table 11 have been used to correct wind speed data from these masts such that it is representative of the wind speed at M1.

Table 11 Wind speed correlation procedures for lead mast M1

Speed data conversion	Wind direction (M1)	Correlation factor applied to wind speed at non-lead mast
M4 to M1	70° ≤ WD < 75°	0.988592
	75° ≤ WD < 105°	1.097402
	105° ≤ WD < 135°	1.076224
	135° ≤ WD < 165°	1.061829
	165° ≤ WD < 195°	1.068266
	195° ≤ WD < 218°	1.000269
M6 to M1	20° ≤ WD < 45°	1.056619
	45° ≤ WD < 70°	1.020335

Lead Meteorological Mast M4

For locations where M4 is the lead mast (R26B, W26A, X21A and Y21A), the applicable wind direction ranges and meteorological masts are shown in Table 12.

Table 12 Mast selection procedure for lead mast M4

Wind direction (M4)	Meteorological mast used for wind speed data
70° ≤ WD < 218°	M4
218° ≤ WD < 340°	M3
340° ≤ WD < 360° & 0° ≤ WD < 70°	M6

For periods where data from M3 or M6 was used as data collected at M4 was potentially wake-affected, the correlation factors summarised in Table 13 have been used to correct wind speed data from these masts such that it is representative of the wind speed at M4.

Table 13 Wind speed correlation procedures for lead mast M4

Speed data conversion	Wind direction (M4)	Correlation factor applied to wind speed at non-lead mast
M3 to M4	218° ≤ WD < 225°	1.056454
	225° ≤ WD < 255°	1.023231
	255° ≤ WD < 285°	1.054981
	285° ≤ WD < 315°	1.085166
	315° ≤ WD < 340°	0.993236
M6 to M4	340° ≤ WD < 345°	1.015667
	345° ≤ WD < 360°	1.064022
	0° ≤ WD < 15°	1.064022
	15° ≤ WD < 45°	0.983088
	45° ≤ WD < 70°	0.999326

Lead Meteorological Mast M6

For the location where M6 is the lead mast (P22A), the applicable wind direction ranges and meteorological masts are shown in Table 14.

Table 14 Mast selection procedure for lead mast M6

Wind direction (M6)	Meteorological mast used for wind speed data
70° ≤ WD < 175°	M4
175° ≤ WD < 360° & 0° ≤ WD < 70°	M6

For periods where data from M4 was used as data collected at M6 was potentially wake-affected, the correlation factors summarised in Table 15 have been used to correct wind speed data from these masts such that it is representative of the wind speed at M6.

Table 15 Wind speed correlation procedures for lead mast M6

Speed data conversion	Wind direction (M6)	Correlation factor applied to wind speed at non-lead mast
M4 to M6	60° ≤ WD < 75°	1.000303
	75° ≤ WD < 105°	1.00651
	105° ≤ WD < 135°	0.97507

Speed data conversion	Wind direction (M6)	Correlation factor applied to wind speed at non-lead mast
M4 to M6	135° ≤ WD < 175°	1.028481
	315° ≤ WD < 340°	0.987351

4.4 WTG runtime data

Runtime data for each of the WTGs at the Macarthur Wind Farm was provided by Vestas in 10-minute intervals for the entire monitoring period. The runtime value for a WTG for a particular 10-minute period represents the number of seconds during that period that the WTG was available to operate if the wind speed was above cut-in. This data was used to identify periods when particular WTGs were not available to operate either due to a fault or scheduled maintenance.

4.5 Rain data

Rain data for the monitoring period was provided by Vestas in 10-minute intervals from the six meteorological masts at the Macarthur Wind Farm site.

5 Data analysis

The raw data collected at each monitoring location is presented with wind speed in Appendix E. This data was analysed in accordance with NZS 6808:1998, and the additional requirements of the Planning Permit, in order to compare the measured wind farm and background noise level to the relevant noise criteria.

5.1 Data exclusion

In certain circumstances, individual 10-minute data points had to be excluded from the analysis.

Firstly, data points were excluded for periods where rain was recorded at one or more of the six meteorological masts due to the potential influence of rain noise on the measured noise level. Over the total monitoring period, 154 10-minute periods were potentially influenced by rain noise.

Secondly, data points were excluded for periods where no data was available for the relevant meteorological mast. On relatively rare occasions, the SCADA system for the wind farm does not record data for each mast and therefore these periods had to be excluded due to a lack of wind speed data. The number of data points excluded due to a lack of data at the mast has been reported separately for each site.

Thirdly, data points were excluded where a sufficient number of WTGs were unavailable for operation at Macarthur Wind Farm for a particular 10-minute period (due to scheduled maintenance or a fault) such that the noise level at the monitoring location would be expected to decrease by 0.5 dB or more relative to a full operation scenario. It is common for a small number of WTGs at Macarthur Wind Farm to be shut down for scheduled maintenance or due to a fault but, due to the relatively large number of WTGs at the site, it is normally unlikely that this would influence noise levels at a receiver location unless multiple nearby WTGs were shut down. Adopting a screening criterion of a decrease of 0.5 dB from full operation, determined based on predicted noise levels at the monitoring location for each 10-minute period, is considered conservative and the remaining data is considered representative of normal operation for nearby dwellings. The number of data points excluded due to WTG shutdowns has been reported separately for each site.

Finally, data was excluded where it had clearly been influenced by extraneous noise. This was generally kept to a minimum as a conservative approach but data was excluded where it clearly influenced the measured noise levels at a site, for example noise from the dawn chorus prior to 7 am influencing the night time noise levels at P22A. Extraneous data was excluded from further analysis where:

- a sudden increase in noise level was not matched by an increase in wind speed or wind farm power output or occurred suddenly at a time where night was changing to day (e.g. the dawn chorus)
- where there was a large (typically > 15 dB) difference between the measured L_{95} noise level and the measured L_{eq} noise level for a particular 10-minute period.

5.2 P22A

Number of data points

Table 16 presents the number of data points available for analysis at P22A for both the all time and night time periods once data had been excluded.

Table 16 Available data points for analysis at P22A

Time period	Situation	Number of data points
All time	Total collected	7173
	Excluded due to lack of met mast data	94
	Excluded due to WTG shutdowns	262
	Excluded due to rain or other extraneous noise	294
	Total available for analysis	**6523**
Night time	Total collected	2700
	Excluded due to lack of met mast data	6
	Excluded due to WTG shutdowns	94
	Excluded due to rain or other extraneous noise	263
	Total available for analysis	**2337**

NZS 6808:1998 requires a minimum of 1440 data points for the all time analysis and it can be seen that this has been significantly exceeded at P22A. The Standard does not specify a minimum requirement for a night time analysis but a minimum of 1440 data points for all time suggests that at least 540 data points would be required for night time analysis. This has also been significantly exceeded at P22A.

Polynomial trendline

Linear and polynomial trendlines were fitted to the P22A data in accordance with NZS 6808:1998 and the coefficients of determination (R^2) for each order of polynomial fit line for both the all time and night time data at P22A are presented in Table 17.

Table 17 Coefficients of determination for each polynomial order – P22A

Time period	Coefficient of determination (R^2)		
	Linear	Second order	Third order
All time	0.5690	**0.5692**	0.5820
Night time	0.6364	0.6418	**0.6575**

The coefficient shown in bold type in Table 17 corresponds to the polynomial order that provided the “best fit” to the measured noise levels, determined as the curve that provided both a good regression coefficient and a sensible match to the data.

P22A analysis results

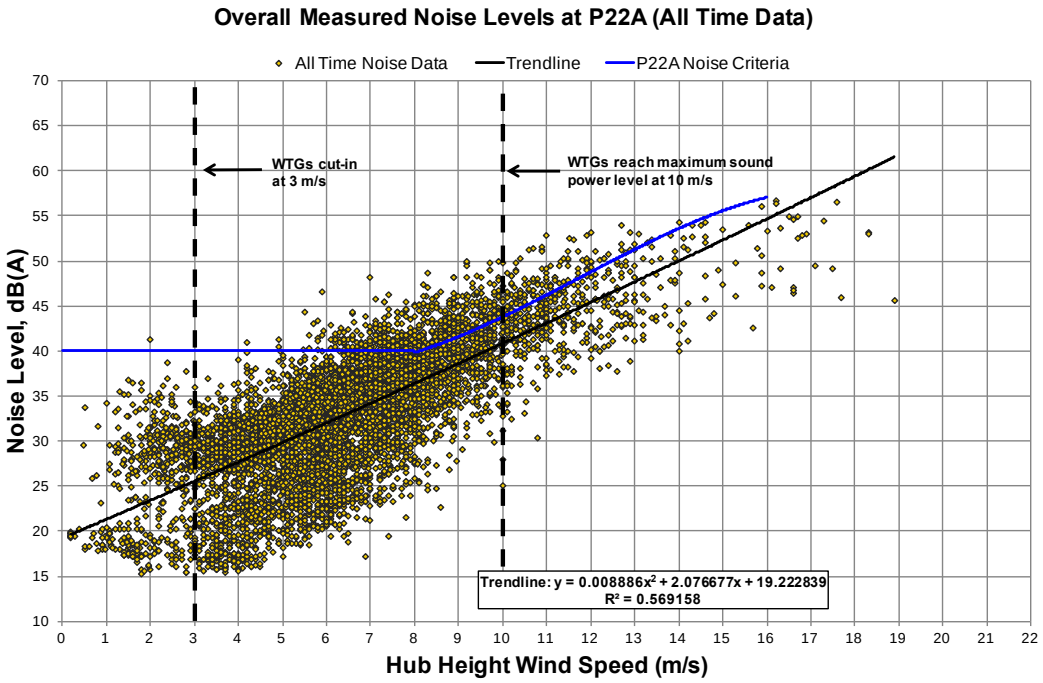

Figure 2 Measured overall noise levels at P22A – all time periods

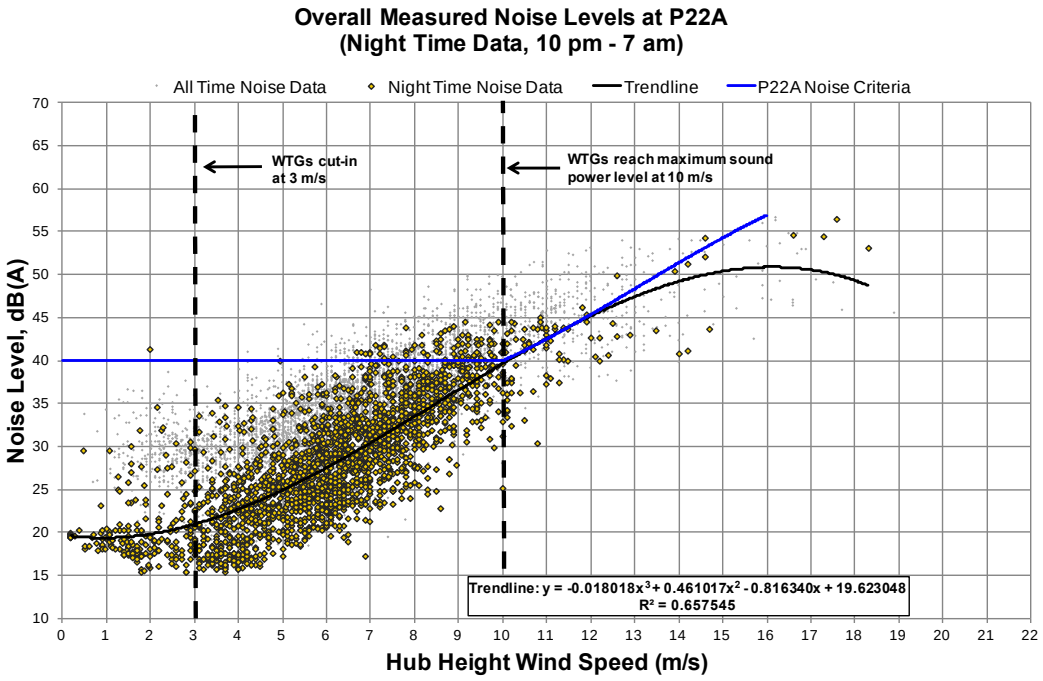

Figure 3 Measured overall noise levels at P22A – night time periods

Table 18 compares the measured overall noise levels (which include both wind farm and background noise) at P22A to the previously determined noise criteria for that location. It can be seen that compliance with the relevant noise criteria is achieved at all wind speeds. While compliance appears marginal for the night time period at wind speeds of 10 to 12 m/s, we note that these are conservative measurements as they include background noise and the actual wind farm noise level would be lower than indicated. During the special audible characteristic tests at P22A, discussed in Section 7, it is noted that background noise due to wind through nearby trees was dominant at P22A during all visits to the site.

Table 18 Measured overall noise levels at P22A

Hub height wind speed	All time periods			Night time period, 10 pm to 7 am		
m/s	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)
0	40	19	✓ 21	40	20	✓ 20
1	40	21	✓ 19	40	19	✓ 21
2	40	23	✓ 17	40	20	✓ 20
3	40	26	✓ 14	40	21	✓ 19
4	40	28	✓ 12	40	23	✓ 17
5	40	30	✓ 10	40	25	✓ 15
6	40	32	✓ 8	40	27	✓ 13
7	40	34	✓ 6	40	30	✓ 10
8	40	36	✓ 4	40	33	✓ 7
9	41	39	✓ 2	40	36	✓ 4
10	44	41	✓ 3	40	40	✓ 0
11	46	43	✓ 3	42	42	✓ 0
12	49	45	✓ 4	45	45	✓ 0
13	51	48	✓ 3	48	47	✓ 1
14	53	50	✓ 3	51	49	✓ 2
15	55	52	✓ 3	54	50	✓ 4
16	57	55	✓ 2	57	51	✓ 6
17	–	57	n/a	–	50	n/a
18	–	59	n/a	–	49	n/a
19	–	62	n/a	–	–	n/a

5.3 Q15A Alternative

Number of data points

Table 19 presents the number of data points available for analysis at the Q15A alternative location for both the all time and night time periods once data had been excluded.

Table 19 Available data points for analysis at the Q15A alternative location

Time period	Situation	Number of data points
All time	Total collected	7155
	Excluded due to lack of met mast data	208
	Excluded due to WTG shutdowns	314
	Excluded due to rain or other extraneous noise	132
	Total available for analysis	**6501**
Night time	Total collected	2700
	Excluded due to lack of met mast data	80
	Excluded due to WTG shutdowns	1
	Excluded due to rain or other extraneous noise	93
	Total available for analysis	**2526**

It can be seen that the NZS 6808:1998 minimum requirement for data points has been significantly exceeded at the Q15A alternative location.

Polynomial trendline

Linear and polynomial trendlines were fitted to the Q15A alternative location data in accordance with NZS 6808:1998 and the coefficients of determination (R^2) for each order of polynomial fit line for both the all time and night time data at the location are presented in Table 20.

Table 20 Coefficients of determination for each polynomial order – Q15A alternative location

Time period	Coefficient of determination (R^2)		
	Linear	Second order	Third order
All time	0.3904	0.3905	**0.3908**
Night time	0.2694	**0.2694**	0.2739

The coefficient shown in bold type in Table 20 corresponds to the polynomial order that provided the “best fit” to the measured noise levels. The “best fit” was determined as the curve that provided both a good regression coefficient and a sensible match to the data.

Q15A alternative location analysis results

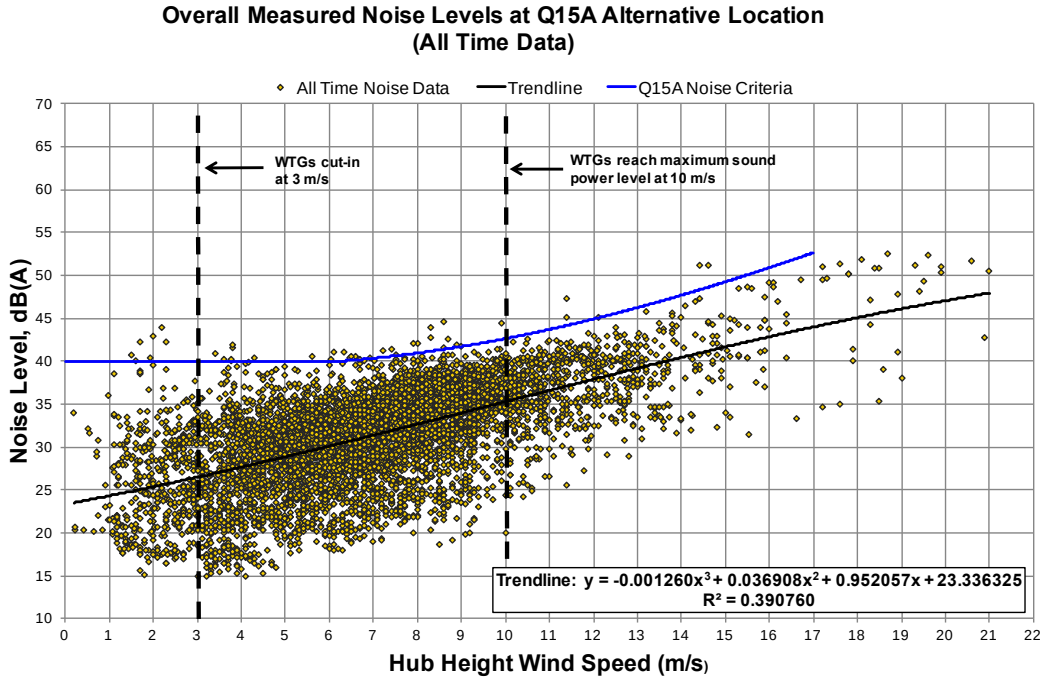

Figure 4 Measured overall noise levels at Q15A alternative location – all time periods

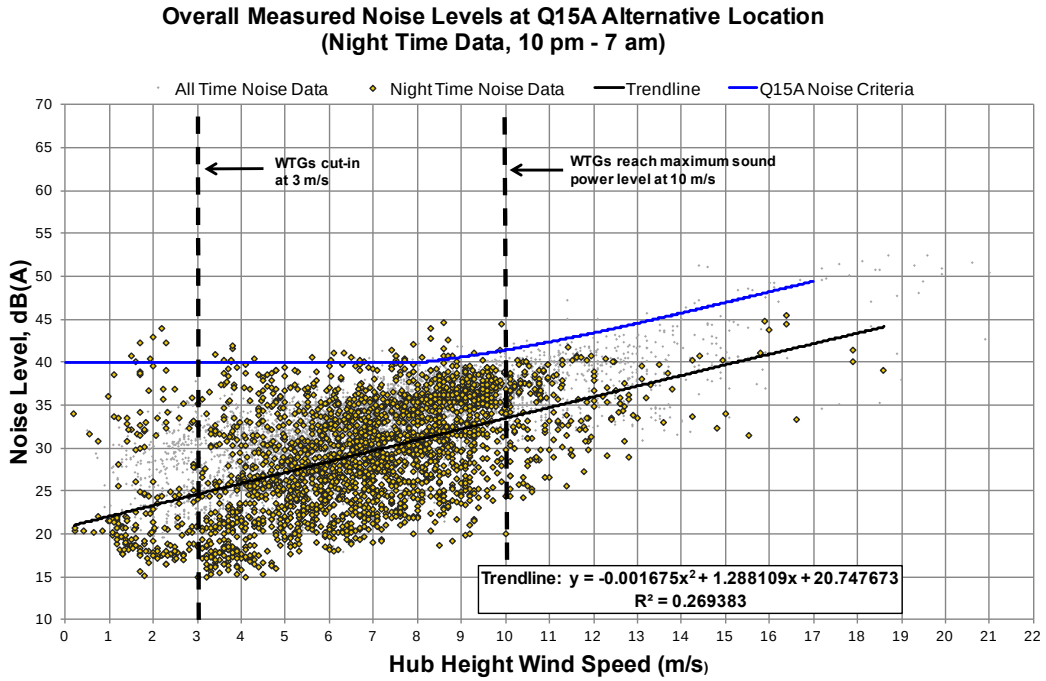

Figure 5 Measured overall noise levels at Q15A alternative location – night time periods

Table 21 compares the measured overall noise levels (which include both wind farm and background noise) at the Q15A alternative location to the previously determined noise criteria for Q15A. It can be seen that compliance with the relevant noise criteria is easily achieved at all wind speeds.

Table 21 Measured overall noise levels at Q15A alternative location

Hub height wind speed	All time periods			Night time period, 10 pm to 7 am		
m/s	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)
0	40	23	✓ 17	40	21	✓ 19
1	40	24	✓ 16	40	22	✓ 18
2	40	25	✓ 15	40	23	✓ 17
3	40	26	✓ 14	40	25	✓ 15
4	40	28	✓ 12	40	26	✓ 14
5	40	29	✓ 11	40	27	✓ 13
6	40	30	✓ 10	40	28	✓ 12
7	40	31	✓ 9	40	30	✓ 10
8	41	33	✓ 8	40	31	✓ 9
9	42	34	✓ 8	40	32	✓ 8
10	43	35	✓ 8	41	33	✓ 8
11	44	37	✓ 7	42	35	✓ 7
12	45	38	✓ 7	43	36	✓ 7
13	46	39	✓ 7	45	37	✓ 8
14	48	40	✓ 8	46	38	✓ 8
15	49	42	✓ 7	47	40	✓ 7
16	51	43	✓ 8	48	41	✓ 7
17	53	44	✓ 9	49	42	✓ 7
18	–	45	n/a	–	43	n/a
19	–	46	n/a	–	45	n/a
20	–	47	n/a	–	–	–
21	–	48	n/a	–	–	–

5.4 R26B

Number of data points

Table 22 presents the number of data points available for analysis at R26B for both the all time and night time periods once data had been excluded.

Table 22 Available data points for analysis at R26B

Time period	Situation	Number of data points
All time	Total collected	7045
	Excluded due to lack of met mast data	49
	Excluded due to WTG shutdowns	196
	Excluded due to rain or other extraneous noise	132
	Total available for analysis	**6668**
Night time	Total collected	2646
	Excluded due to lack of met mast data	19
	Excluded due to WTG shutdowns	85
	Excluded due to rain or other extraneous noise	95
	Total available for analysis	**2447**

It can be seen that the NZS 6808:1998 minimum requirement for data points has been significantly exceeded at R26B.

Polynomial trendline

Linear and polynomial trendlines were fitted to the R26B data in accordance with NZS 6808:1998 and the coefficients of determination (R^2) for each order of polynomial fit line for both the all time and night time data at the location are presented in Table 23.

Table 23 Coefficients of determination for each polynomial order – R26B

Time period	Coefficient of determination (R^2)		
	Linear	Second order	Third order
All time	0.3082	0.3105	**0.3133**
Night time	0.3463	0.3485	**0.3556**

The coefficient shown in bold type in Table 23 corresponds to the polynomial order that provided the “best fit” to the measured noise levels. The “best fit” was determined as the curve that provided both a good regression coefficient and a sensible match to the data.

