Vestas Australian Wind Technology Pty Ltd

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Macarthur Wind Farm

Noise Compliance Assessment

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Noise Compliance Assessment

Prepared for

Vestas Australian Wind Technology Pty Ltd

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Executive Summary

AECOM Australia Pty Ltd (AECOM) was commissioned by Vestas Australian Wind Technology Pty Ltd (Vestas), acting on behalf of AGL Energy Limited (AGL), to perform a noise compliance assessment in relation to noise emissions from Macarthur Wind Farm. The objective of the noise compliance assessment was 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 on 7 April 2011.

The Planning Permit requires that noise compliance monitoring be undertaken at the six reference dwellings (reference locations) originally used to measure the background sound levels prior to the Planning Permit Application.

Compliance noise monitoring was conducted at four of the reference locations between 8 February 2013 and 27 March 2013. Monitoring was not undertaken at two reference locations; T20A, where the dwelling was removed during construction of the wind farm and the land is now understood to be subject to a restrictive covenant preventing any dwelling being developed or constructed in future, and X21A, where the landowner refused access to conduct compliance monitoring.

Whilst noise levels have been measured at dwelling V16A, this dwelling has been decommissioned and is understood to be subject to a restrictive covenant preventing any dwelling being developed or constructed on this land in the future. Notwithstanding this, noise levels have been measured and are included for information purposes only, as the results are not subject to compliance obligations.

In accordance with the the Planning Permit, the noise levels at each applicable reference location must comply with a noise limit of the greater of 40 dB(A), or 5 dB(A) above the background noise level, when assessed in accordance with NZS 6808:1998 "*Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators.*

Environmental noise loggers were installed at the reference locations and configured in accordance with the requirements of NZS 6808:1998 and the Macarthur Wind Farm Planning Permit.

The measured noise level data was correlated with wind speed data that was collected at the Wind Farm, and provided to AECOM.

In accordance with the methodology prescribed by NZS 6808:1998, regression analysis was used to determine the noise level at each reference location for each wind speed, based on the $L_{95(10\ min)}$ noise level vs wind speed data pairs measured for each 10-minute interval during the noise monitoring period.

At each measurement location, the wind farm noise levels at each integer wind speed were measured to comply with the applicable noise criteria.

Pursuant to NZS 6808:1998, subjective assessments of the wind farm noise were also undertaken at each reference location during the monitoring period, in order to determine if the noise from the wind farm exhibits any special audible characteristics (SACs) that may require a penalty adjustment to be applied.

Special audible characteristics have not been determined to be present at any of the reference locations. Therefore, it is determined that no penalty adjustment for special audible characteristics is applicable.

Based on the noise monitoring and assessments that have been conducted, as outlined in this report, the noise emissions from Macarthur Wind Farm comply with the acoustic requirements of the Macarthur Wind Farm Planning Permit.

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by Vestas Australian Wind Technology Pty Ltd (Vestas), acting on behalf of AGL Energy Limited (AGL), to perform a noise compliance assessment of the noise emissions from Macarthur Wind Farm. The objective of the noise compliance assessment was 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 on 7 April 2011.

This report documents the methodology and results of the noise compliance assessment which has been performed based on noise measurements conducted during February and March 2013.

A glossary of the acoustic terms used in this report is presented in Appendix A.

2.0 Wind Farm Description

Macarthur Wind Farm is located approximately 16km east of Macarthur township, between Hamilton and Warrnambool in south-western Victoria. Figure 1 shows the site location.

Figure 1 Macarthur Wind Farm Location (Source: Google Earth Pro)

The wind farm consists of 140 Vestas V112 3MW wind turbines spread over an area of approximately 5500 hectares.

The land on which the wind farm is situated is used predominantly for grazing of livestock, and the terrain is generally flat open grassland, with minor undulations.

There are approximately 30 residential dwellings within the predicted 35 dB L_{A95} noise contour of the wind farm, including residences owned by the landowners who host wind turbines on their property (host landowners).

The wind farm layout is shown in Appendix B and details of the wind turbines are presented in Appendix C.

3.0 Noise Criteria

3.1 Planning Permit Requirements

Conditions 16 to 33 of the Macarthur Wind Farm Planning Permit set out the noise-related requirements for the operation of the wind farm. A copy of the relevant section of the Planning Permit is presented in Appendix D.

Condition 16 of the Planning Permit states 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 6806:1998* [sic]. *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 measure 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 compliance noise monitoring be carried out at the six reference dwellings (reference locations) where background sound levels were originally measured prior to the Planning Permit Application, subject to the approval of their owners. These reference locations are listed in Table 1, below, and are marked on the site map presented in Appendix B.

Table 1 Planning Permit Noise Monitoring 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

In relation to the above reference locations the following should be noted:

1) Whilst operational noise levels have been measured at V16A, the dwelling has been decommissioned and the land is understood to be subject to a restrictive covenant preventing the development or construction of any dwelling in the future. The change in status of this particular land has been brought about through changed ownership from McKenry to Robertson (wind farm host landowner) since the Planning Permit was issued. Notwithstanding this, noise measurements have been conducted at this reference location and the results included for information only.

2) 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 changed ownership from Sharp to Officer (wind farm host landowner) since the Planning Permit was issued.

3) The owner of the property at X21A refused access to conduct noise compliance monitoring at that reference location. In accordance with Condition 22 of the Planning Permit, the requirement to conduct noise compliance