R26B analysis results

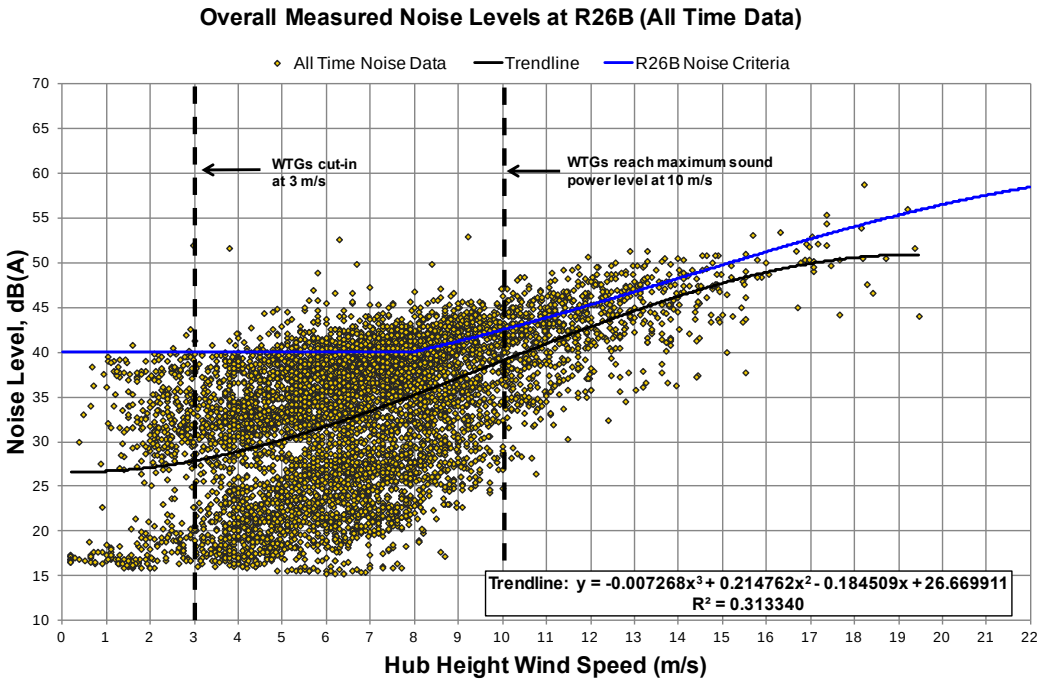

Figure 6 Measured overall noise levels at R26B – all time periods

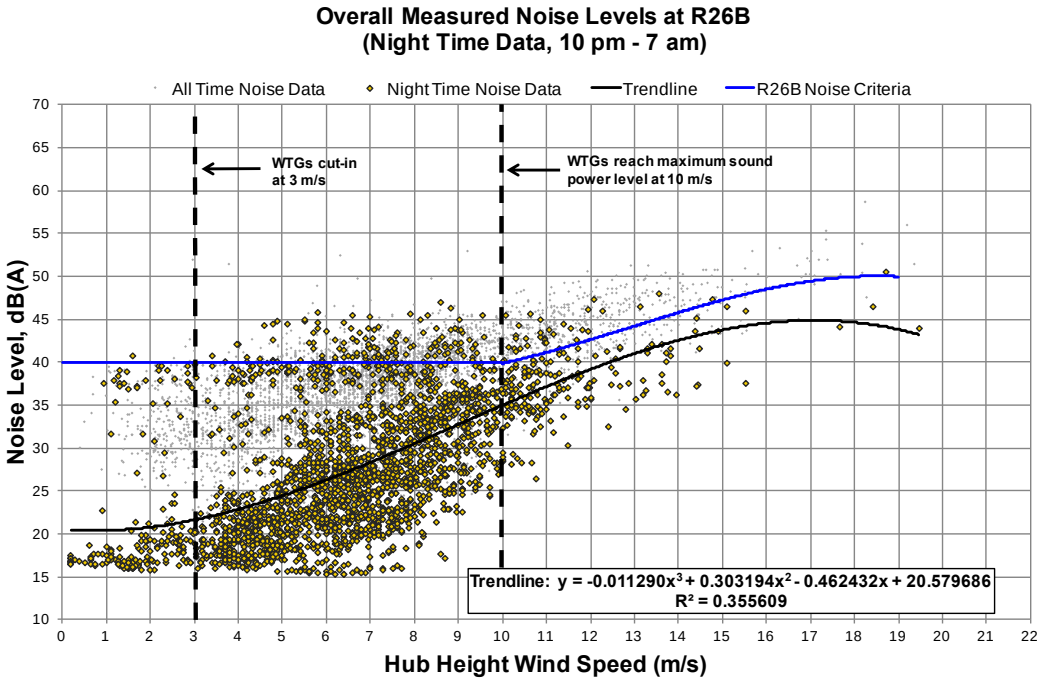

Figure 7 Measured overall noise levels at R26B – night time periods

Table 24 compares the measured overall noise levels (which include both wind farm and background noise) at R26B to the previously determined noise criteria for that location. It can be seen that compliance with the relevant noise criteria is achieved at all wind speeds.

Table 24 Measured overall noise levels at R26B

Hub height wind speed	All time periods			Night time period, 10 pm to 7 am		
m/s	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)
0	40	27	✓ 13	40	21	✓ 19
1	40	27	✓ 13	40	20	✓ 20
2	40	27	✓ 13	40	21	✓ 19
3	40	28	✓ 12	40	22	✓ 18
4	40	29	✓ 11	40	23	✓ 17
5	40	30	✓ 10	40	24	✓ 16
6	40	32	✓ 8	40	26	✓ 14
7	40	33	✓ 7	40	28	✓ 12
8	40	35	✓ 5	40	31	✓ 9
9	41	37	✓ 4	40	33	✓ 7
10	42	39	✓ 3	40	35	✓ 5
11	44	41	✓ 3	41	37	✓ 4
12	45	43	✓ 2	43	39	✓ 4
13	47	45	✓ 2	44	41	✓ 3
14	48	46	✓ 2	46	43	✓ 3
15	50	48	✓ 2	47	44	✓ 3
16	51	49	✓ 2	48	45	✓ 3
17	52	50	✓ 2	49	45	✓ 4
18	54	51	✓ 3	50	45	✓ 5
19	55	51	✓ 4	50	44	✓ 6
20	56	–	–	–	–	–
21	58	–	–	–	–	–
22	58	–	–	–	–	–

5.5 V16A

Number of data points

Table 25 presents the number of data points available for analysis at V16A for both the all time and night time periods once data had been excluded.

Table 25 Available data points for analysis at V16A

Time period	Situation	Number of data points
All time	Total collected	7042
	Excluded due to lack of met mast data	183
	Excluded due to WTG shutdowns	597
	Excluded due to rain or other extraneous noise	132
	Total available for analysis	**6130**
Night time	Total collected	2646
	Excluded due to lack of met mast data	60
	Excluded due to WTG shutdowns	265
	Excluded due to rain or other extraneous noise	95
	Total available for analysis	**2226**

It can be seen that the NZS 6808:1998 minimum requirement for data points has been significantly exceeded at V16A.

Polynomial trendline

Linear and polynomial trendlines were fitted to the V16A data in accordance with NZS 6808:1998 and the coefficients of determination (R^2) for each order of polynomial fit line for both the all time and night time data at the location are presented in Table 26.

Table 26 Coefficients of determination for each polynomial order – V16A

Time period	Coefficient of determination (R^2)		
	Linear	Second order	Third order
All time	0.7399	0.7429	**0.7501**
Night time	0.7330	0.7344	**0.7517**

The coefficient shown in bold type in Table 26 corresponds to the polynomial order that provided the “best fit” to the measured noise levels. The “best fit” was determined as the curve that provided both a good regression coefficient and a sensible match to the data.

V16A analysis results

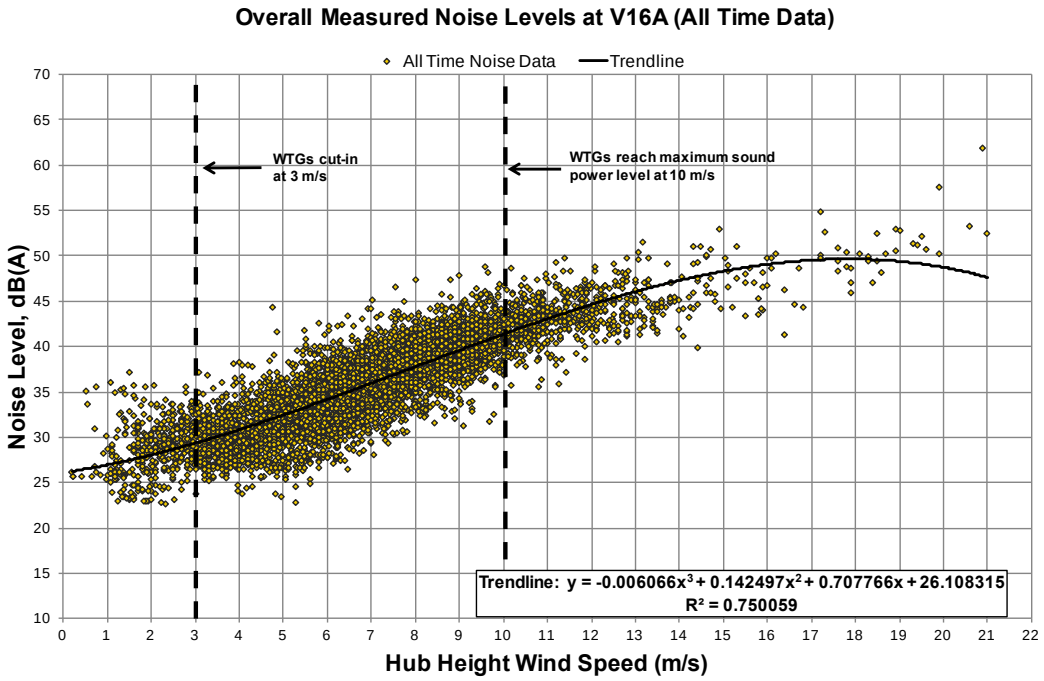

Figure 8 Measured overall noise levels at V16A – all time periods

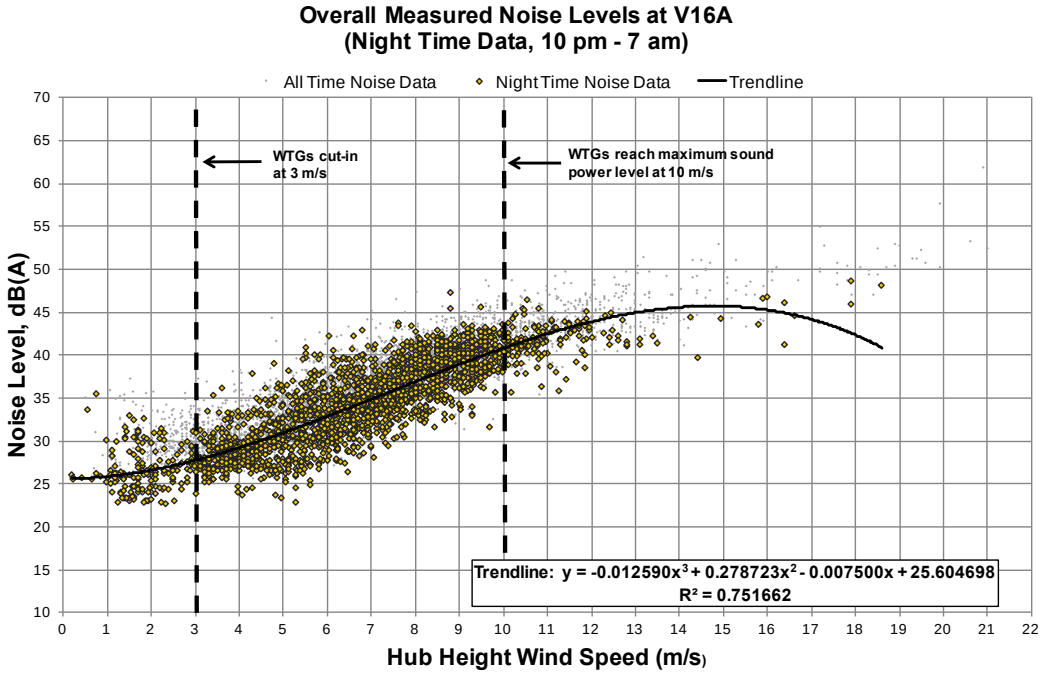

Figure 9 Measured overall noise levels at V16A – night time periods

Table 27 presents the measured overall noise levels (which include both wind farm and background noise) at V16A. Note that no noise criteria are presented as the dwelling at V16A has been decommissioned.

Table 27 Measured overall noise levels at V16A

Hub height wind speed	Measured noise level for all time periods	Measured noise level for night time period, 10 pm to 7 am
m/s	dB(A)	dB(A)
0	26	26
1	27	26
2	28	27
3	29	28
4	31	29
5	32	31
6	34	33
7	36	35
8	38	37
9	40	39
10	41	41
11	43	42
12	45	44
13	46	45
14	47	46
15	48	46
16	49	45
17	50	44
18	50	42
19	49	–
20	49	–
21	48	–

Given that no noise criteria are applicable at V16A, the measurements conducted at V16A have been used to calibrate a noise model of the Macarthur Wind Farm. The noise model has then been used to predict noise levels at residences also to the northeast of the wind farm but further from the site. The calibrated noise predictions are presented in Section 6.

5.6 W26A

Number of data points

Table 28 presents the number of data points available for analysis at W26A for both the all time and night time periods once data had been excluded.

Table 28 Available data points for analysis at W26A

Time period	Situation	Number of data points
All time	Total collected	7146
	Excluded due to lack of met mast data	20
	Excluded due to WTG shutdowns	198
	Excluded due to rain or other extraneous noise	138
	Total available for analysis	**6790**
Night time	Total collected	2700
	Excluded due to lack of met mast data	4
	Excluded due to WTG shutdowns	90
	Excluded due to rain or other extraneous noise	93
	Total available for analysis	**2513**

It can be seen that the NZS 6808:1998 minimum requirement for data points has been significantly exceeded at W26A.

Polynomial trendline

Linear and polynomial trendlines were fitted to the W26A data in accordance with NZS 6808:1998 and the coefficients of determination (R^2) for each order of polynomial fit line for both the all time and night time data at the location are presented in Table 29.

Table 29 Coefficients of determination for each polynomial order – W26A

Time period	Coefficient of determination (R^2)		
	Linear	Second order	Third order
All time	0.3485	0.3619	**0.3659**
Night time	0.2953	0.3144	**0.3160**

The coefficient shown in bold type in Table 29 corresponds to the polynomial order that provided the “best fit” to the measured noise levels. The “best fit” was determined as the curve that provided both a good regression coefficient and a sensible match to the data.

W26A analysis results

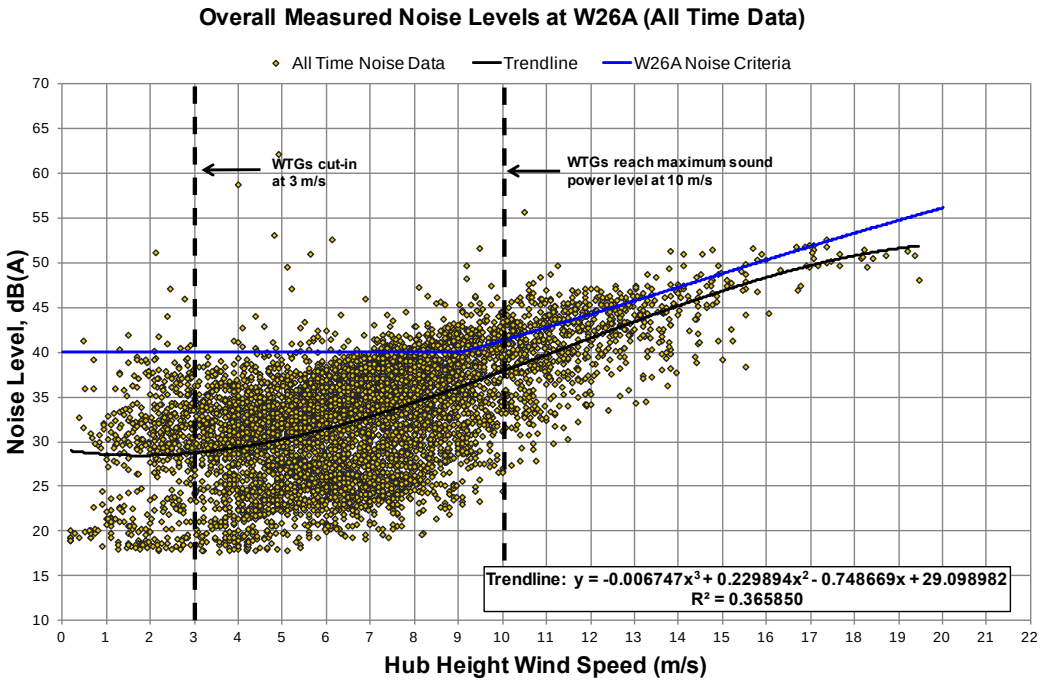

Figure 10Measured overall noise levels at W26A – all time periods

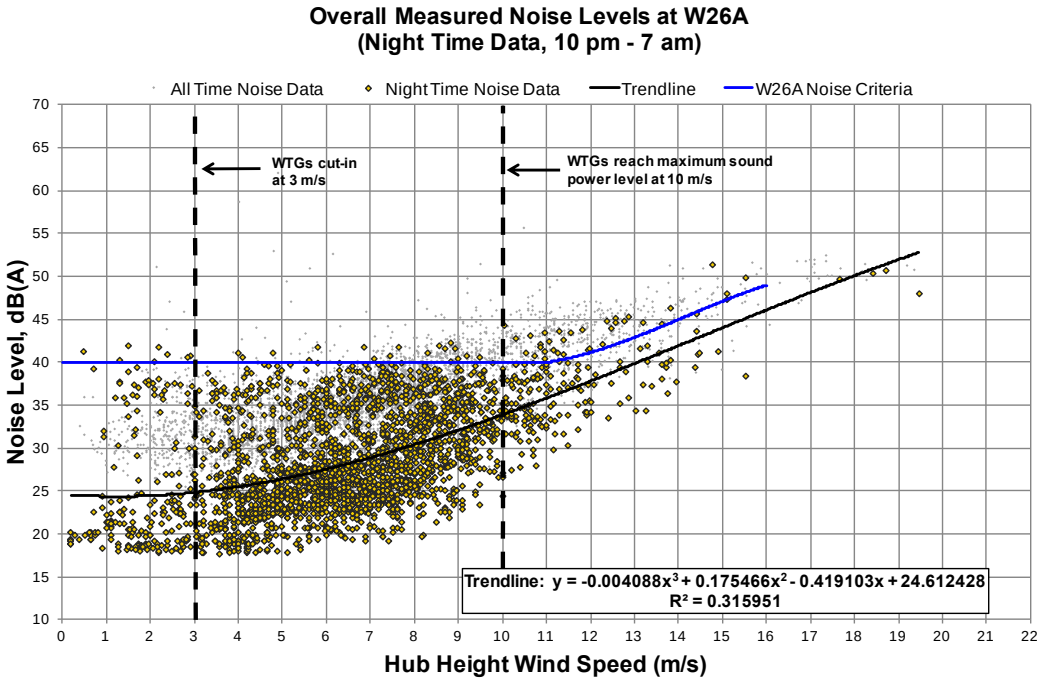

Figure 11Measured overall noise levels at W26A – night time periods

Table 30 compares the measured overall noise levels (which include both wind farm and background noise) at W26A to the previously determined noise criteria for that location. It can be seen that compliance with the relevant noise criteria is achieved at all wind speeds.

Table 30 Measured overall noise levels at W26A

Hub height wind speed	All time periods			Night time period, 10 pm to 7 am		
m/s	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)
0	40	29	✓ 11	40	25	✓ 15
1	40	29	✓ 11	40	24	✓ 16
2	40	28	✓ 12	40	24	✓ 16
3	40	29	✓ 11	40	25	✓ 15
4	40	29	✓ 11	40	25	✓ 15
5	40	30	✓ 10	40	26	✓ 14
6	40	31	✓ 9	40	28	✓ 12
7	40	33	✓ 7	40	29	✓ 11
8	40	34	✓ 6	40	30	✓ 10
9	40	36	✓ 4	40	32	✓ 8
10	41	38	✓ 3	40	34	✓ 6
11	43	40	✓ 3	40	36	✓ 4
12	44	42	✓ 2	41	38	✓ 3
13	46	43	✓ 3	43	40	✓ 3
14	47	45	✓ 2	45	42	✓ 3
15	49	47	✓ 2	47	44	✓ 3
16	50	48	✓ 2	49	46	✓ 3
17	52	50	✓ 2	–	48	n/a
18	53	51	✓ 2	–	50	n/a
19	55	52	✓ 3	–	52	n/a
20	56	–	–	–	–	–

5.7 X21A Alternative

Number of data points

Table 31 presents the number of data points available for analysis at the X21A alternative location for both the all time and night time periods once data had been excluded.

Table 31 Available data points for analysis at the X21A alternative location

Time period	Situation	Number of data points
All time	Total collected	2562
	Excluded due to lack of met mast data	76
	Excluded due to WTG shutdowns	0
	Excluded due to rain or other extraneous noise	45
	Total available for analysis	**2441**
Night time	Total collected	972
	Excluded due to lack of met mast data	49
	Excluded due to WTG shutdowns	0
	Excluded due to rain or other extraneous noise	19
	Total available for analysis	**904**

It can be seen that the NZS 6808:1998 minimum requirement for data points has been significantly exceeded at the X21A alternative location.

Polynomial trendline

Linear and polynomial trendlines were fitted to the X21A alternative location data in accordance with NZS 6808:1998 and the coefficients of determination (R^2) for each order of polynomial fit line for both the all time and night time data at the location are presented in Table 32.

Table 32 Coefficients of determination for each polynomial order – X21A alternative location

Time period	Coefficient of determination (R^2)		
	Linear	Second order	Third order
All time	0.5996	0.6072	**0.6181**
Night time	0.3851	0.3917	**0.3993**

The coefficient shown in bold type in Table 32 corresponds to the polynomial order that provided the “best fit” to the measured noise levels. The “best fit” was determined as the curve that provided both a good regression coefficient and a sensible match to the data.

X21A alternative location analysis results

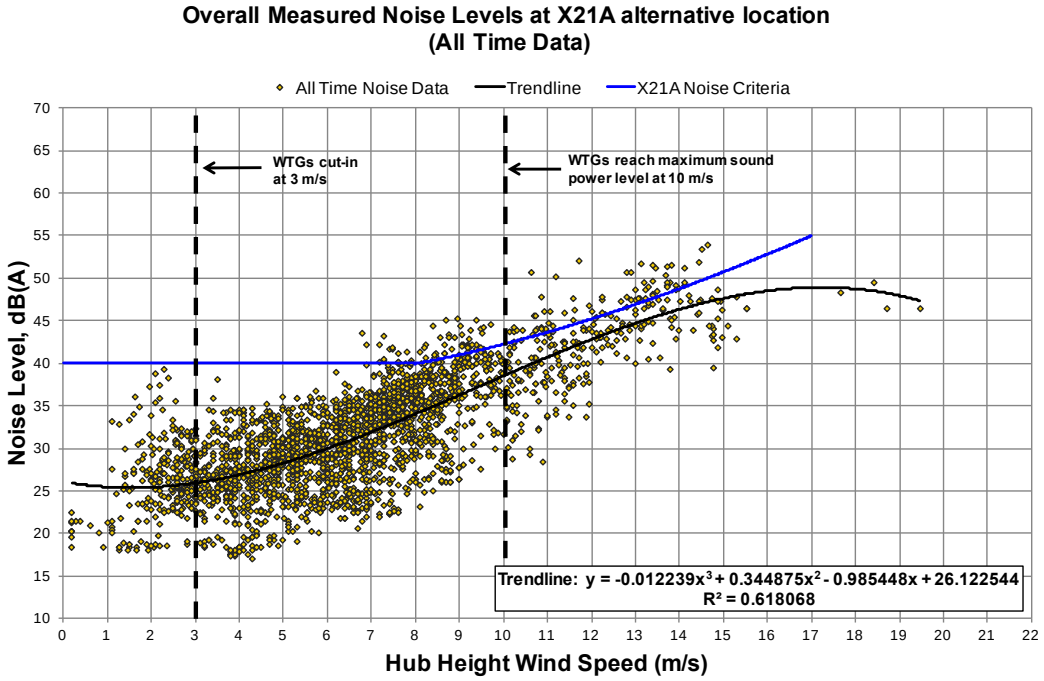

Figure 12Measured overall noise levels at X21A alternative location – all time periods

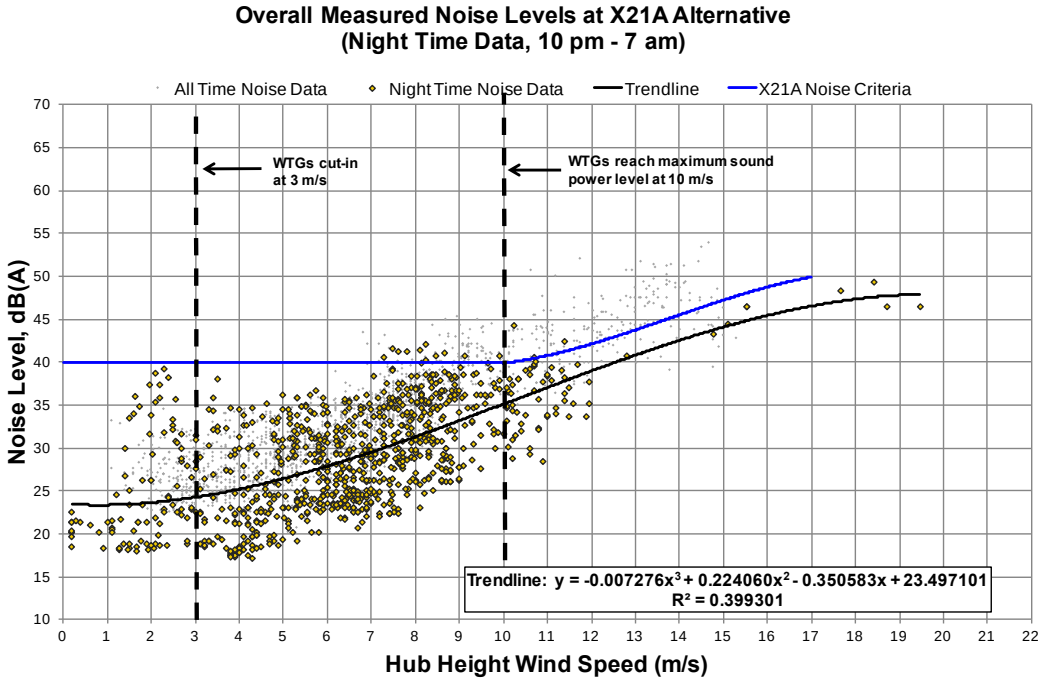

Figure 13Measured overall noise levels at X21A alternative location – night time periods

Table 33 compares the measured overall noise levels (which include both wind farm and background noise) at the X21A alternative location to the previously determined noise criteria for X21A. It can be seen that compliance with the relevant noise criteria is achieved at all wind speeds.

Table 33 Measured overall noise levels at X21A alternative location

Hub height wind speed	All time periods			Night time period, 10 pm to 7 am		
m/s	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)
0	40	26	✓ 14	40	23	✓ 17
1	40	25	✓ 15	40	23	✓ 17
2	40	25	✓ 15	40	24	✓ 16
3	40	26	✓ 14	40	24	✓ 16
4	40	27	✓ 13	40	25	✓ 15
5	40	28	✓ 12	40	26	✓ 14
6	40	30	✓ 10	40	28	✓ 12
7	40	32	✓ 8	40	30	✓ 10
8	40	34	✓ 6	40	31	✓ 9
9	41	36	✓ 5	40	33	✓ 7
10	42	39	✓ 3	40	35	✓ 5
11	44	41	✓ 3	40	37	✓ 3
12	45	43	✓ 2	42	39	✓ 3
13	47	45	✓ 2	44	41	✓ 3
14	49	46	✓ 3	46	43	✓ 3
15	51	48	✓ 3	47	44	✓ 3
16	53	49	✓ 4	49	45	✓ 4
17	55	49	✓ 6	50	47	✓ 3
18	–	49	n/a	–	47	n/a
19	–	48	n/a	–	48	n/a

5.8 Y21A

Number of data points

Table 34 presents the number of data points available for analysis at Y21A for both the all time and night time periods once data had been excluded.

Table 34 Available data points for analysis at Y21A

Time period	Situation	Number of data points
All time	Total collected	8569
	Excluded due to lack of met mast data	118
	Excluded due to WTG shutdowns	1
	Excluded due to rain or other extraneous noise	201
	Total available for analysis	**8249**
Night time	Total collected	3240
	Excluded due to lack of met mast data	66
	Excluded due to WTG shutdowns	0
	Excluded due to rain or other extraneous noise	99
	Total available for analysis	**3075**

It can be seen that the NZS 6808:1998 minimum requirement for data points has been significantly exceeded at Y21A.

Polynomial trendline

Linear and polynomial trendlines were fitted to the Y21A data in accordance with NZS 6808:1998 and the coefficients of determination (R^2) for each order of polynomial fit line for both the all time and night time data at the location are presented in Table 35.

Table 35 Coefficients of determination for each polynomial order – Y21A

Time period	Coefficient of determination (R^2)		
	Linear	Second order	Third order
All time	0.4877	0.4916	**0.4987**
Night time	0.4266	0.4476	**0.4573**

The coefficient shown in bold type in Table 35 corresponds to the polynomial order that provided the “best fit” to the measured noise levels. The “best fit” was determined as the curve that provided both a good regression coefficient and a sensible match to the data.

Y21A analysis results

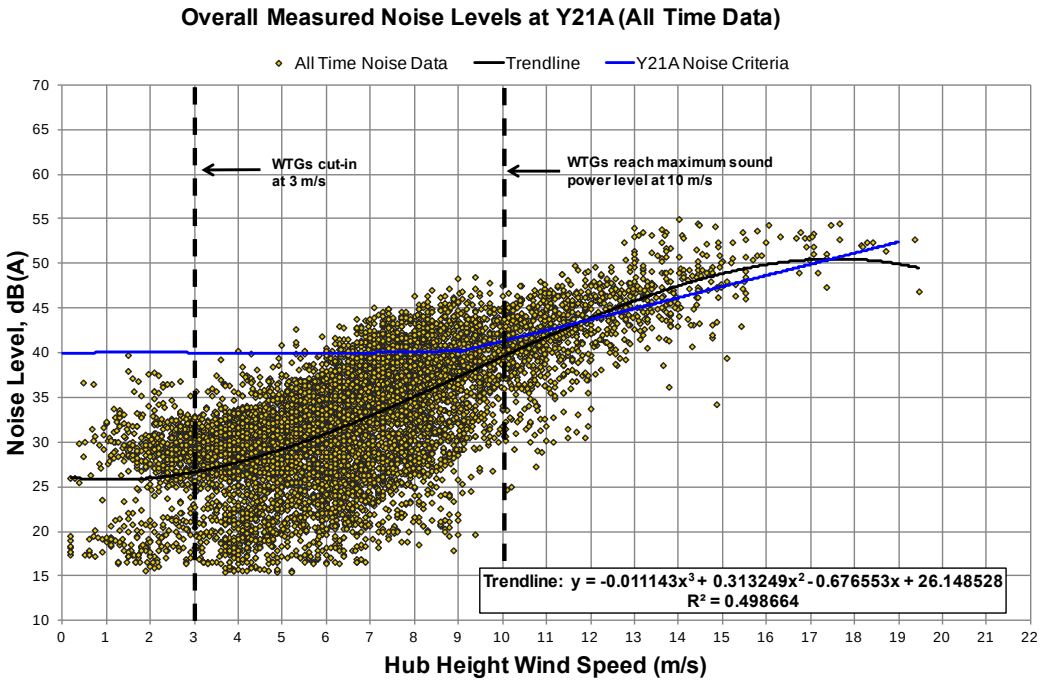

Figure 14Measured overall noise levels at Y21A – all time periods

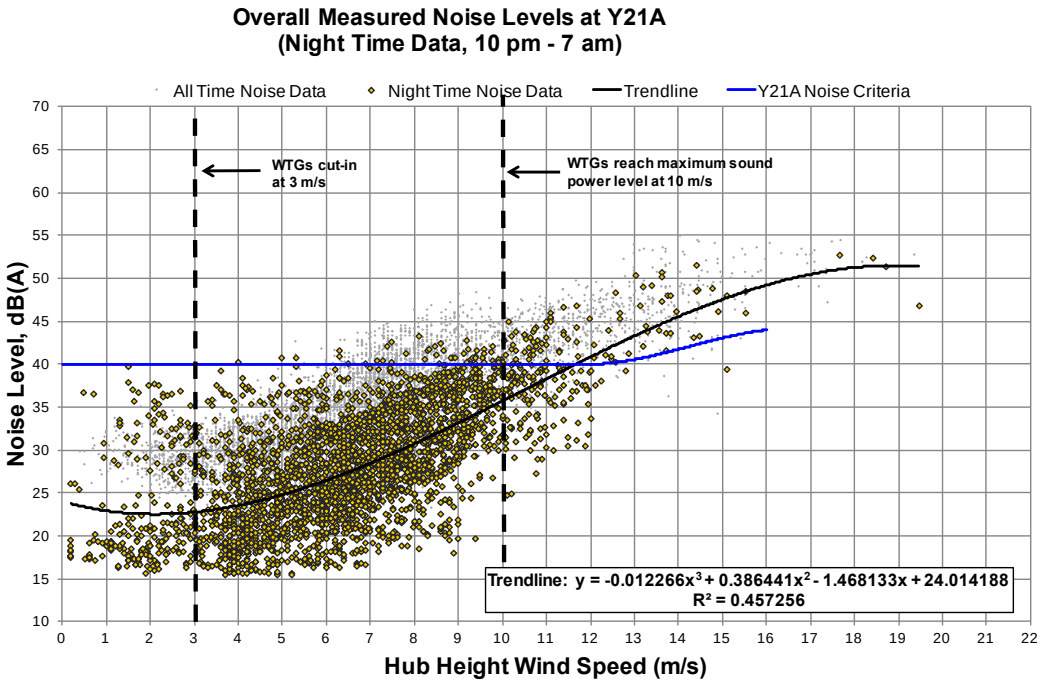

Figure 15Measured overall noise levels at Y21A – night time periods

Table 36 compares the measured overall noise levels (which include both wind farm and background noise) at Y21A to the previously determined noise criteria for that location. It can be seen that, for wind speeds below 12 m/s, compliance is achieved with the relevant noise criteria. However, at higher wind speeds the measured overall noise levels are above the noise criteria. This is considered to be the result of background noise, rather than wind farm noise, and is discussed further in Section 5.9.

Table 36 Measured overall noise levels at Y21A

Hub height wind speed	All time periods			Night time period, 10 pm to 7 am		
m/s	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)	Noise criteria, dB(A)	Measured noise level, dB(A)	Compliance and margin, dB(A)
0	40	26	✓ 14	40	24	✓ 16
1	40	26	✓ 14	40	23	✓ 17
2	40	26	✓ 14	40	23	✓ 17
3	40	27	✓ 13	40	23	✓ 17
4	40	28	✓ 12	40	24	✓ 16
5	40	29	✓ 11	40	25	✓ 15
6	40	31	✓ 9	40	26	✓ 14
7	40	33	✓ 7	40	28	✓ 12
8	40	35	✓ 5	40	31	✓ 9
9	40	37	✓ 3	40	33	✓ 7
10	41	40	✓ 1	40	36	✓ 4
11	43	42	✓ 1	40	38	✓ 2
12	44	44	✓ 0	40	41	*
13	45	46	*	41	43	*
14	46	47	*	42	46	*
15	48	49	*	43	48	*
16	49	50	*	44	49	*
17	50	50	*	–	50	n/a
18	51	50	*	–	51	n/a
19	53	50	*	–	51	n/a

* These measured noise levels above the criteria are considered to be the result of high levels of background noise at Y21A. Further discussion is provided in Section 5.9.

5.9 Discussion of results

The measured noise levels presented for each monitoring location comply with the nominated noise criteria at all wind speeds, with the exception of those measured at Y21A. It is considered that the measured noise levels at Y21A are the result of background noise, rather than wind farm noise, for the following reasons:

- The measured noise levels at Y21A are compliant up to a hub height wind speed of 11 m/s for both all time and night time periods. The WTGs reach their maximum sound power level at a wind speed of 10 m/s and, while there may be some variation in wind speed across a site, it is highly unlikely that there would be significant increases in wind turbine noise above 11 m/s. Therefore, the significant increases that do occur at these higher wind speeds at Y21A are expected to be a result of background noise and not wind turbine noise.
- At wind speeds higher than 10 m/s, the measured noise levels at Y21A are up to 4 dB higher than those at the X21A alternative location despite Y21A being significantly further from the wind farm. Based on the increased distance of Y21A from the wind farm, it is predicted that the wind farm noise level at the X21A alternative location would be 5 dB higher. Therefore, the higher measured noise level at Y21A indicates that this is a result of background noise and not wind turbine noise.
- There was some uncertainty regarding the location of the previous background noise measurement location at Y21A and significant vegetation around the selected monitoring site. Relatively small changes between positions between the periods and growth in vegetation over time introduce a significant risk of an increase in background noise, which appears to have occurred in this instance.
- During the visits to the residence at Y21A described in Section 7, wind turbine noise was only very faintly audible or completely inaudible.

Considering that compliance is achieved at all wind speeds at the closer X21A alternative location and up to a wind speed of 10 m/s at Y21A, it is considered that compliance with the noise criteria has been achieved at Y21A.

It should also be noted that, at all locations, the measurements that indicate compliance with the noise criteria include both wind farm and background noise. The Planning Permit for Macarthur Wind Farm sets a noise limit based on wind farm noise only and therefore this assessment is conservative as the wind farm noise level would be lower than indicated by the measurements.

Based on measurements conducted around Macarthur Wind Farm between October and December 2015 and detailed in this report, noise from the Macarthur Wind Farm achieves compliance with the noise criteria determined from the Planning Permit and NZS 6808:1998.

6 Validated noise predictions

In the absence of applicable noise criteria at location V16A, the peer review for Moyne Shire Council (SLR Consulting Australia Pty Ltd) has requested that the measured noise levels at V16A be used to assess the compliance of non-involved receptors to the northeast of the wind farm.

6.1 Noise model

A computer noise model of the Macarthur Wind Farm has been developed in SoundPlan environmental noise modelling software version 7.4, and has incorporated the following inputs:

- coordinates for each of the 140 WTGs as provided by AGL at a height of 84 m above ground, refer to Appendix G
- coordinates for the V16A monitoring location as recorded by GPS
- coordinates for the other receptors around the Macarthur Wind Farm as provided by AGL, refer to Appendix G
- 10 m spaced topographical contours for the Macarthur Wind Farm as provided by AGL
- overall sound power levels with wind speed as per Appendix A
- sound power spectrum as per the typical spectrum for 10 m/s at hub height as shown in Table 37, based on a test report provided by Vestas[3]
- ISO 9613-2 prediction algorithm with 10°C and 80% humidity
- ground absorption of 50% which has been shown to provide good agreement between measured and predicted wind farm noise levels at relatively flat sites in Australia.

Table 37 Assumed sound power spectrum for Vestas V112 WTGs at 10 m/s at hub height

Hub height wind speed	Sound power level in dB(A) re 10^{-12} W at octave band centre frequency in Hz								
m/s	31.5	63	125	250	500	1k	2k	4k	Overall
10	77.5	89.8	95.6	97.7	100.0	101.8	98.7	92.0	106.5

6.2 Predicted versus measured noise levels at V16A

Table 38 presents the predicted versus measured noise levels at the V16A monitoring location. Note that the measured night time noise levels up to a hub height wind speed of 12 m/s have been used for the calibration as:

- Night time measured noise levels are more likely to be controlled by wind turbine noise than daytime noise levels when other sources may influence the measured levels.
- Limited data was captured above 12 m/s and the wind turbine sound power level does not increase above 10 m/s at hub height. Increases in noise levels as wind speed increase above 10 m/s are therefore likely to be a result of extraneous noise rather than wind turbine noise.

[3] DELTA, 20 September 2011, *Measurement of Noise Emission from a Vestas V112-3.0 MW mode 0 Wind Turbine*, DANAK 100/2847 Rev1

The comparison in Table 38 indicates that the noise model over-predicts by at least 3 dB up to a wind speed of 10 m/s. This decreases at wind speeds above 10 m/s, likely due to extraneous noise at the measurement location resulting in higher measured noise levels.

Table 38 Predicted vs measured noise levels at V16A monitoring location

Hub height wind speed	Predicted noise level	Measured night noise level	Predicted – Measured
m/s	dB(A)	dB(A)	dB(A)
4	33.2	29.2	4.0
5	34.0	31	3.0
6	36.7	32.9	3.8
7	40.0	34.9	5.1
8	42.7	36.9	5.8
9	44.3	38.9	5.4
10	44.6	40.8	3.8
11	44.6	42.5	2.1
12	44.6	43.9	0.7

As a conservative approach, we have based our predictions at other residential locations on the unadjusted predictions from the noise model. Based on the comparison of predicted and measured noise levels up to a hub height wind speed of 10 m/s, this results in an over-prediction of the wind farm noise levels of at least 3 dB.

6.3 Predicted noise levels at receivers

The two nearest non-involved residences to the northeast are:

- W14A – 192 Jubbs Road
- X16A – 763 Gerrigerrup-Minhamite Road.

These two residential locations are shown on Figure 1.

The predicted noise levels at these two locations, and the other residential locations mentioned within this report are shown in Table 39. The predicted levels are shown for a hub height wind speed of 10 m/s, the wind speed at which the turbines reach maximum sound power level, and compared to the minimum applicable criterion of 40 dB(A). This is a conservative approach as, where background noise levels exceed 35 dB(A) at 10 m/s, the criterion is higher than indicated.

It can be seen from Table 39 that the conservatively predicted noise levels at all receivers are at least 2 dB below the minimum applicable criterion of 40 dB(A). Therefore, based on the monitoring at V16A, compliance is expected at all residences adjacent to the wind farm.

Table 39 Predicted wind farm noise level at non-involved receivers

Non-involved receiver	Predicted wind farm noise level at hub height wind speed of 10 m/s and above	Minimum possible criterion
	dB(A)	dB(A)
Nearest receivers to northeast		
W14A	37	40
X16A	38	40
Other receivers		
P22A	38	40
Q15A	38	40
R26B	35	40
T25A	36	40
W26A	33	40
X21A	38	40
Y21A	32	40

Noise contours for the Macarthur Wind Farm at a wind speed of 10 m/s based on the validated noise model are included as Appendix H.

7 Special audible characteristics

Condition 16b of the Macarthur Wind Farm Planning Permit states that:

> If the sound has a special audible characteristic, the measured sound level of the source shall have a 5 dB penalty applied.

This Section details the assessment of special audible characteristics undertaken during this compliance monitoring.

7.1 Special audible characteristics

Section 5.3.1 of NZS 6808:1998 defines wind turbine noise as having special audible characteristics if it has one or more of the following:

- A clearly audible tone – a concentration of sound at a particular frequency resulting in sound with a definite pitch. Examples include transformer 'hum' or the beeping of a traditional reversing beeper.
- Impulses – banging or thumping noises exhibiting a rapid increase and decrease in noise levels.
- Modulation of sound levels – excessive variation of the wind farm noise level at the blade pass frequency. While audible wind farm noise will normally have a relatively small level of amplitude modulation as a fundamental characteristic, the more recent version of the NZ Standard (NZS 6808:2010) states that this refers to excessive amplitude modulation.

7.2 Assessment procedure

An assessment procedure for special audible characteristics was agreed with Moyne Shire Council's external acoustic consultant (SLR Consulting Australia Pty Ltd) prior to undertaking the compliance monitoring.

The procedure involved both a Resonate Acoustics consultant and an SLR consultant attending each of the monitoring locations to listen to the noise present at the location at the time. In total, five attended monitoring visits occurred, with two of them occurring during the night time. Due to the monitoring at the X21A alternative location commencing late during the compliance monitoring process, only two visits were conducted to that location.

Generally, the visits were conducted at the monitoring position although during the night time the visits were conducted at a nearby location that could be safely accessed at night and was typically closer to the wind farm than the monitoring position.

7.3 Assessment results

Table 40 summarises the assessment of the special audible characteristics undertaken at each location. Note that the wind speed and direction refer to that determined from the relevant meteorological masts in accordance with the wind data assessment procedure.

Table 40 Special audible characteristic assessment

Date and time	Hub height wind speed and direction	Measured noise level, dB(A)	Comments
P22A			
22 October 3:00 pm	7 m/s 193° (SSW)	44 dB(A) L_{eq} 40 dB(A) L_{95}	Wind farm faintly audible in background before becoming inaudible. No noted special audible characteristics. Noise level generally controlled by wind in trees.
22 October 11:30 pm	6 m/s 171° (S)	34 dB(A) L_{eq} 28 dB(A) L_{95}	Wind farm audible in background. Low level of modulation, changing to steady but faint hum. Noise level generally controlled by wind in trees.
12 November 11:20 am	3.3 m/s 170° (S)	39 dB(A) L_{eq} 30 dB(A) L_{95}	Wind farm faintly audible in background before becoming inaudible. No noted special audible characteristics. Noise level generally controlled by wind in trees.
11 December 1:40 am	6.2 m/s 273° (W)	38 dB(A) L_{eq} 33 dB(A) L_{95}	Wind farm inaudible. Noise level controlled by wind in trees.
11 December 10:10 am	6.7 m/s 272° (W)	45 dB(A) L_{eq} 41 dB(A) L_{95}	Wind farm inaudible. Noise level controlled by wind in trees and some noise from nearby logging.
Q15A alternative			
22 October 5:10 pm	8.7 m/s 189° (S)	40 dB(A) L_{eq} 37 dB(A) L_{95}	Wind farm audible at low level in background. Noise level generally controlled by wind through grass.
23 October 12:10 am	4.5 m/s 167° (SSE)	30 dB(A) L_{eq} 28 dB(A) L_{95}	Wind farm audible with normal level of swish and faint hum.
12 November 12:10 pm	4.8 m/s 180° (S)	37 dB(A) L_{eq} 32 dB(A) L_{95}	Wind farm audible in background with normal level of swish and faint hum.
11 December 2:00 am	7.9 m/s 271° (W)	33 dB(A) L_{eq} 27 dB(A) L_{95}	Wind farm inaudible. Noise level controlled by wind through vegetation.
11 December 9:30 am	7.9 m/s 284° (WNW)	41 dB(A) L_{eq} 33 dB(A) L_{95}	Wind farm audible in background with faint steady hum occasionally audible.

Date and time	Hub height wind speed and direction	Measured noise level, dB(A)	Comments
R26B			
22 October 11:10 pm	5.4 m/s 178° (S)	36 dB(A) L_{eq} 32 dB(A) L_{95}	Wind farm inaudible. Noise level controlled by wind in trees, with contributions from lambs bleating and crickets.
23 October 12:30 pm	4.3 m/s 165° (SSE)	43 dB(A) L_{eq} 32 dB(A) L_{95}	Wind farm inaudible. Noise level controlled by wind in trees and distant farm activity.
12 November 10:20 am	2.5 m/s 164° (SSE)	38 dB(A) L_{eq} 33 dB(A) L_{95}	Wind farm inaudible, nearest wind turbines just starting to cut-in based on visual assessment. Noise level controlled by wind in trees.
11 December 1:20 am	8 m/s 282° (W)	28 dB(A) L_{eq} 26 dB(A) L_{95}	Wind turbine noise inaudible. Noise in trees controlling measured level.
11 December 10:40 am	7.9 m/s 263° (W)	47 dB(A) L_{eq} 38 dB(A) L_{95}	Wind turbine noise inaudible. Noise in trees controlling measured level.
V16A			
23 October 12:40 am	5.1 m/s 169° (SSE)	39 dB(A) L_{eq} 37 dB(A) L_{95}	Turbine to south clearly audible, low level steady hum and normal level of blade swish audible.
23 October 11:10 am	3.9 m/s 150° (SSE)	41 dB(A) L_{eq} 31 dB(A) L_{95}	Wind farm audible, normal level of blade swish audible.
12 November 1:10 pm	4.5 m/s 166° (SSE)	41 dB(A) L_{eq} 35 dB(A) L_{95}	Wind farm audible. Mid-frequency whistling noise faintly audible when local wind dropped away.
11 December 2:20 am	8.6 m/s 272° (W)	38 dB(A) L_{eq} 35 dB(A) L_{95}	Nearest wind turbines audible, with slight steady hum at lower frequency. Mid-frequency whistling noise also audible.
11 December 8:50 am	6.4 m/s 287° (WNW)	40 dB(A) L_{eq} 35 dB(A) L_{95}	Nearest wind turbines audible, with slight steady hum at lower frequency.
W26A			
22 October 7:50 pm	5.5 m/s 175° (S)	39 dB(A) L_{eq} 28 dB(A) L_{95}	Wind farm noise inaudible. Noise levels controlled by wind in trees and nearby vegetation.

Date and time	Hub height wind speed and direction	Measured noise level, dB(A)	Comments
22 October 10:50 pm	6 m/s 167° (SSE)	33 dB(A) L_{eq} 24 dB(A) L_{95}	Wind farm noise inaudible. Noise levels controlled by wind in trees, lambs bleating, frogs and crickets.
12 November 10:10 am	2.5 m/s 164° (SSE)	43 dB(A) L_{eq} 28 dB(A) L_{95}	Wind farm noise inaudible, nearest wind turbines just starting to cut-in based on visual assessment. Noise levels controlled by wind in trees, with L_{eq} influenced by dogs barking.
11 December 3:00 am	7.2 m/s 282° (W)	30 dB(A) L_{eq} 28 dB(A) L_{95}	Wind turbine noise faintly audible as a rumble. Noise in trees generally controlling measured level.
11 December 11:00 am	9.2 m/s 246° (WSW)	47 dB(A) L_{eq} 38 dB(A) L_{95}	Wind turbine noise inaudible. Noise in trees controlling measured level, some contribution from dogs barking.
X21A alternative monitoring location			
11 December 3:00 am	7.1 m/s 280° (W)	35 dB(A) L_{eq} 34 dB(A) L_{95}	Wind turbine noise audible as a relatively steady rumbling noise in the background.
11 December 11:30 am	10.1 m/s 231° (SW)	46 dB(A) L_{eq} 42 dB(A) L_{95}	Wind turbine noise audible in background with normal level of blade swish. Noise in nearby vegetation controlling overall noise level.
Y21A			
22 October 6:50 pm	7.2 m/s 172° (S)	41 dB(A) L_{eq} 35 dB(A) L_{95}	Wind farm inaudible. Noise controlled by wind in nearby trees and vegetation.
23 October 1:10 am	4.1 m/s 177° (S)	36 dB(A) L_{eq} 30 dB(A) L_{95}	Wind farm inaudible. Noise controlled by wind in nearby trees and vegetation.
12 November 1:50 pm	6.6 m/s 173° (S)	44 dB(A) L_{eq} 37 dB(A) L_{95}	Wind farm inaudible. Noise controlled by wind in nearby trees and vegetation.
11 December 2:40 am	7.4 m/s 267° (WSW)	37 dB(A) L_{eq} 35 dB(A) L_{95}	Wind turbine noise audible in background, faint but steady hum. Controlled by noise from wind in nearby trees and vegetation.

Date and time	Hub height wind speed and direction	Measured noise level, dB(A)	Comments
11 December 11:50 am	12.4 m/s 225° (SW)	50 dB(A) L_{eq} 46 dB(A) L_{95}	Wind turbine noise inaudible. Controlled by noise from wind in nearby trees and vegetation.

As summarised in Table 40, while the wind farm was noted as at least faintly audible at all locations on at least one occasion other than at R26B, generally noise from the wind farm was only audible in the background. The exception to this was at location V16A, which is a now-decommissioned residence owned by a wind farm host landowner and therefore much closer to the wind farm than the nearest occupied residences.

On occasion, a faint hum was detected at the nearest residences but this was not considered to be clearly audible as required by NZS 6808:1998. Similarly, any modulation in the wind farm noise that was detected was considered to be at a normal level and there was no evidence of any impulsive noise. Therefore, based on this agreed assessment procedure, it is not considered that noise from Macarthur Wind Farm warrants a 5 dB penalty for a special audible characteristic.

8 Conclusion

This report presents the results of a compliance noise monitoring assessment conducted of the Macarthur Wind Farm, based on monitoring results from October to December 2015. The assessment has been conducted in accordance with the requirements of the Macarthur Wind Farm Planning Permit and NZS 6808:1998.

Continuous compliance monitoring was undertaken at seven locations around the wind farm, with the locations selected to be representative of the reference locations required by the Planning Permit. Where permission was not obtained to measure at a reference location, an alternative location was selected.

At six of the monitoring locations, measured overall (combined wind farm and background) noise levels were found to comply with the relevant assessment criteria. At one location, Y21A, measured noise levels exceeded the wind farm criteria at high speed but, with due consideration of a closer monitoring location and the acoustic properties of the WTGs at Macarthur Wind Farm, it is considered that these higher noise levels at high wind speeds were due to changes in background noise and not wind farm noise.

The measurements at V16A to the northeast, an unoccupied and decommissioned dwelling, were used to validate a noise model of the Macarthur Wind Farm and predict noise levels at the closest residences to the northeast as well as those elsewhere around the wind farm. The predictions, which were conducted in a conservative manner, indicated that wind farm noise levels at all residences considered in this report were not expected to be any higher than 38 dB(A) and therefore compliant with the relevant assessment criteria.

Attended visits were made on five occasions to site to undertake a subjective assessment of special audible characteristics as part of noise from the Macarthur Wind Farm. These were conducted in conjunction with an acoustic consultant appointed by Moyne Shire Council. While wind farm noise was audible at all but one site on occasions, it was determined that the wind farm noise did not exhibit special audible characteristics during any attended test and therefore no penalty for such characteristics is considered warranted.

Based on the noise monitoring and assessments conducted during October to December 2015, as documented in this report, it is considered that the noise from the Macarthur Wind Farm comply with the requirements of the Planning Permit. This is consistent with the findings of the previous compliance noise monitoring conducted in 2013 and 2014.

Appendix A—WTG details

Vestas V112-3MW WTG details

The following details have been sourced from the relevant Vestas General Specification for the WTGs installed at the Macarthur Wind Farm.[4]

General information

Manufacturer	Vestas
Model	V112
Rated power output	3 MW
Regulation	Pitch regulated
Number of blades	3
Rotor diameter	112 m
Hub height	84 m
Rotational speed	4.4 – 17.7 rpm
Orientation	Upwind
Cut-in wind speed	3 m/s hub height
Cut-out wind speed	25 m/s hub height

General Specification sound power levels

Hub height wind speed, m/s	**Sound power level, dB(A) re 10^{-12} W Noise Mode 0**
4.3	95
5.7	97.7
7.2	102.5
8.6	105.7
10	106.5
11.5	106.5
12.9	106.5
14.3	106.5
15.8	106.5
17.2	106.5
18.6	106.5

[4] Vestas General Specification V112-3.0MW IEC IIA, T05, Item no. 0004-7993V02, dated 3 December 2009.

Appendix B—Relevant Planning Permit conditions

Planning and Environment Regulations 2005 Form 11

Section 97F

PLANNING PERMIT GRANTED BY THE MINISTER UNDER DIVISION 6 OF PART 4 OF THE PLANNING AND ENVIRONMENT ACT 1987

f) a timetable for implementation of all landscaping works; and

g) a maintenance and monitoring program.

14. The use and development must be carried out in accordance with the endorsed On-site and Off-site Landscape Plans.

15. A copy of the approved Landscape Plan must also be given to those landowners of land where planting is proposed to be included in the Landscape Plan. Where non-contracted landowners elect to defer a decision on planting until after the wind turbines have been constructed, the development plans shall be amended to include any such agreed planting, and resubmitted to the responsible authority for approval

NOISE STANDARD

16. The operation of the wind energy facility must comply with the New Zealand Standard 'Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators' (NZS 6808:1998) (the 'Standard'), at any dwelling existing in the vicinity of the wind energy facility as at 7 February 2006. In determining compliance with the Standard, the following shall apply:

a) The sound level from the operating wind energy facility, measured outdoors within 10 metres of a dwelling at any relevant nominated wind speed, shall not exceed the background level (L_{95}) by more than 5dBA or a level of 40dBA L_{95}, whichever is the greater. This 'background sound level' shall be determined by the method specified in NZS 6806:1998. Compliance shall be determined separately for all time data and for night time data. Night time is defined as 10pm to 7am.

b) If sound has a special audible characteristic the measured sound level of the source shall have a 5 dB penalty applied. The EMP must provide detail on how special audible characteristics are to be determined and the penalty is to be applied

17. Condition 16 does not apply to any dwelling on land on which part of the wind energy facility is erected. That exemption shall be given affect through an agreement with the landowner that shall apply to any occupant of the dwelling and must be registered on the title to the land.

18. Prior to any construction work commencing a detailed investigation shall be carried out at the background noise monitoring location identified as 'Location 7' being at the dwelling identified as 'T20A', to ascertain the apparent extraneous noise sources that prevented a reliable determination of background noise being achieved at this site. The location is identified in Report No 03.543-01 in Supplement A of the Planning Permit Application Report dated July 2005.

19. The existing data shall either be corrected, if that is possible and provides sufficient number of data points, or further background noise measurements made, subject to the approval of the owner, with those extraneous noise sources excluded. The Preliminary Environmental Management Plan dated 3 March 2006 provides further detail on this matter.

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Section 97F

PLANNING PERMIT GRANTED BY THE MINISTER UNDER DIVISION 6 OF PART 4 OF THE PLANNING AND ENVIRONMENT ACT 1987

NOISE COMPLIANCE ASSESSMENT

20. A post-construction noise monitoring and compliance assessment program must be undertaken by the wind energy facility operator. This must be to the satisfaction of the responsible authority with regard to timing, program design, determination of compliance, any necessary remedial action, and information dissemination. The PEMP provides more detailed requirements on this.

21. The initial compliance noise monitoring program must commence within 2 months of the commissioning of the last turbine in the wind energy facility or, if the facility is constructed in groups of turbines, separate programs within 2 months of the commissioning of each group. The date at which 'commissioning' has been deemed to occur and the extent of the noise compliance monitoring shall be agreed between the responsible authority and the wind energy facility operator.

22. After the complete wind energy facility is commissioned the monitoring shall be carried out at all six reference dwellings used to measure background sound levels, subject to the approval of their owners.

23. The location shall be monitored concurrently, and with the wind turbines operating in their normal mode. As fas as possible the noise meter calibration and noise monitoring program shall be carried out by organisations accredited with the National Association of Testing Authorities (NATA).

24. The design of the program and the evaluation of the acoustic data must be carried by an independent expert who has had experience in the analysis, interpretation and presentation of acoustic data from wind turbines, and who is preferably a member of a recognised professional association in that field.

25. Compliance at noise reference locations is determined by comparing the curve of the operational wind farm noise results, to which has been arithmetically added the 5 dB penalty for any special audible characteristics should such be required, with the noise criterion curves for each site and for each time period. Compliance is demonstrated by the noise curve for the operational wind farm falling below the noise criterion curve at all wind speeds.

26. Should compliance be demonstrated by the program above the compliance noise monitoring program must be repeated commencing not less than 10 months and not greater than 12 months after the commencement of the initial compliance noise monitoring program for the whole site. Should that further monitoring program demonstrate compliance with the noise criteria no further noise compliance monitoring shall be required at those locations unless otherwise determined by the responsible authority.

27. The responsible authority may require noise compliance monitoring at a dwelling or dwellings other than those reference dwellings of condition 22 above on the basis of a reasonable belief that noise criteria may not be being complied with.

NOISE COMPLIANCE ENFORCEMENT

28. If the initial monitoring of any stage of the wind energy facility of the complete facility shows non-compliance with the noise criterion for any location or time period

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Section 97F

PLANNING PERMIT GRANTED BY THE MINISTER UNDER DIVISION 6 OF PART 4 OF THE PLANNING AND ENVIRONMENT ACT 1987

the operator will, within 30 days of submitting the compliance monitoring report, provide to the responsible authority, and make publicly available a detailed plan, including time lines, of actions proposed to be taken to secure compliance. Details on what might be included in such a plan should be provided in the EMP.

29. Within 60 days of approval by the responsible authority of the plan to remedy any such breach of environmental noise criteria, the operator will implement those actions that are possible within the time period and any additional interim actions, pending longer term modifications, to bring the wind energy facility into noise compliance.

30. Within 30 days of completing all the noise reduction actions in condition 29 above the operator must commence a further noise monitoring program as described in conditions 20 to 27 above, but only at those sites and for those time periods for which compliance had not been demonstrated.

31. Reports of the noise monitoring and investigation programs shall be provided to the responsible authority and made publicly available within 60 days of the completion of each monitoring stage or investigation program. The reports will be written so as to be accessible by lay persons, with appendices as needed to contain the more technically detailed material. Detail on this provision of information must be provided in the EMP.

NOISE COMPLAINTS

32. Before commissioning the first group of turbines of the wind energy facility a complaints evaluation and response process must be developed by the wind energy facility operator, and be submitted to the responsible authority for approval. The draft of the proposed process must be made available for comment to occupiers of dwellings within 5km of the nearest wind turbine.

33. The specific matters that should be included in the complaints, evaluation and response process must be provided in the EMP.

BLADE SHADOW FLICKER

34. Shadow flicker from the wind energy facility must not exceed 30 hours per annum at any dwelling existing prior to 26th October 2006.

This condition does not apply to any dwelling on land on which part of the wind energy facility is erected. (This exemption will be given effect through an agreement with the landowner that will apply to any occupant of the dwelling).

35. Before the use starts, details of a complaint evaluation and response process must be submitted to and approved by the Minister for Planning to assess any alleged breach of Condition 34. Thereafter, the use must be carried out in accordance with the approved process and alleged breaches identified by this process must be addressed to the satisfaction of the Minister for Planning.

TELEVISION RECEPTION AND INTERFERENCE

36. A pre-construction survey shall be offered to residents at all dwellings up to 3kms from a wind turbine to determine television reception strength. The proponent shall

Appendix C—Monitoring locations

P22A

Figure C1 Aerial image of P22A noise monitoring location

Figure C2 View north from P22A noise monitoring location

Figure C3 View east from P22A noise monitoring location

Figure C4 View south from P22A noise monitoring location

Figure C5 View west from P22A noise monitoring location

Q15A Alternative

Figure C6 Aerial image of Q15A alternative noise monitoring location

Figure C7 View north from Q15A alternative noise monitoring location

Figure C8 View east from Q15A alternative noise monitoring location

Figure C9 View south from Q15A alternative noise monitoring location

Figure C10 View west from Q15A alternative noise monitoring location

R26B

Figure C11 Aerial image of R26B noise monitoring location

Figure C12 View north from R26B noise monitoring location

Figure C13 View east from R26B noise monitoring location

Figure C14 View south from R26B noise monitoring location

Figure C15 View west from R26B noise monitoring location

V16A

Figure C16 Aerial image of V16A noise monitoring location

Figure C17 View north from V16A noise monitoring location

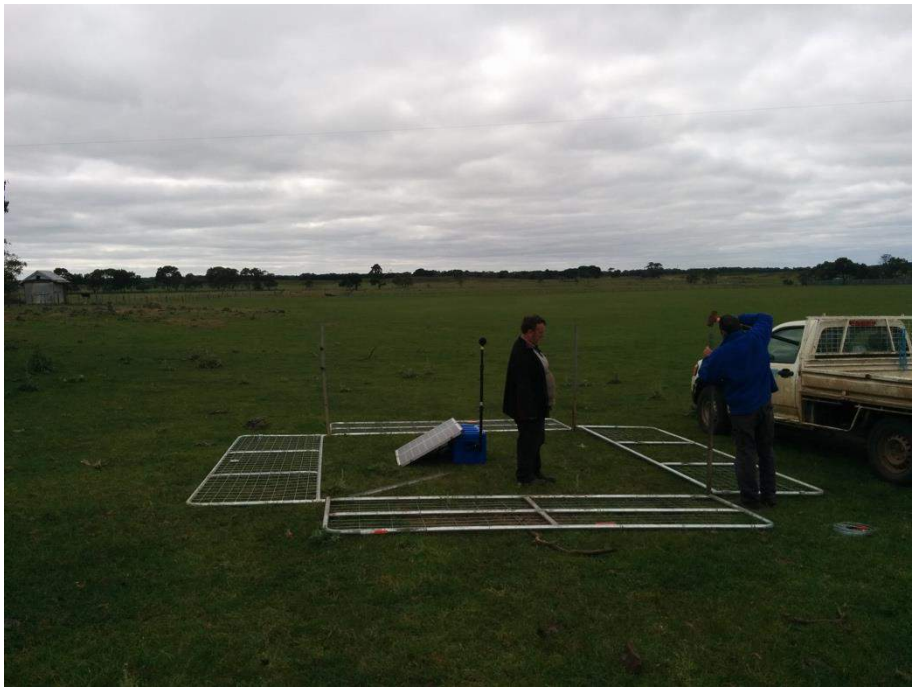


Figure C18 View east from V16A noise monitoring location

Figure C19 View south from V16A noise monitoring location

Figure C20 View west from V16A noise monitoring location

W26A

Figure C21 Aerial image of W26A noise monitoring location

Figure C22 View north from W26A noise monitoring location

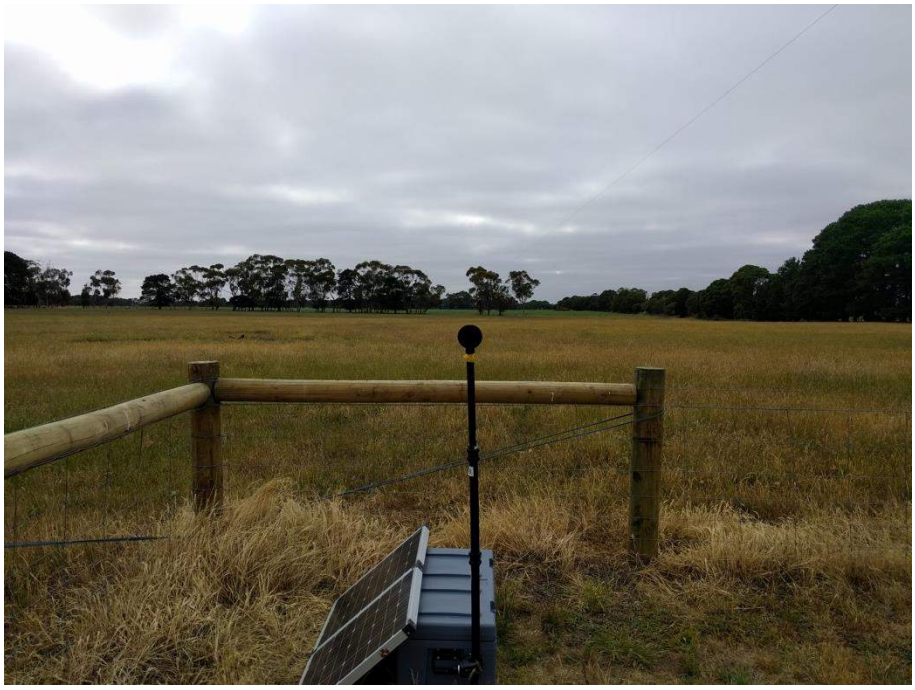


Figure C23 View east from W26A noise monitoring location

Figure C24 View south from W26A noise monitoring location

Figure C25 View west from W26A noise monitoring location

X21A Alternative

Figure C26 Aerial image of X21A alternative noise monitoring location

Figure C27 View north from X21A alternative noise monitoring location

Figure C28 View east from X21A alternative noise monitoring location

Figure C29 View south from X21A alternative noise monitoring location

Figure C30 View west from X21A alternative noise monitoring location

Y21A

Figure C31 Aerial image of Y21A noise monitoring location

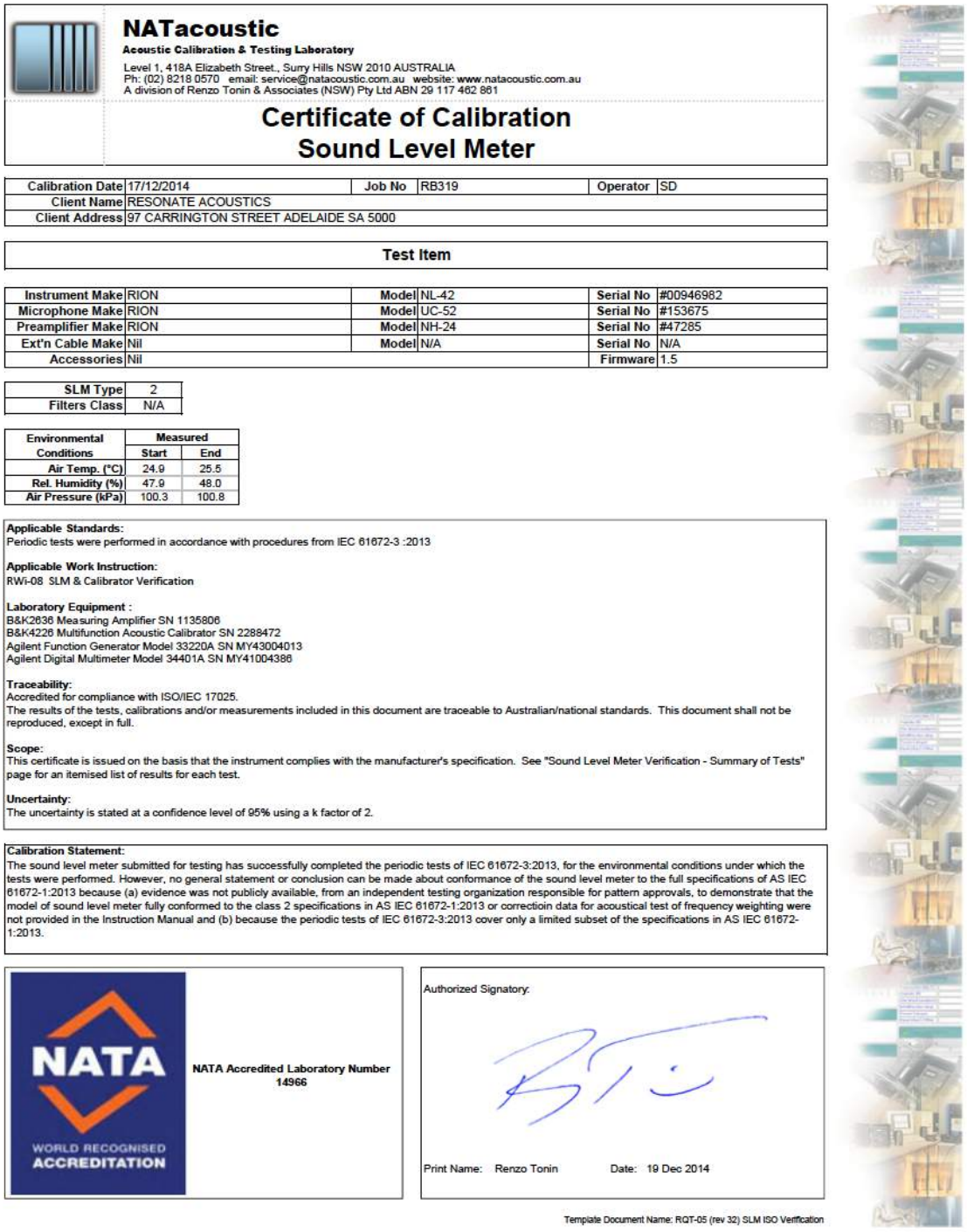
Figure C32 View north from Y21A noise monitoring location

Figure C33 View east from Y21A noise monitoring location

Figure C34 View south from Y21A noise monitoring location

Figure C35 View west from Y21A noise monitoring location

Appendix D—Calibration certificates



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Certificate of Calibration
Sound Level Meter

Calibration Date	17/12/2014	Job No	RB319	Operator	SD
Client Name	RESONATE ACOUSTICS				
Client Address	97 CARRINGTON STREET ADELAIDE SA 5000				

Test Item

Instrument Make	RION	Model	NL-42	Serial No	#00946982
Microphone Make	RION	Model	UC-52	Serial No	#153675
Preamplifier Make	RION	Model	NH-24	Serial No	#47285
Ext'n Cable Make	Nil	Model	N/A	Serial No	N/A
Accessories	Nil			Firmware	1.5

SLM Type	2
Filters Class	N/A

Environmental Conditions	Measured Start	Measured End
Air Temp. (°C)	24.9	25.5
Rel. Humidity (%)	47.9	48.0
Air Pressure (kPa)	100.3	100.8

Applicable Standards:
Periodic tests were performed in accordance with procedures from IEC 61672-3 :2013

Applicable Work Instruction:
RWi-08 SLM & Calibrator Verification

Laboratory Equipment :
B&K2636 Measuring Amplifier SN 1135806
B&K4226 Multifunction Acoustic Calibrator SN 2288472
Agilent Function Generator Model 33220A SN MY43004013
Agilent Digital Multimeter Model 34401A SN MY41004386

Traceability:
Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
The uncertainty is stated at a confidence level of 95% using a k factor of 2.

Calibration Statement:
The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of AS IEC 61672-1:2013 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the class 2 specifications in AS IEC 61672-1:2013 or correctioin data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in AS IEC 61672-1:2013.

NATA
WORLD RECOGNISED ACCREDITATION

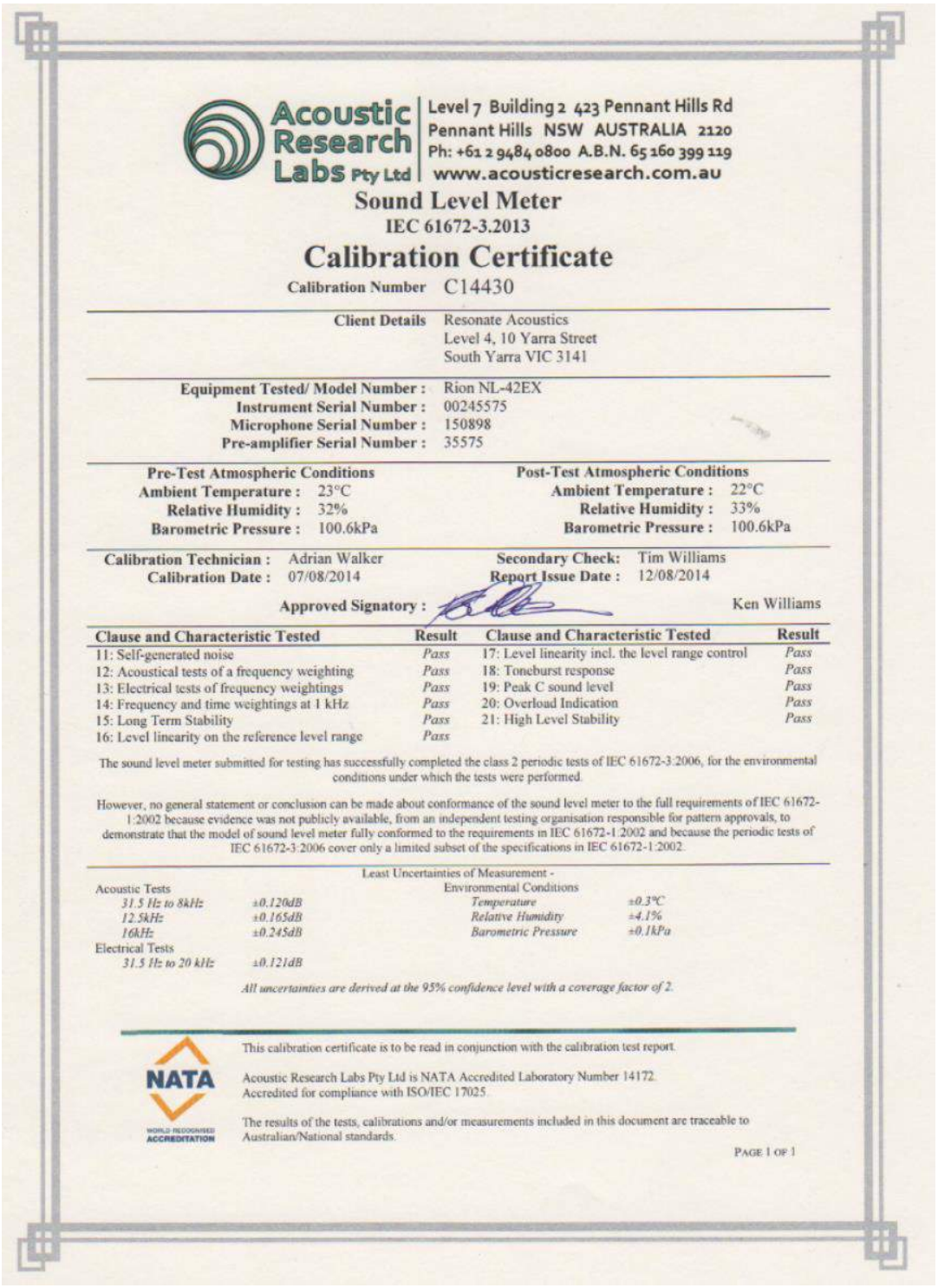
NATA Accredited Laboratory Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 19 Dec 2014

Template Document Name: RQT-05 (rev 32) SLM ISO Verification

Figure D1 Calibration certificate for Rion NL-42 noise logger used at P22A



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Ph: +61 2 9484 0800 A.B.N. 65 160 399 119
www.acousticresearch.com.au

Sound Level Meter
IEC 61672-3.2013

Calibration Certificate

Calibration Number C14430

Client Details Resonate Acoustics
Level 4, 10 Yarra Street
South Yarra VIC 3141

Equipment Tested/ Model Number : Rion NL-42EX
Instrument Serial Number : 00245575
Microphone Serial Number : 150898
Pre-amplifier Serial Number : 35575

Pre-Test Atmospheric Conditions		Post-Test Atmospheric Conditions	
Ambient Temperature :	23°C	**Ambient Temperature :**	22°C
Relative Humidity :	32%	**Relative Humidity :**	33%
Barometric Pressure :	100.6kPa	**Barometric Pressure :**	100.6kPa

Calibration Technician : Adrian Walker
Calibration Date : 07/08/2014
Secondary Check: Tim Williams
Report Issue Date : 12/08/2014

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
11: Self-generated noise	*Pass*	17: Level linearity incl. the level range control	*Pass*
12: Acoustical tests of a frequency weighting	*Pass*	18: Toneburst response	*Pass*
13: Electrical tests of frequency weightings	*Pass*	19: Peak C sound level	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	20: Overload Indication	*Pass*
15: Long Term Stability	*Pass*	21: High Level Stability	*Pass*
16: Level linearity on the reference level range	*Pass*		

The sound level meter submitted for testing has successfully completed the class 2 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2002 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002 and because the periodic tests of IEC 61672-3:2006 cover only a limited subset of the specifications in IEC 61672-1:2002.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.120dB*	*Temperature*	*±0.3°C*
12.5kHz	*±0.165dB*	*Relative Humidity*	*±4.1%*
16kHz	*±0.245dB*	*Barometric Pressure*	*±0.1kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.121dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

NATA WORLD-RECOGNISED ACCREDITATION

This calibration certificate is to be read in conjunction with the calibration test report.

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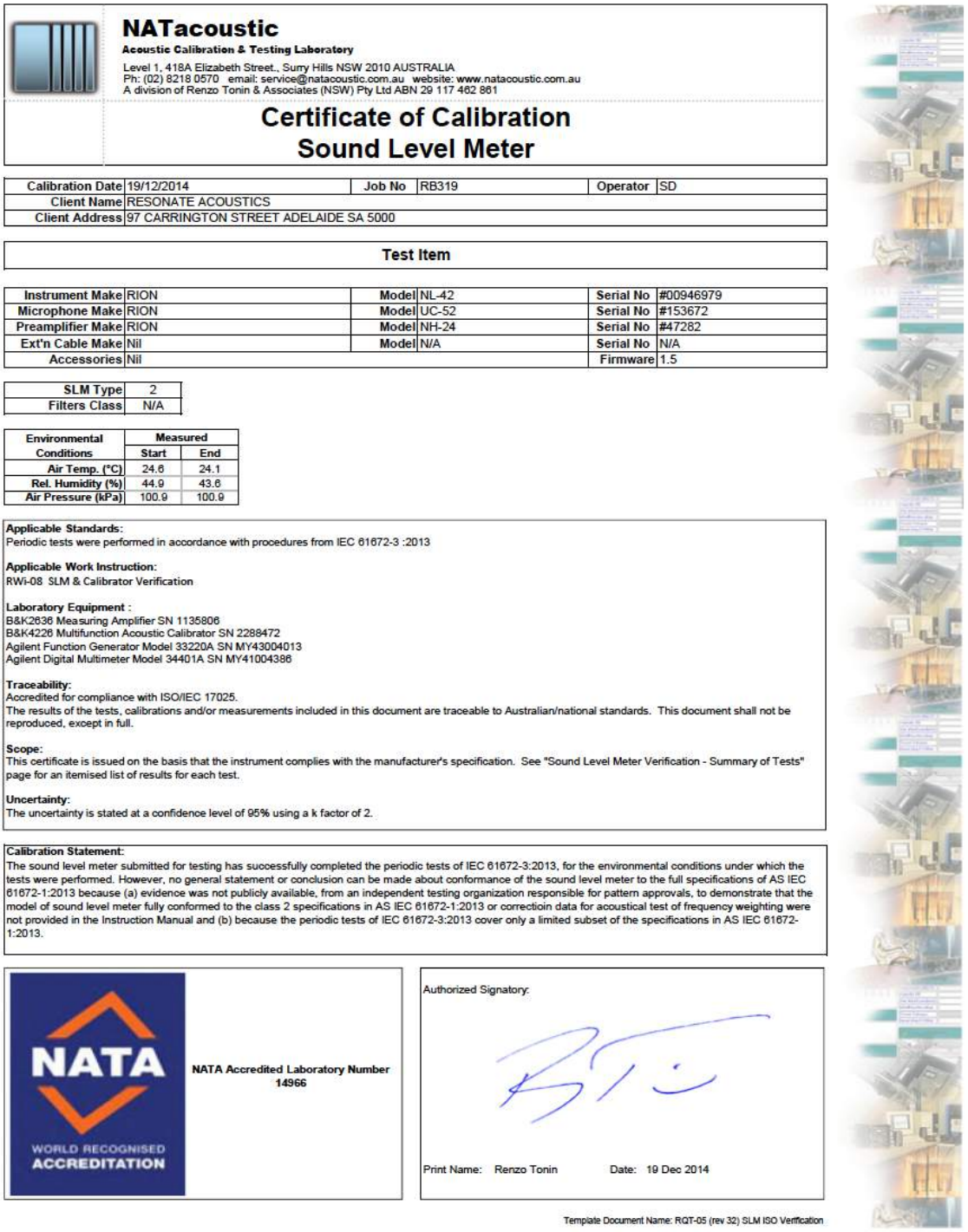
PAGE 1 OF 1

Figure D2 Calibration certificate for Rion NL-42 noise logger used at Q15A alternative location



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Certificate of Calibration
Sound Level Meter

Calibration Date	19/12/2014	Job No	RB319	Operator	SD
Client Name	RESONATE ACOUSTICS				
Client Address	97 CARRINGTON STREET ADELAIDE SA 5000				

Test Item

Instrument Make	RION	Model	NL-42	Serial No	#00946979
Microphone Make	RION	Model	UC-52	Serial No	#153672
Preamplifier Make	RION	Model	NH-24	Serial No	#47282
Ext'n Cable Make	Nil	Model	N/A	Serial No	N/A
Accessories	Nil			Firmware	1.5

SLM Type	2
Filters Class	N/A

Environmental Conditions	Measured	
	Start	End
Air Temp. (°C)	24.6	24.1
Rel. Humidity (%)	44.9	43.6
Air Pressure (kPa)	100.9	100.9

Applicable Standards:
Periodic tests were performed in accordance with procedures from IEC 61672-3 :2013

Applicable Work Instruction:
RWi-08 SLM & Calibrator Verification

Laboratory Equipment :
B&K2636 Measuring Amplifier SN 1135806
B&K4226 Multifunction Acoustic Calibrator SN 2288472
Agilent Function Generator Model 33220A SN MY43004013
Agilent Digital Multimeter Model 34401A SN MY41004386

Traceability:
Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
The uncertainty is stated at a confidence level of 95% using a k factor of 2.

Calibration Statement:
The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of AS IEC 61672-1:2013 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the class 2 specifications in AS IEC 61672-1:2013 or correctioin data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in AS IEC 61672-1:2013.

NATA
WORLD RECOGNISED ACCREDITATION

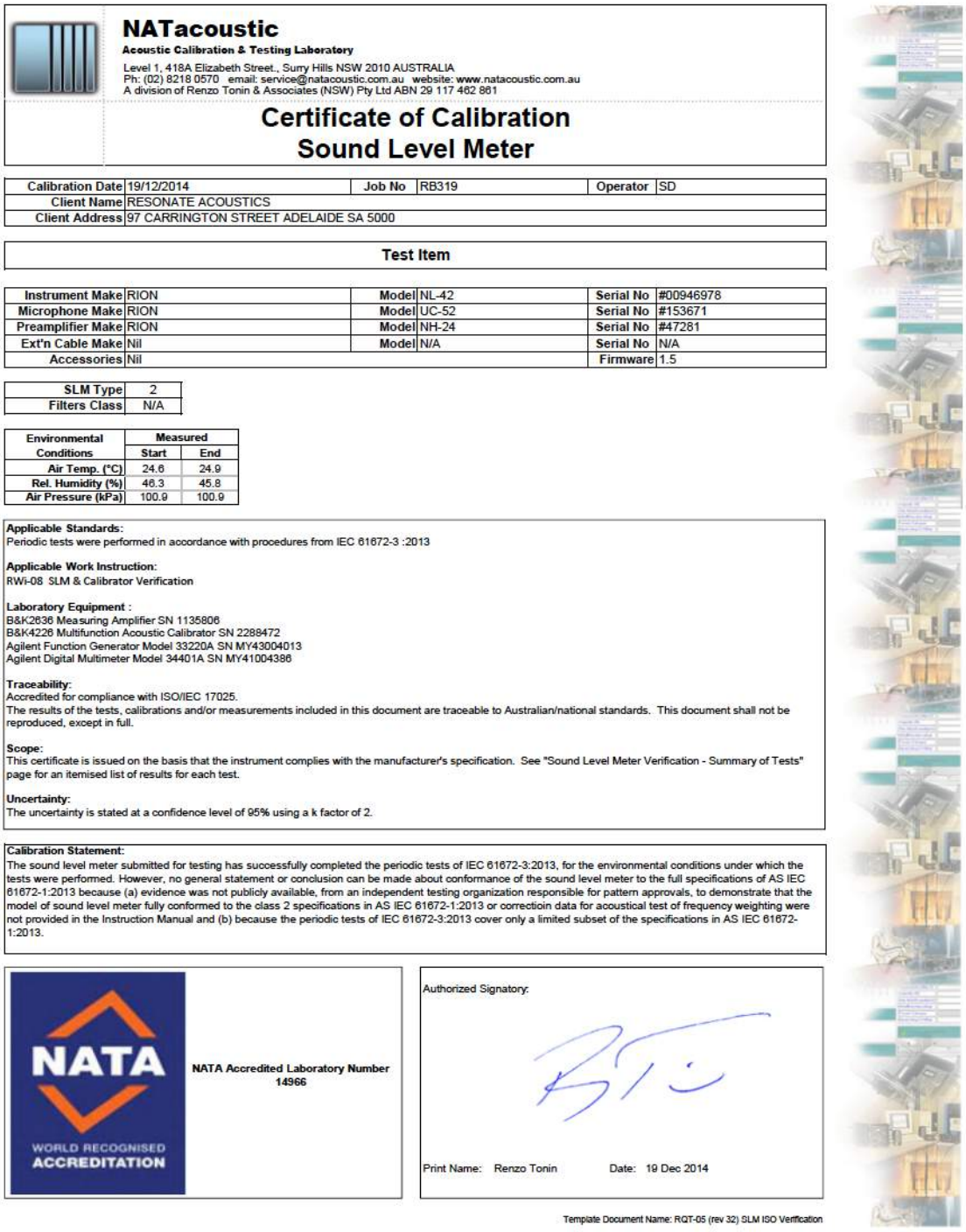
NATA Accredited Laboratory Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 19 Dec 2014

Template Document Name: RQT-05 (rev 32) SLM ISO Verification

Figure D3 Calibration certificate for Rion NL-42 noise logger used at R26B



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Certificate of Calibration
Sound Level Meter

Calibration Date	19/12/2014	Job No	RB319	Operator	SD
Client Name	RESONATE ACOUSTICS				
Client Address	97 CARRINGTON STREET ADELAIDE SA 5000				

Test Item

Instrument Make	RION	Model	NL-42	Serial No	#00946978
Microphone Make	RION	Model	UC-52	Serial No	#153671
Preamplifier Make	RION	Model	NH-24	Serial No	#47281
Ext'n Cable Make	Nil	Model	N/A	Serial No	N/A
Accessories	Nil			Firmware	1.5

SLM Type	2
Filters Class	N/A

Environmental Conditions	Measured	
	Start	End
Air Temp. (°C)	24.6	24.9
Rel. Humidity (%)	46.3	45.8
Air Pressure (kPa)	100.9	100.9

Applicable Standards:
Periodic tests were performed in accordance with procedures from IEC 61672-3 :2013

Applicable Work Instruction:
RWi-08 SLM & Calibrator Verification

Laboratory Equipment :
B&K2636 Measuring Amplifier SN 1135806
B&K4226 Multifunction Acoustic Calibrator SN 2288472
Agilent Function Generator Model 33220A SN MY43004013
Agilent Digital Multimeter Model 34401A SN MY41004386

Traceability:
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Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
The uncertainty is stated at a confidence level of 95% using a k factor of 2.

Calibration Statement:
The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of AS IEC 61672-1:2013 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the class 2 specifications in AS IEC 61672-1:2013 or correctioin data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in AS IEC 61672-1:2013.

NATA
WORLD RECOGNISED ACCREDITATION

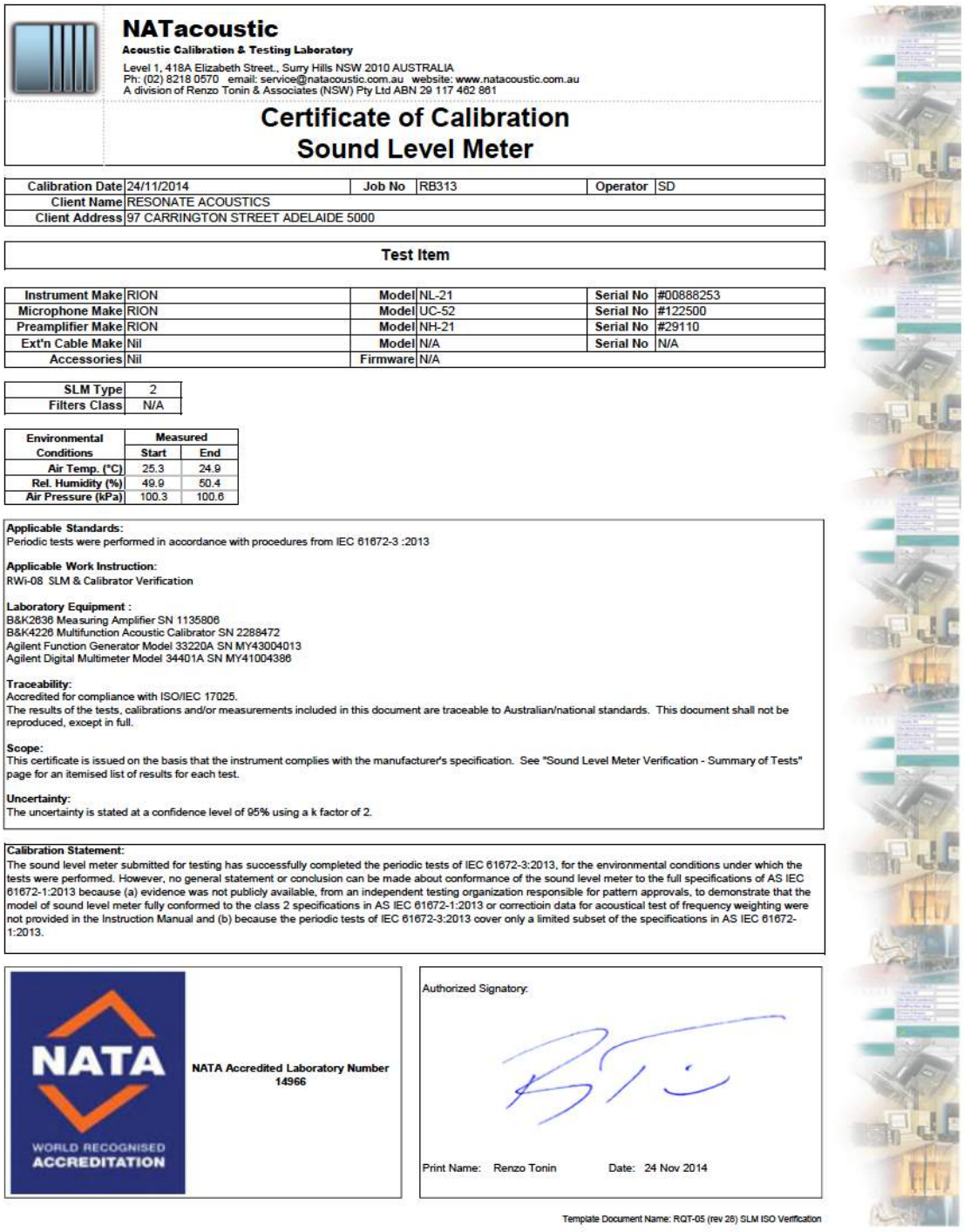
NATA Accredited Laboratory Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 19 Dec 2014

Template Document Name: RQT-05 (rev 32) SLM ISO Verification

Figure D4 Calibration certificate for Rion NL-42 noise logger used at V16A



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Certificate of Calibration
Sound Level Meter

Calibration Date	24/11/2014	Job No	RB313	Operator	SD
Client Name	RESONATE ACOUSTICS				
Client Address	97 CARRINGTON STREET ADELAIDE 5000				

Test Item

Instrument Make	RION	Model	NL-21	Serial No	#00888253
Microphone Make	RION	Model	UC-52	Serial No	#122500
Preamplifier Make	RION	Model	NH-21	Serial No	#29110
Ext'n Cable Make	Nil	Model	N/A	Serial No	N/A
Accessories	Nil	Firmware	N/A		

SLM Type	2
Filters Class	N/A

Environmental Conditions	Measured	
	Start	End
Air Temp. (°C)	25.3	24.9
Rel. Humidity (%)	49.9	50.4
Air Pressure (kPa)	100.3	100.6

Applicable Standards:
Periodic tests were performed in accordance with procedures from IEC 61672-3 :2013

Applicable Work Instruction:
RWi-08 SLM & Calibrator Verification

Laboratory Equipment :
B&K2636 Measuring Amplifier SN 1135806
B&K4226 Multifunction Acoustic Calibrator SN 2288472
Agilent Function Generator Model 33220A SN MY43004013
Agilent Digital Multimeter Model 34401A SN MY41004386

Traceability:
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Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
The uncertainty is stated at a confidence level of 95% using a k factor of 2.

Calibration Statement:
The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of AS IEC 61672-1:2013 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the class 2 specifications in AS IEC 61672-1:2013 or correctioin data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in AS IEC 61672-1:2013.

NATA
WORLD RECOGNISED ACCREDITATION

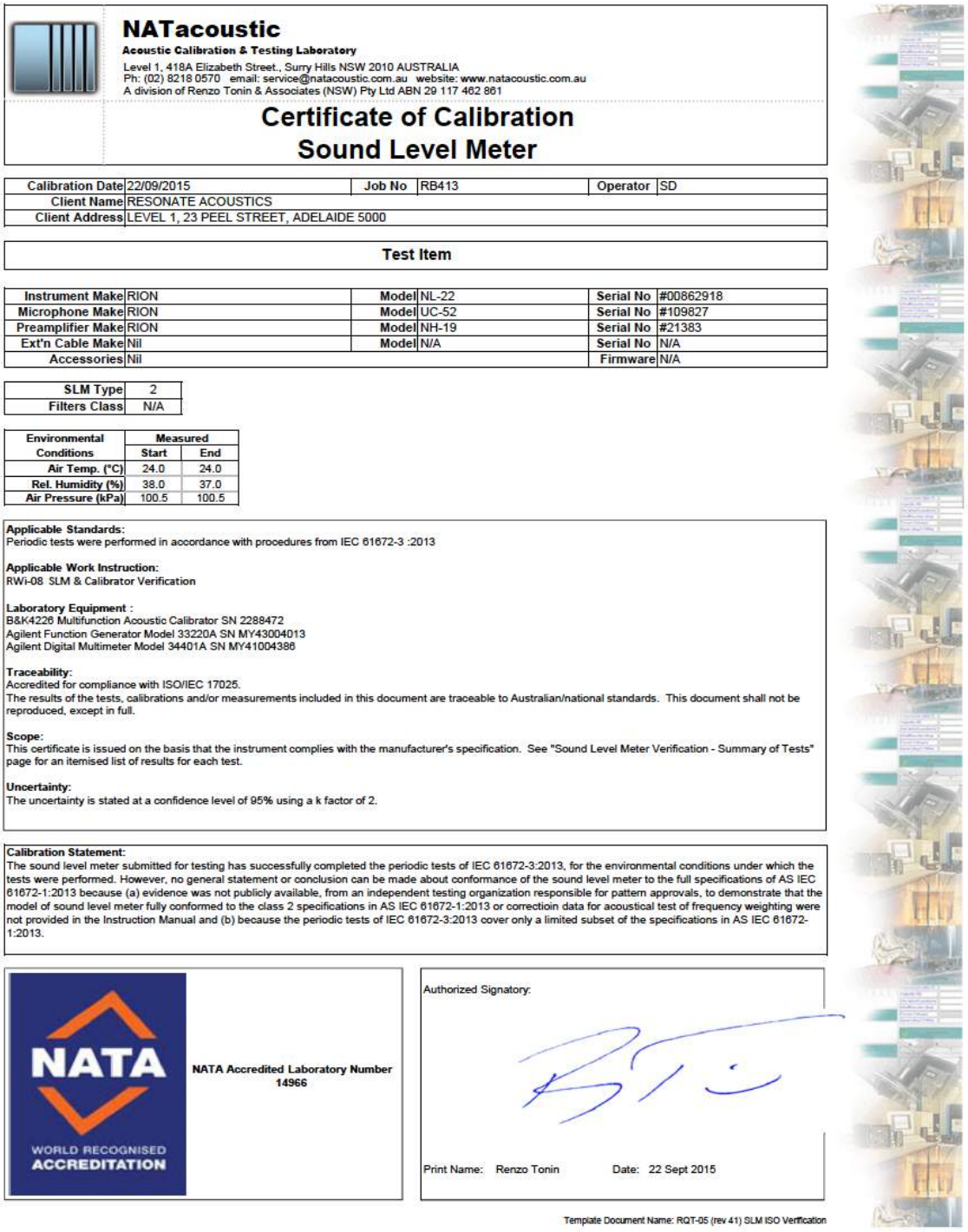
NATA Accredited Laboratory Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 24 Nov 2014

Template Document Name: RQT-05 (rev 26) SLM ISO Verification

Figure D5 Calibration certificate for Rion NL-21 noise logger used at W26A



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Certificate of Calibration
Sound Level Meter

Calibration Date	22/09/2015	Job No	RB413	Operator	SD
Client Name	RESONATE ACOUSTICS				
Client Address	LEVEL 1, 23 PEEL STREET, ADELAIDE 5000				

Test Item

Instrument Make	RION	Model	NL-22	Serial No	#00862918
Microphone Make	RION	Model	UC-52	Serial No	#109827
Preamplifier Make	RION	Model	NH-19	Serial No	#21383
Ext'n Cable Make	Nil	Model	N/A	Serial No	N/A
Accessories	Nil			Firmware	N/A

SLM Type	2
Filters Class	N/A

Environmental Conditions	Measured	
	Start	End
Air Temp. (°C)	24.0	24.0
Rel. Humidity (%)	38.0	37.0
Air Pressure (kPa)	100.5	100.5

Applicable Standards:
Periodic tests were performed in accordance with procedures from IEC 61672-3 :2013

Applicable Work Instruction:
RWi-08 SLM & Calibrator Verification

Laboratory Equipment :
B&K4226 Multifunction Acoustic Calibrator SN 2288472
Agilent Function Generator Model 33220A SN MY43004013
Agilent Digital Multimeter Model 34401A SN MY41004386

Traceability:
Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
The uncertainty is stated at a confidence level of 95% using a k factor of 2.

Calibration Statement:
The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of AS IEC 61672-1:2013 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the class 2 specifications in AS IEC 61672-1:2013 or correctioin data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in AS IEC 61672-1:2013.

NATA
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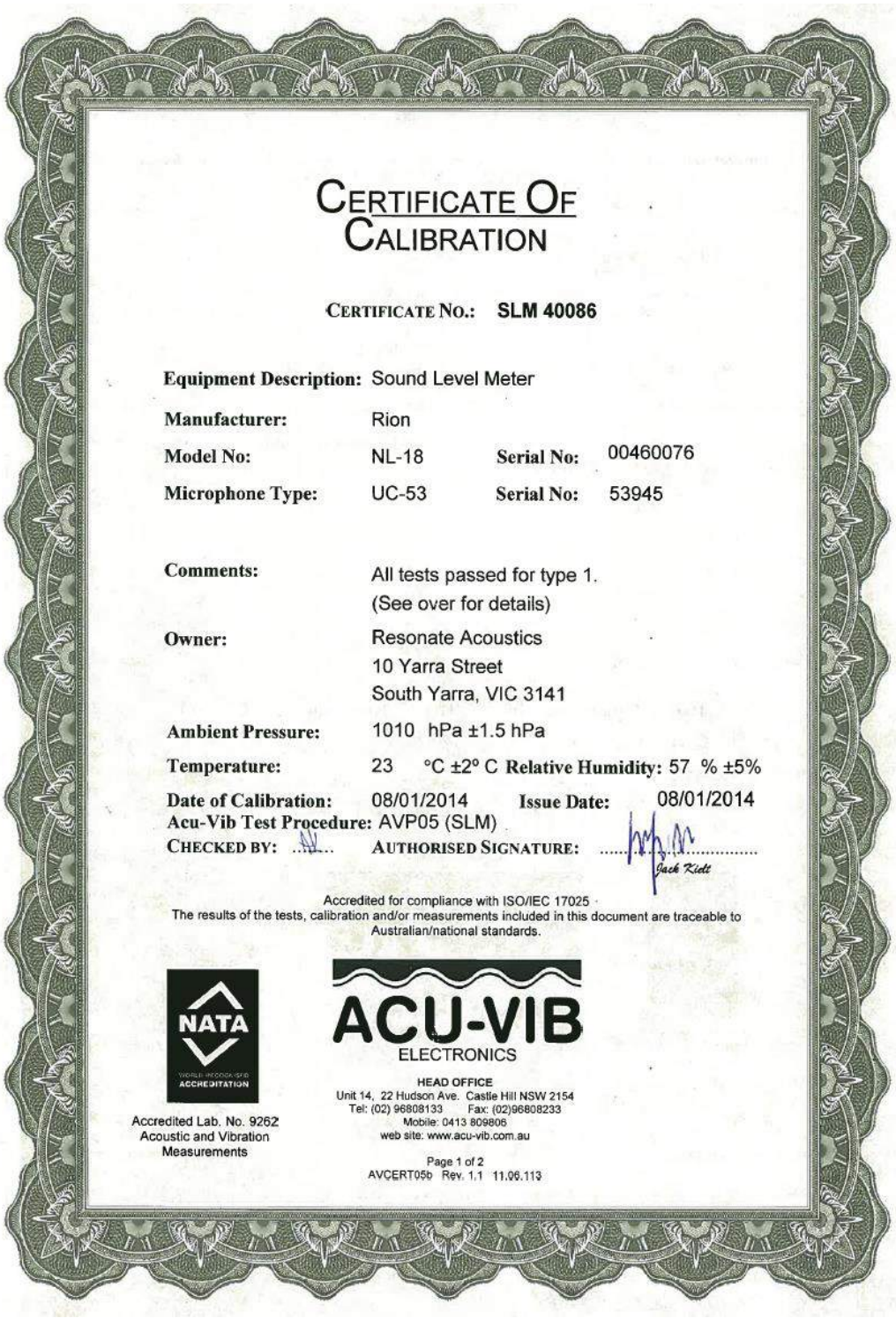
NATA Accredited Laboratory Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 22 Sept 2015

Template Document Name: RQT-05 (rev 41) SLM ISO Verification

Figure D6 Calibration certificate for Rion NL-22 noise logger used at X21A alternative location



CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 40086

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-18	**Serial No:**	00460076
Microphone Type:	UC-53	**Serial No:**	53945
Comments:	All tests passed for type 1. (See over for details)		
Owner:	Resonate Acoustics 10 Yarra Street South Yarra, VIC 3141		
Ambient Pressure:	1010 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	57 % ±5%
Date of Calibration:	08/01/2014	**Issue Date:**	08/01/2014

Acu-Vib Test Procedure: AVP05 (SLM)

CHECKED BY: ..... **AUTHORISED SIGNATURE:** .....

Jack Kidd

Accredited for compliance with ISO/IEC 17025
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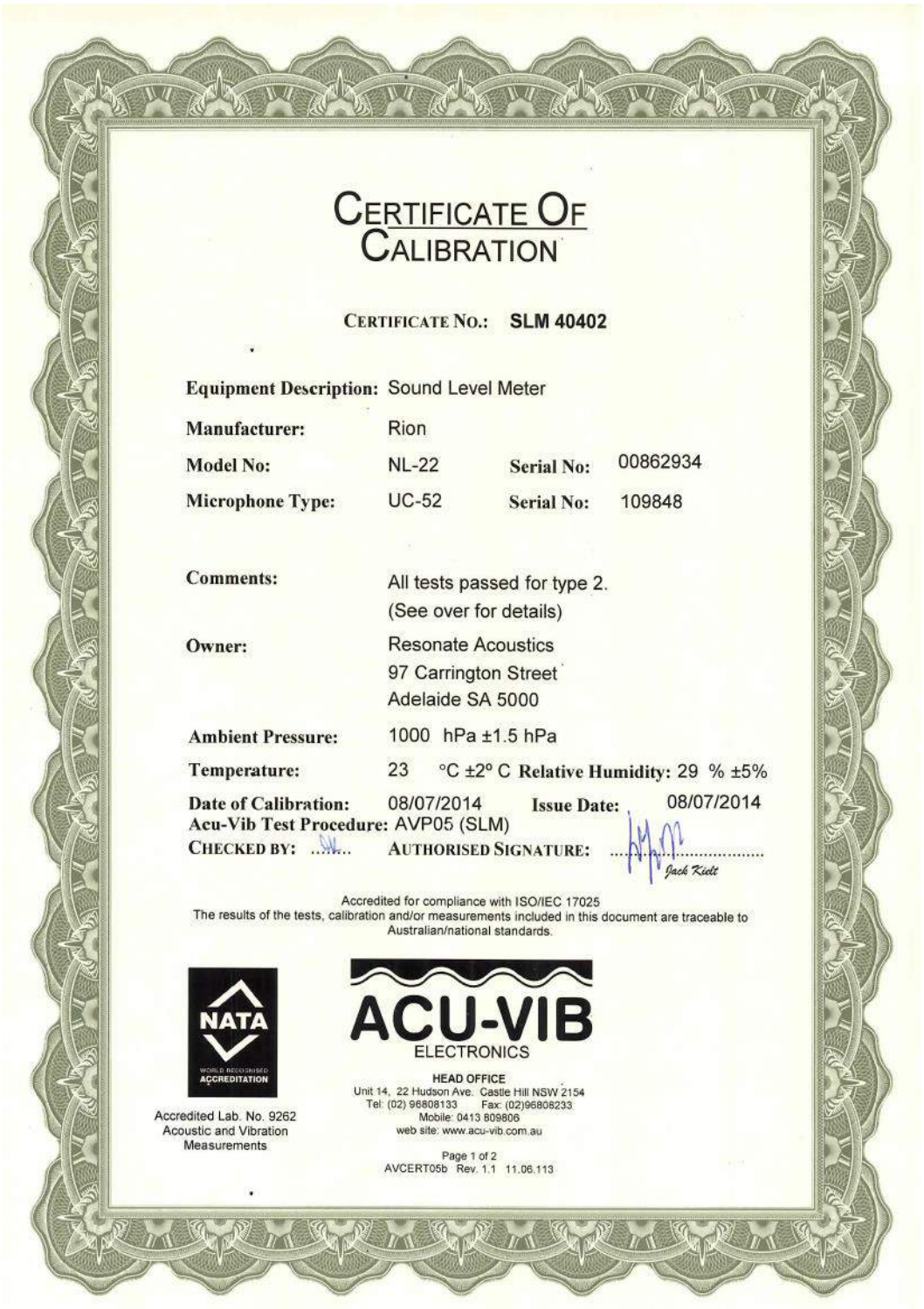
Figure D7 Calibration certificate for Rion NL-18 noise logger used at Y21A from 22/10 to 12/11



CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 40402

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-22	**Serial No:**	00862934
Microphone Type:	UC-52	**Serial No:**	109848
Comments:	All tests passed for type 2. (See over for details)		
Owner:	Resonate Acoustics 97 Carrington Street Adelaide SA 5000		
Ambient Pressure:	1000 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	29 % ±5%
Date of Calibration:	08/07/2014	**Issue Date:**	08/07/2014
Acu-Vib Test Procedure:	AVP05 (SLM)		
CHECKED BY:	.....	**AUTHORISED SIGNATURE:**	..... Jack Kidd

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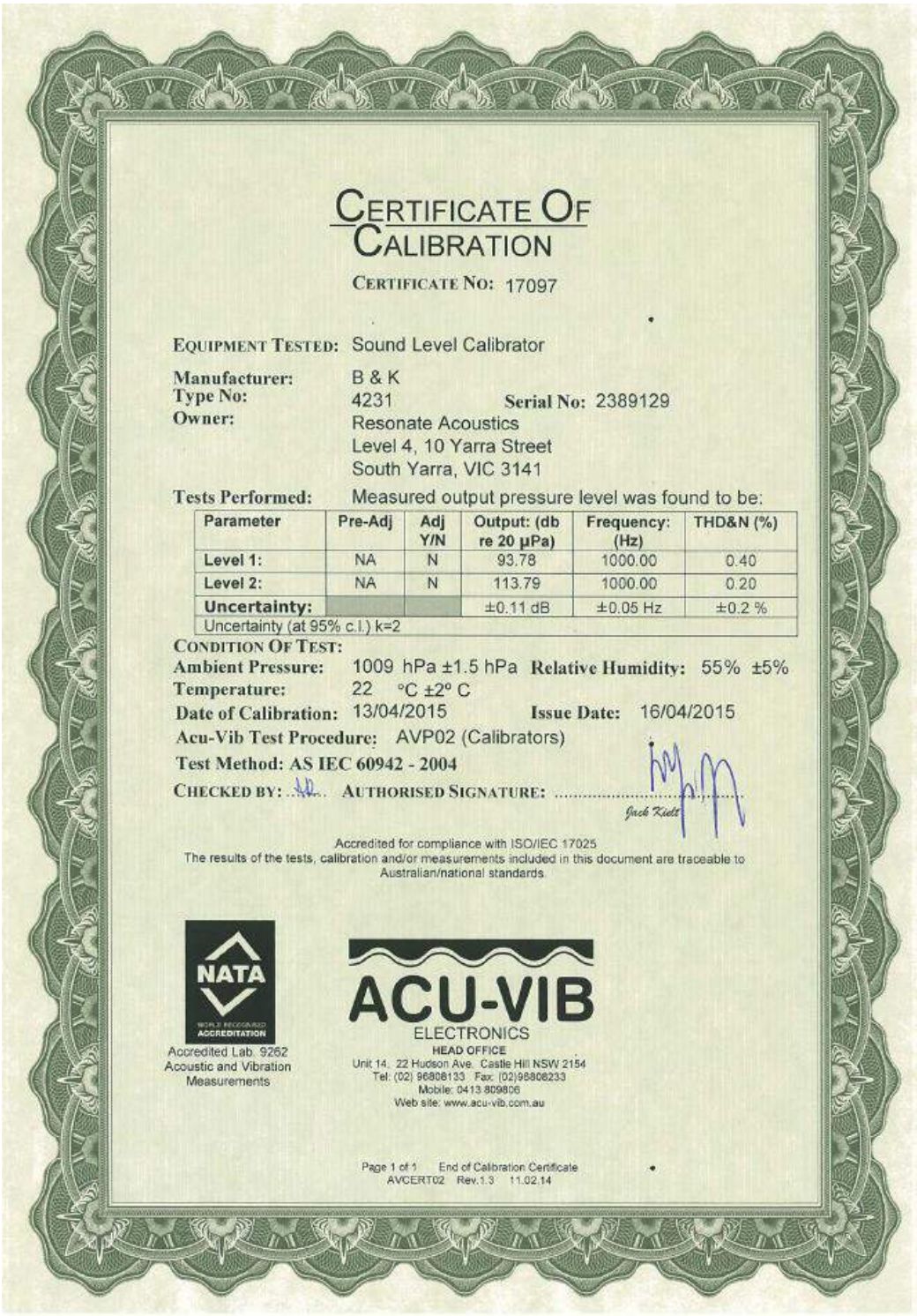
Figure D8 Calibration certificate for Rion NL-22 noise logger used at Y21A from 12/11 to 21/12



CERTIFICATE OF CALIBRATION

CERTIFICATE NO: 17097

EQUIPMENT TESTED: Sound Level Calibrator

Manufacturer: B & K
Type No: 4231 **Serial No:** 2389129
Owner: Resonate Acoustics
Level 4, 10 Yarra Street
South Yarra, VIC 3141

Tests Performed: Measured output pressure level was found to be:

Parameter	Pre-Adj	Adj Y/N	Output: (db re 20 µPa)	Frequency: (Hz)	THD&N (%)
Level 1:	NA	N	93.78	1000.00	0.40
Level 2:	NA	N	113.79	1000.00	0.20
Uncertainty:			±0.11 dB	±0.05 Hz	±0.2 %
Uncertainty (at 95% c.l.) k=2					

CONDITION OF TEST:
Ambient Pressure: 1009 hPa ±1.5 hPa **Relative Humidity:** 55% ±5%
Temperature: 22 °C ±2° C
Date of Calibration: 13/04/2015 **Issue Date:** 16/04/2015
Acu-Vib Test Procedure: AVP02 (Calibrators)
Test Method: AS IEC 60942 - 2004
CHECKED BY: ..... **AUTHORISED SIGNATURE:** .....
Jack Kiely

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

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Page 1 of 1 End of Calibration Certificate
AVCERT02 Rev.1.3 11.02.14

Figure D9 Calibration certificate for B&K 4231 sound level calibrator used at all locations

Appendix E—DNV GL wind speed analysis report

GL Garrad Hassan

TECHNICAL NOTE

Title	**Macarthur – Wind Data For Background And Compliance Noise Testing**
Client	**AGL Energy Limited**
Contact	**Adam Mackett**
Document No.	**45347/PT/02**
Issue	**C**
Classification	**Client's discretion**
Author	**Elena Bašić**
Checked	**Christian Peake and Timothy Johnson**
Approved	**Christian Peake**

History

Issue:	Date:	Summary
A	15 Jan 13	First issue
B	19 Mar 13	Update to include generation of compliance test wind data
C	30 Apr 13	Update with further background

CONTENTS

1 INTRODUCTION

AGL Energy (AGL) ("The Client") and Meridian Energy Australia (ME) have developed the Macarthur Wind Farm ("The Project") in southwest Victoria. The wind farm reached practical completion on 31 January 2013 and consists of 140 Vestas V112 3.0 MW turbines at 84 m hub height.

AGL has instructed GL Garrad Hassan (GL GH) to generate a report which summarises the work conducted in define wind data to be used for background and compliance noise testing at the Macarthur Wind Farm.

Background and compliance noise testing requires and consistent source of wind data, which can be used to generate noise curves before and after construction of the wind farm. If the noise produced by the wind farm is to be assessed accurately, the consistency of the wind data in the background and compliance noise curves is of paramount importance.

This report defines the generation of a time series of wind speed and direction data at the site's permanent masts, for the purposes of generating background noise curves. A process to obtain consistent wind data even after the wind farm is constructed is defined and this is intended to be included in compliance testing.

The results of the analysis are reported below with a time series provided for each mast as a separate excel file.

2 BACKGROUND – WIND FARM NOISE TESTING

Noise assessment and testing is an important part of developing a wind farm. The aim of this is to design a wind farm which will be compliant with planning requirements and, then, conduct actual noise measurements at the site to confirm that this is the case.

Verification of wind farm noise requires two main sets of noise measurements, one before and one after the wind farm is operational. By comparing these two noise measurements, the impact of the operational wind farm can be assessed.

Noise measurements are firstly conducted before the wind farm is operational to measure the level of ambient 'Background' noise. Background noise can be produced by many sources, however, in a rural setting this is commonly dominated by the noise of the wind. Wind moving through vegetation will produce more Background noise with increasing wind speed and, therefore, Background noise measurements are commonly regressed against wind speed to produce a Background noise curve.

Compliance noise monitoring is similar to Background noise monitoring however it is conducted after the wind farm becomes operational. Compliance noise monitoring therefore includes any noise produced by the operation of the wind farm. Compliance noise data are also regressed against wind speed to produce a Compliance noise curve.

Comparison of the background and compliance noise curves can give an indication of the influence that the wind farm is having on noise levels, however, it is important that both curves have a consistent source of wind data to ensure a fair comparison. This report details the generation of a consistent source of wind data for both the Background and Compliance noise curves.

3 WIND SPEED TIME SERIES FOR BACKGROUND NOISE CURVES

3.1 Summary

In summary, the wind speed time series will be generated by calculating directional correlation ratios between the decommissioned energy development masts and the current permanent masts.

These correlation ratios will be used to synthesise the historic wind speed and direction data that would have been recorded by the permanent masts over the period August 2010 to January 2011, before they were constructed.

The synthesis process will use the Officer and Robertson Masts as a reference.

The details of the six permanent masts (M1-M6) and the reference masts ("Officer" and "Robertson") used in this analysis are summarised in Table 1.

Mast	Wind speed measurement height [m]	Wind direction measurement height [m]	Data start date	Data end date
M1	84	82	30 Jul 2011	31 Oct 2012
M2	84	82	8 Sep 2011	31 Oct 2012
M3	84	82	12 Nov 2011	31 Oct 2012
M4	84	82	22 Jul 2011	31 Oct 2012
M5	84	82	1 Aug 2011	31 Oct 2012
M6	84	82	13 Nov 2011	31 Oct 2012
Officer	90	50	15 Dec 2007	1 Jun 2012
Robertson	90	88	14 Dec 2007	6 Aug 2012

Table 1 Details of meteorological mast data used

3.2 Reference data - energy development masts

Given that it is preferable to have a consistent reference station for the whole site, data recorded at permanent masts M1-M6 were initially correlated with both the Officer and Robertson masts to determine the most suitable reference mast. The correlation uncertainties were assessed in conjunction with the mast location map, to select the most appropriate reference mast for the synthesis process.

It was found that, on average, the Robertson Mast has a lower uncertainty when correlating to the permanent masts. Furthermore, the map of the site presented in Figure 1 shows the Robertson mast is, on balance, more centrally located. In addition, the average overlap period between the Robertson and the permanent mast data is 332 days, compared with 266 days for the Officer mast.

Wind vane at 50m was used at the Officer mast due to significant gaps in the 70m and 88m vane data. As a linear relationship was observed between all wind vanes on the mast, it is considered that this will not have a significant impact on the assessment.

From the above assessment, it is considered appropriate to use the Robertson mast as the primary reference mast for all subsequent calculations across the site.

3.3 Generation of wind speed time series

Correlations were conducted from the Robertson mast to each of the permanent masts. An example of the correlation across the site is presented in Figure 2, which shows the relationship between the Robertson mast and Mast M1. This has been selected as the example as it represents the most challenging correlation at the site due to the large distance between these two masts.

The following steps are taken to synthesise data at Mast M1:

- Directions correlation ratios are obtained from the correlation.
- Wind data are obtained for the Robertson mast over the period of interest, August 2010 to January 2011.
- Directions correlation ratios are applied to the Robertson mast data to synthesise wind data at Mast M1.

A similar process to this has been applied to synthesise data at each of the permanent masts.

Some short periods of missing data were found in the Robertson data set and therefore, during these periods data from the Officer Mast were used in the correlation and data synthesis. Remaining periods where data from both the Robertson and Officer Masts were not available are denoted at a '999' in the time series data supplied.

4 WIND SPEED TIME SERIES FOR COMPLIANCE NOISE CURVES

In order to ensure that all data used for compliance noise monitoring is consistent with that used for the background noise curves, wake-free data at each of the permanent masts must be compiled using correlation ratios for the various direction sectors. The strategy and ratios required for the data synthesis is summarised in Table 2 and Table 3 below.

To obtain wake free data for a given permanent mast:

- Noise data from each noise logger will need to be correlated with wind speed recordings from the nearest permanent met mast (PMM).

  To maintain consistency with the background noise curves, these wind speed recordings must be wake free.
- During compliance testing, the wind turbines will be operational and therefore, data at a given PMM must be synthesised to remove wake effects in some direction sectors.

  This process uses data from other permanent masts, as defined in Table 2.
- Synthesised data at a PMM is obtained by applying the directional correlation ratios listed in Table 3.

For example, wake free data at Mast M1 is obtained by:

- When the direction at M1 is between 70-218°, the mast is affected by turbine wake and synthesis from M4 is required.

  For each directions sector, the relevant directional correlation ratio, between Mast M4 and M1, is applied to the M4 wind data, to synthesise wake free data at M1.
- For wind directions between 20-70°, the relevant directional correlation ratio between Mast M6 and M1 is applied to the M6 wind data, to synthesise wake free data at M1.
- Measured data at mast M1 for wind directions between 218-20° are wake free.
- The synthesised and measured data generated above are combined to generate one time series of wind speed data, which is considered to be wake free. Direction data from M1 should be included.

Noise logger	PMM	Data source for each direction
Y16A	M1	M4 (70-218^{o}), M1 (218-20^{o}), M6 (20-70^{o})
Y18A	M1	M4 (70-218^{o}), M1 (218-20^{o}), M6 (20-70^{o})
Y21A	M4	M4 (70-218^{o}), M3 (218-340^{o}), M6 (340-70^{o})
W26A	M4	M4 (70-218^{o}), M3 (218-340^{o}), M6 (340-70^{o})
S26A	M4	M4 (70-218^{o}), M3 (218-340^{o}), M6 (340-70^{o})
R26B	M4	M4 (70-218^{o}), M3 (218-340^{o}), M6 (340-70^{o})
O17A	M6	M4 (70-175^{o}), M6 (175-70^{o})
O23A	M6	M4 (70-175^{o}), M6 (175-70^{o})
Q20A	M6	M4 (70-175^{o}), M6 (175-70^{o})

Table 2 Strategy to compile wake free data at permanent masts

M4 to M1	
Bin centres (degrees)	**Speedup ratio**
0	0.96543
30	1.050769
60	0.988592
90	1.097402
120	1.076224
150	1.061829
180	1.068266
210	1.000269
240	0.980692
270	0.981011
300	1.008541
330	1.068897
All directional	**1.016492**

M6 to M1	
Bin centres (degrees)	**Speedup ratio**
0	1.034547
30	1.056619
60	1.020335
90	1.087069
120	1.068844
150	1.047645
180	1.068453
210	1.114299
240	1.165274
270	1.194899
300	1.182525
330	1.096741
All directional	**1.094051**

M3 to M4	
Bin centres (degrees)	**Speedup ratio**
0	1.026274
30	0.961163
60	0.975658
90	0.971357
120	0.978159
150	1.013695
180	1.022938
210	1.056454
240	1.023231
270	1.054981
300	1.085166
330	0.993236
All directional	**1.023826**

M6 to M4	
Bin centres (degrees)	**Speedup ratio**
0	1.064022
30	0.983088
60	0.999326
90	0.991799
120	1.023324
150	0.976371
180	1.037683
210	1.145282
240	1.185487
270	1.213244
300	1.139725
330	1.015667
All directional	**1.071545**

M4 to M6	
Bin centres (degrees)	**Speedup ratio**
0	0.932446
30	1.002183
60	1.000303
90	1.00651
120	0.97507
150	1.028481
180	0.987351
210	0.88845
240	0.839709
270	0.826959
300	0.864311
330	0.971517
All directional	**0.933305**

Table 3 Directional correlation ratios between permanent met masts

5 CONCLUSIONS

Generation of wind speed data for background noise curves

A wind speed time series for each permanent mast has been generated by calculating directional correlation ratios between the decommissioned energy development masts and the current permanent masts.

These correlation ratios were used to synthesise the historic wind speed and direction data that would have been recorded by the permanent masts over the period August 2010 to January 2011, before they were constructed.

The synthesis process used the Officer and Robertson Masts as a reference.

Wind data for compliance testing

In order to ensure that all data used for compliance noise monitoring is consistent with that used for the background noise curves, wake-free data at each of the permanent masts must be compiled using correlation ratios for the various direction sectors.

The strategy and ratios required for the data synthesis is summarised in Table 2 and Table 3.

6 REFERENCES

1. AECOM Australia Pty Ltd, “Macarthur Wind Farm: Background Noise Monitoring Report”, Document No. A11C01RP-01, 6 July 2011.

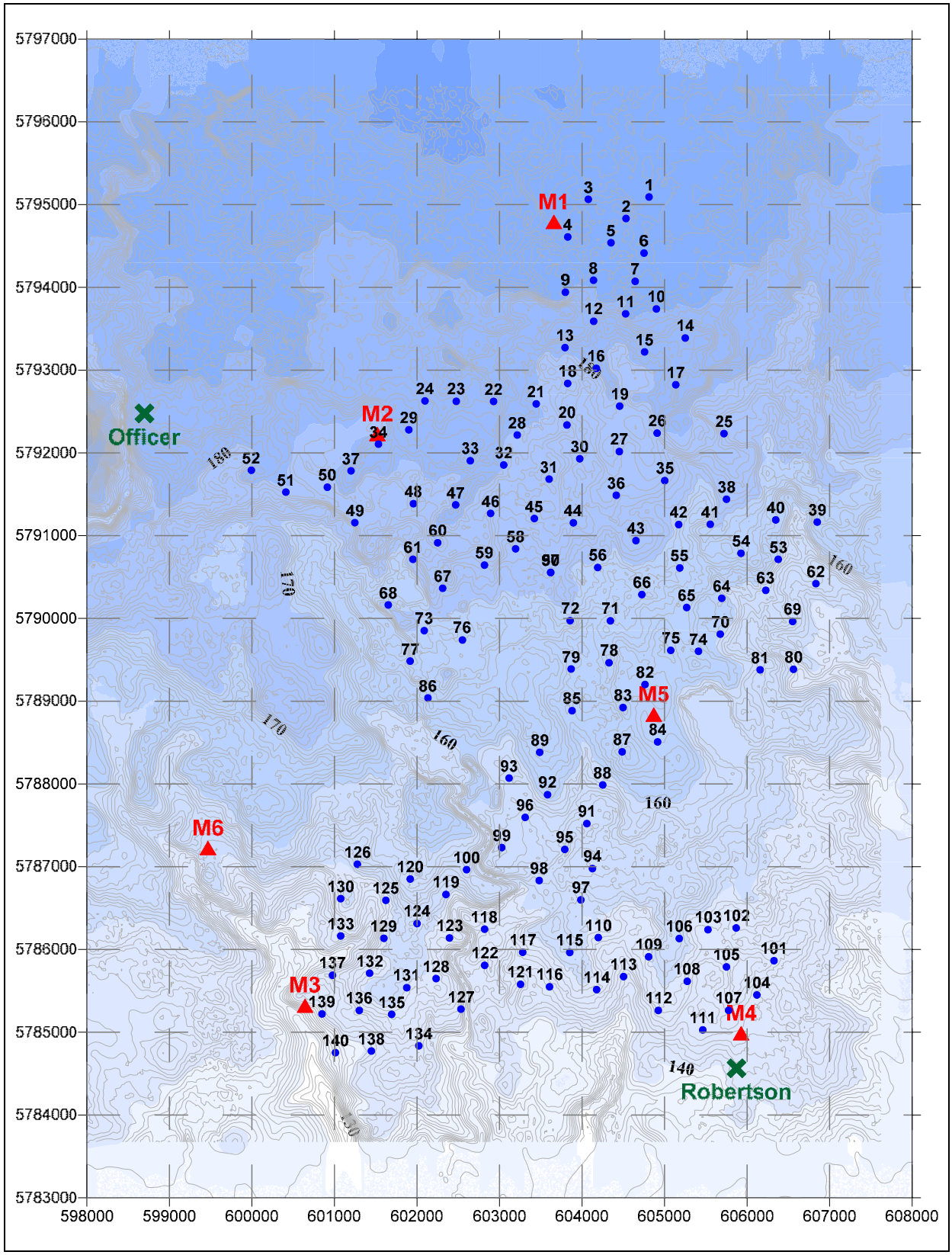

Figure 1 Macarthur wind farm site and mast locations

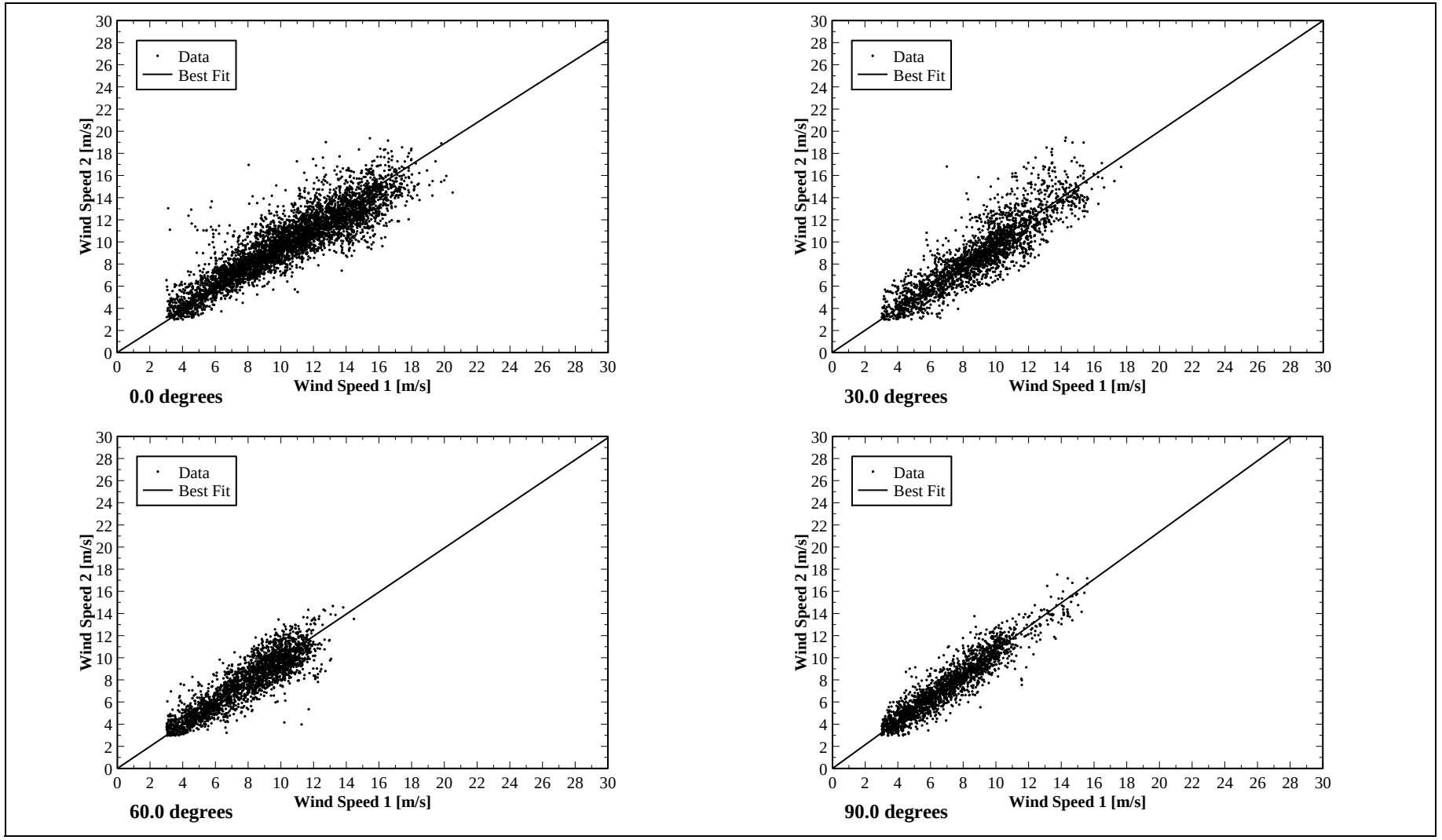

Figure 2 Directional correlation of wind speeds recorded at Robertson (1) and Mast M1 (2)

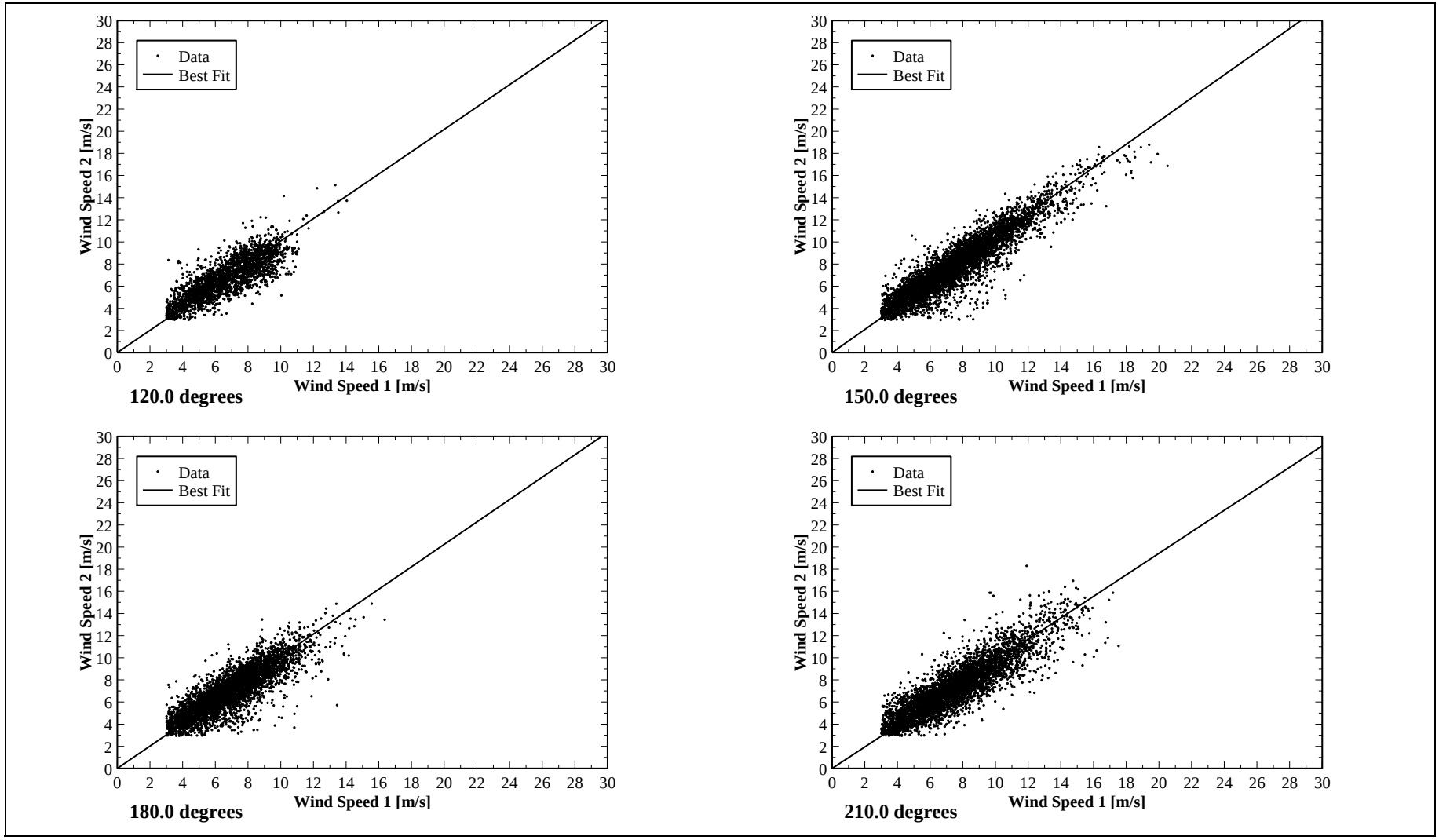

Figure 2 Directional correlation of wind speeds recorded at Robertson (1) and Mast M1 (2)

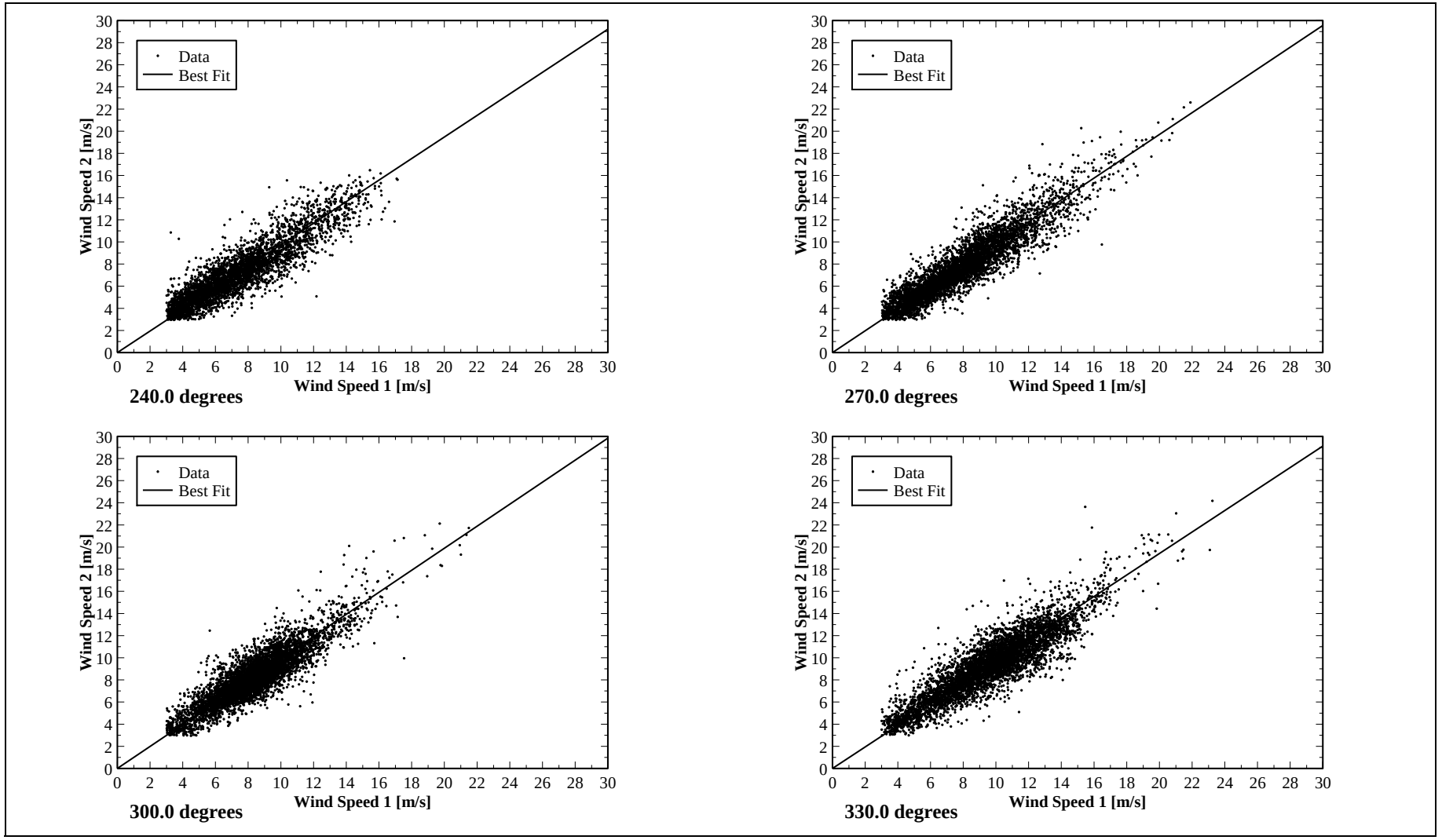

Figure 2 Directional correlation of wind speeds recorded at Robertson (1) and Mast M1 (2)

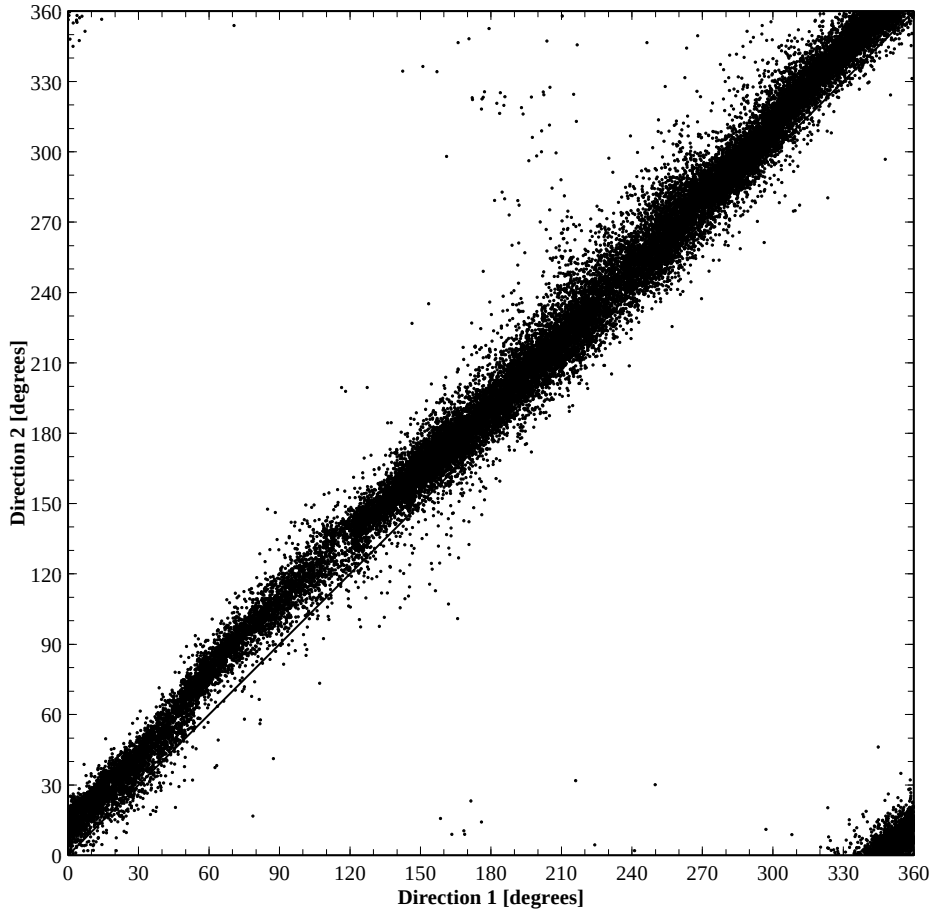

Figure 2 Directional correlation of wind direction recorded at Robertson (1) and Mast M1 (2)

Appendix F—All measured data points

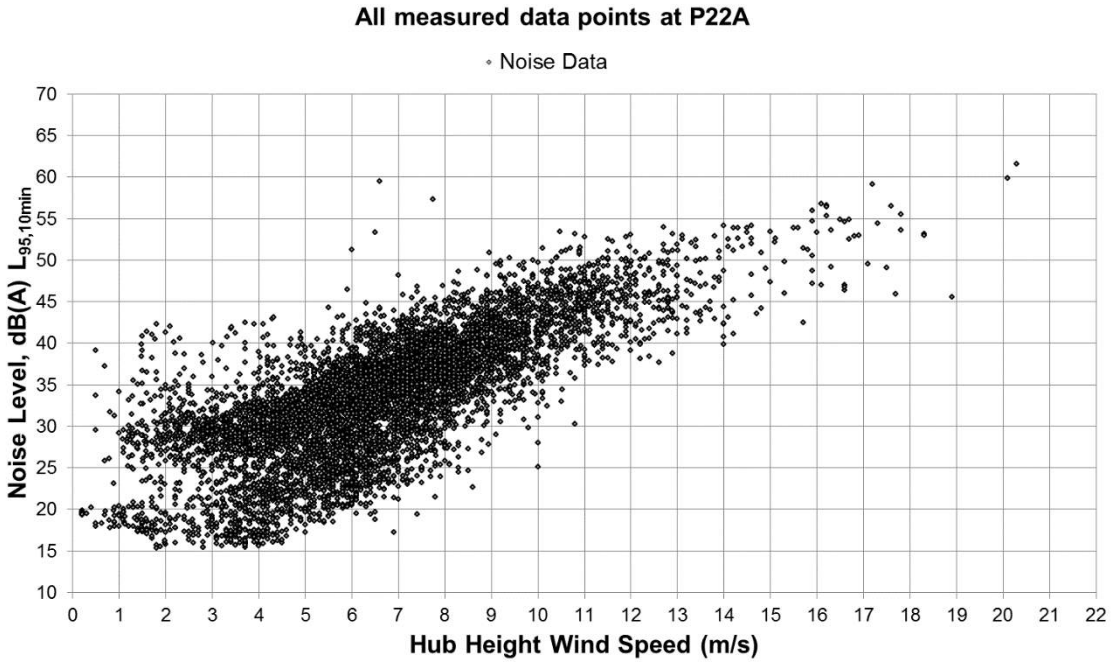

Figure F1 All measured data points at P22A

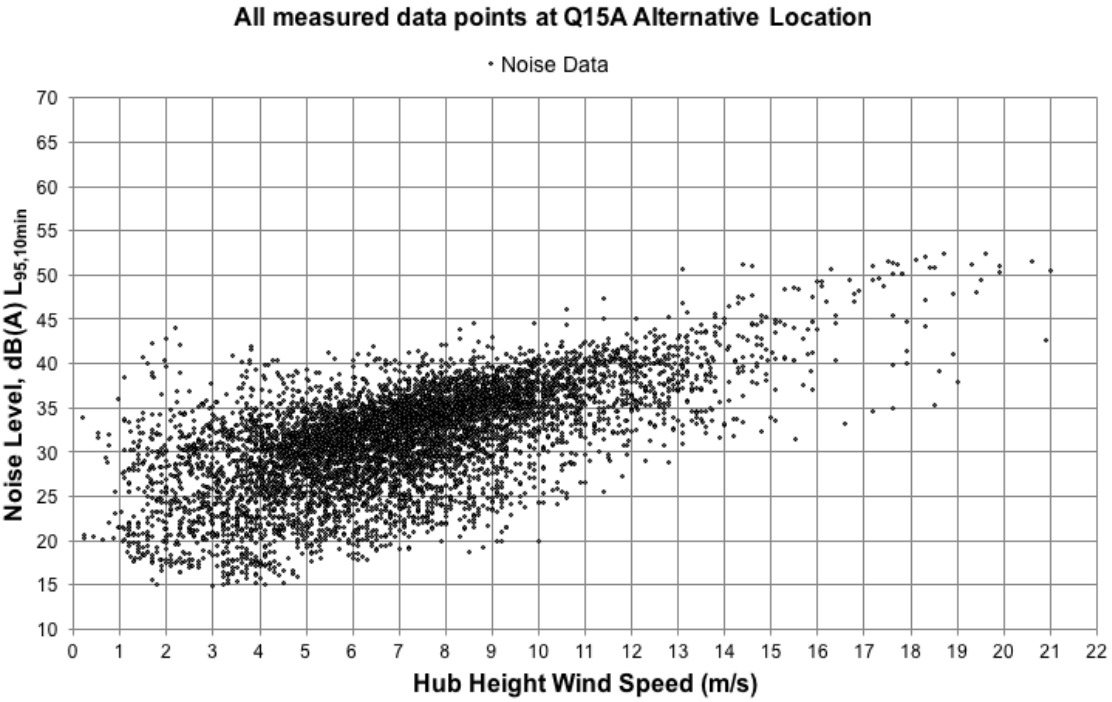

Figure F2 All measured data points at Q15A alternative location

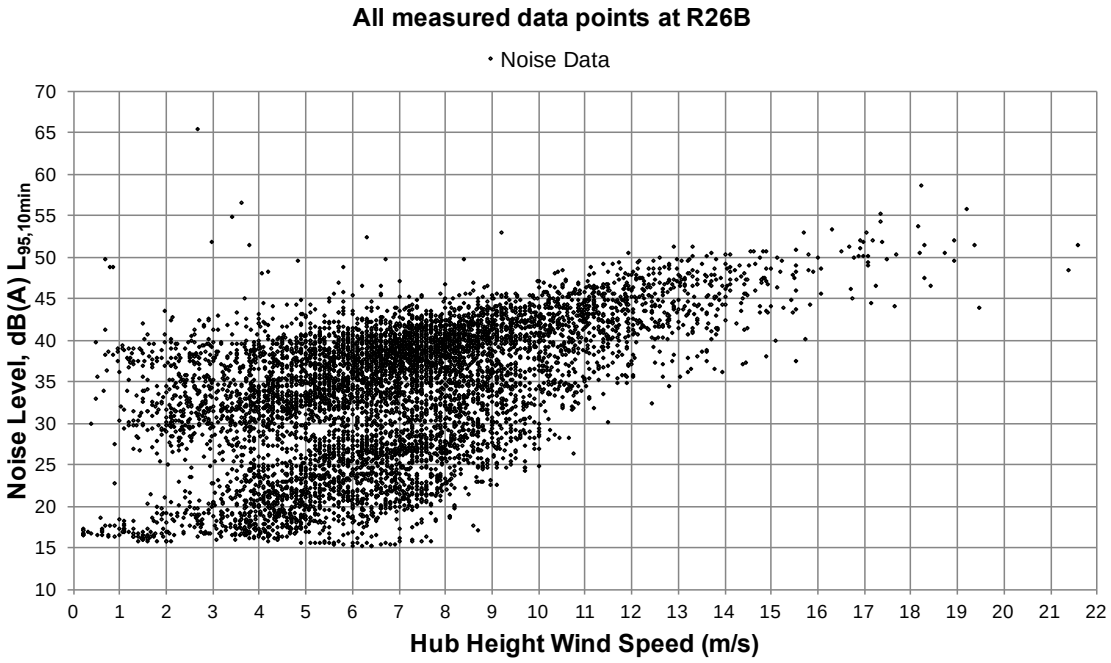

Figure F3 All measured data points at R26B

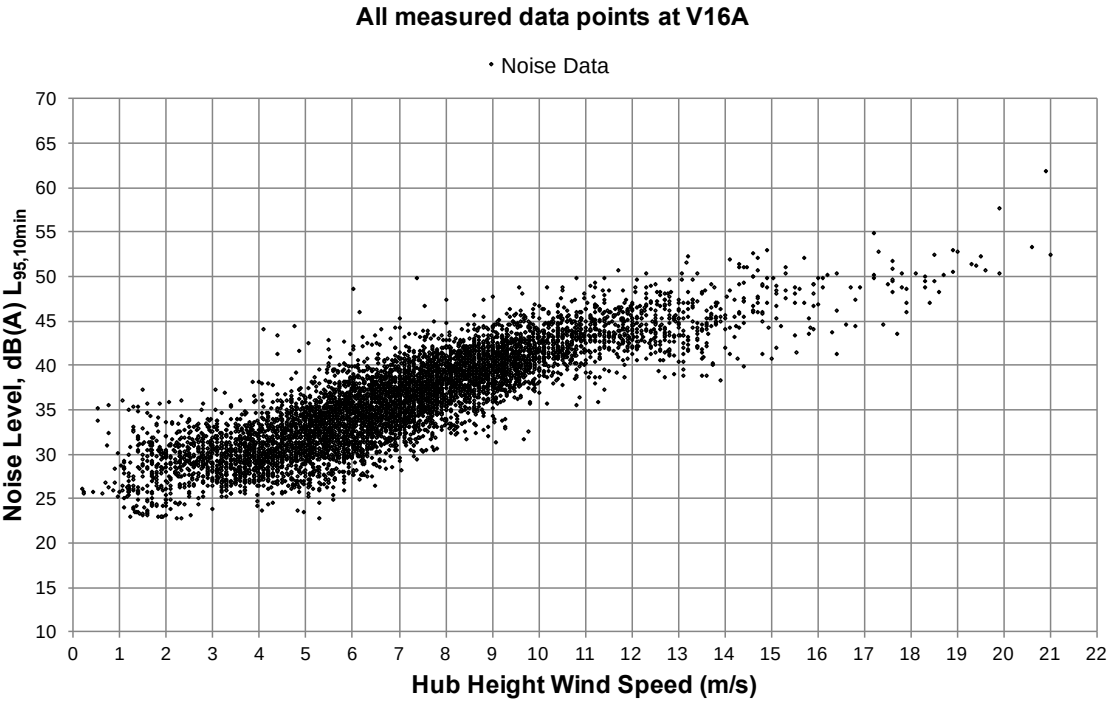

Figure F4 All measured data points at V16A

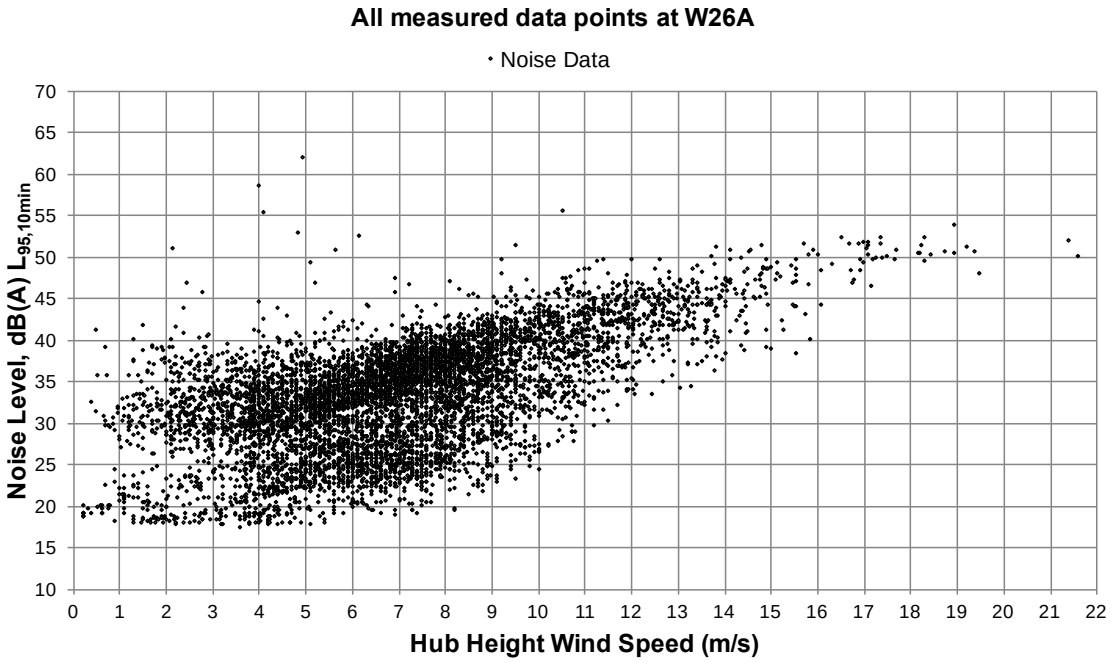

Figure F5 All measured data points at W26A

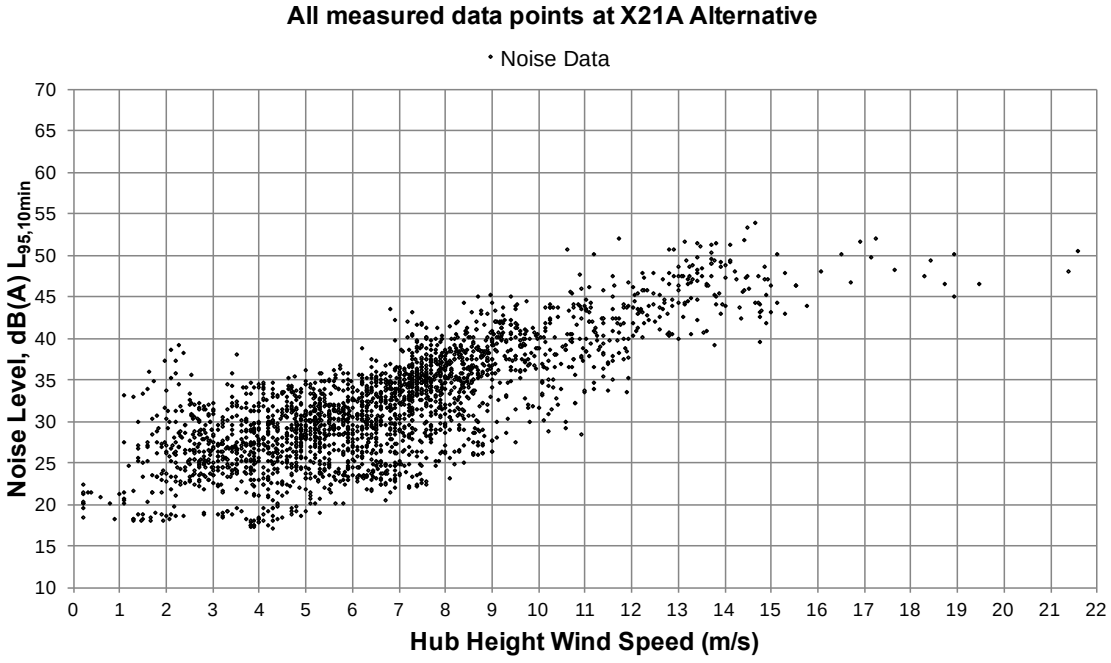

Figure F6 All measured data points at X21A alternative location

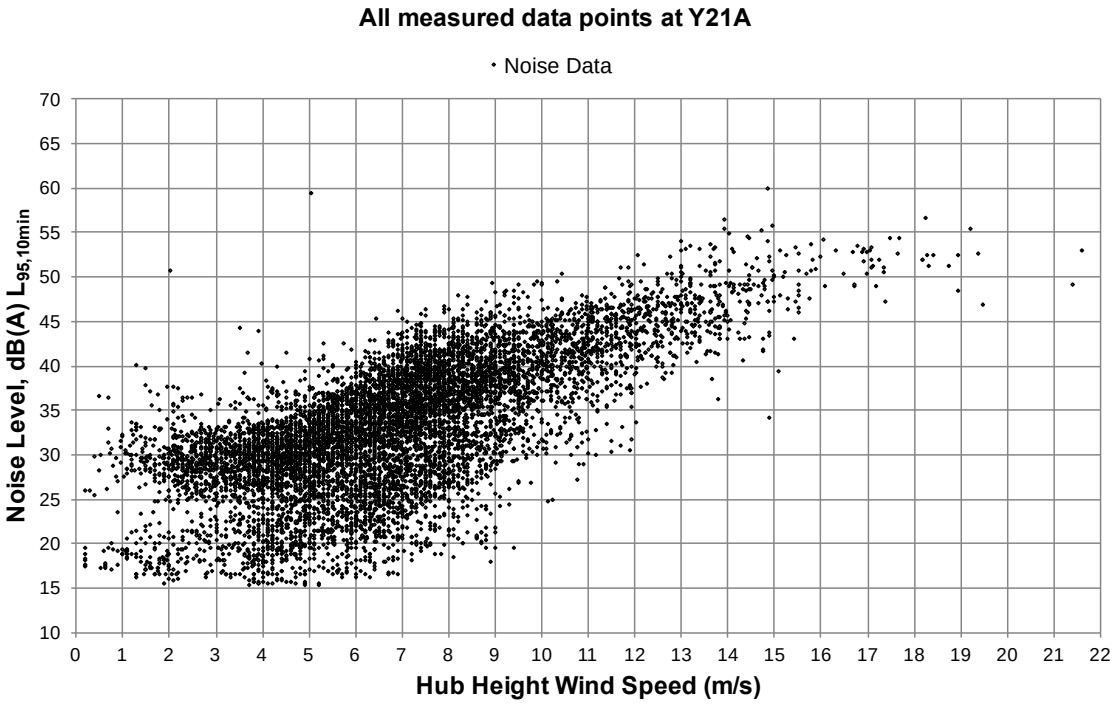

Figure F7 All measured data points at Y21A

Appendix G—WTG and receiver locations for noise model

Table G1 WTG coordinates

WTG	Coordinates UTM WGS84 Zone 54S		WTG	Coordinates UTM WGS84 Zone 54S	
	Easting	Northing		Easting	Northing
1	604811	5795092	29	601897	5792279
2	604532	5794832	30	603970	5791930
3	604075	5795064	31	603600	5791683
4	603826	5794609	32	603050	5791854
5	604350	5794539	33	602645	5791905
6	604750	5794414	34	601525	5792114
7	604642	5794073	35	605000	5791664
8	604138	5794086	36	604415	5791489
9	603797	5793941	37	601200	5791783
10	604900	5793739	38	605750	5791439
11	604526	5793680	39	606848	5791164
12	604140	5793590	40	606346	5791189
13	603793	5793272	41	605554	5791136
14	605250	5793389	42	605169	5791134
15	604750	5793214	43	604650	5790939
16	604173	5793021	44	603895	5791155
17	605135	5792823	45	603421	5791207
18	603825	5792839	46	602886	5791277
19	604455	5792565	47	602478	5791382
20	603816	5792337	48	601956	5791386
21	603444	5792592	49	601246	5791157
22	602927	5792622	50	600913	5791585
23	602475	5792623	51	600410	5791526
24	602096	5792628	52	599992	5791790
25	605708	5792220	53	606375	5790714
26	604900	5792239	54	605925	5790789
27	604450	5792015	55	605184	5790612
28	603224	5792216	56	604190	5790616

WTG	Coordinates UTM WGS84 Zone 54S		WTG	Coordinates UTM WGS84 Zone 54S	
	Easting	Northing		Easting	Northing
57	603619	5790555	85	603875	5788889
58	603194	5790841	86	602132	5789040
59	602817	5790644	87	604495	5788388
60	602250	5790914	88	604250	5787989
61	601950	5790714	89	603485	5788383
62	606832	5790420	90	602724	5788513
63	606225	5790339	91	604057	5787521
64	605691	5790232	92	603580	5787871
65	605267	5790134	93	603114	5788070
66	604725	5790289	94	604125	5786977
67	602310	5790364	95	603790	5787209
68	601650	5790164	96	603310	5787597
69	606550	5789964	97	603985	5786600
70	605674	5789811	98	603483	5786834
71	604340	5789968	99	603026	5787232
72	603855	5789973	100	602600	5786964
73	602087	5789852	101	606325	5785864
74	605410	5789603	102	605866	5786261
75	605074	5789614	103	605525	5786239
76	602550	5789739	104	606125	5785439
77	601916	5789485	105	605750	5785789
78	604325	5789464	106	605177	5786132
79	603863	5789387	107	605775	5785264
80	606560	5789384	108	605275	5785614
81	606156	5789379	109	604806	5785912
82	604761	5789200	110	604198	5786147
83	604506	5788923	111	605462	5785029
84	604915	5788508	112	604923	5785264

WTG	Coordinates UTM WGS84 Zone 54S		WTG	Coordinates UTM WGS84 Zone 54S	
	Easting	Northing		Easting	Northing
113	604499	5785663	127	602532	5785280
114	604176	5785516	128	602231	5785649
115	603850	5785964	129	601598	5786136
116	603604	5785548	130	601075	5786614
117	603280	5785967	131	601875	5785539
118	602819	5786246	132	601425	5785714
119	602350	5786664	133	601075	5786164
120	601917	5786851	134	602022	5784837
121	603256	5785583	135	601692	5785217
122	602819	5785809	136	601300	5785264
123	602393	5786140	137	600975	5785689
124	602000	5786314	138	601446	5784774
125	601622	5786594	139	600848	5785222
126	601277	5787030	140	601011	5784754

Table G2 Receiver coordinates

Receiver	Coordinates UTM WGS84 Zone 54S		Receiver	Coordinates UTM WGS84 Zone 54S	
	Easting	Northing		Easting	Northing
P22A	599499	5786217	W14A	606609	5794537
Q15A	600458	5793430	W26A	606189	5783062
R26B	601343	5782890	X16A	607370	5792812
T25A	603605	5783634	X21A	607248	5787900
V16A Noise Monitor	605805	5792902	Y21A	608846	5788025

Appendix H—Noise contour map

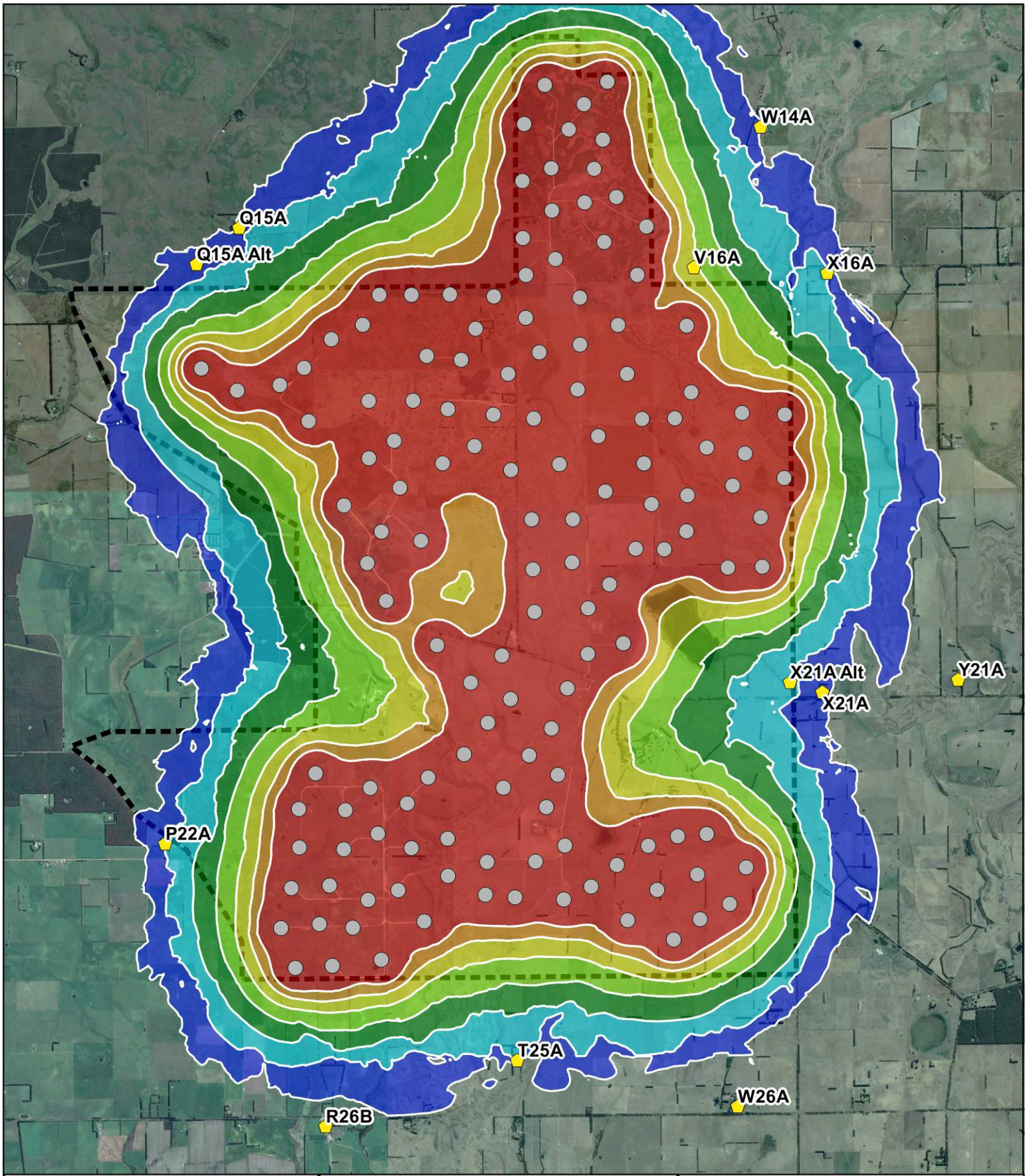

FIGURE H1:
Macarthur Wind Farm Noise contours at 10 m/s at hub height

Legend

WTG
Wind Farm Boundary
Residential or Monitoring Location

Predicted wind farm noise level

- 36 - 38 dB(A)
- 38 - 40 dB(A)
- 40 - 42 dB(A)
- 42 - 44 dB(A)
- 44 - 46 dB(A)
- 46 - 48 dB(A)
- > 48 dB(A)

0 1000 2000 3000 m

Datum WGS 84, Projection UTM ZONE 54S

PROJECT NUMBER	M15491
DRAWN BY	TRE
DATE ISSUED	October 2016
CLIENT	AGL Energy

Resonate acoustics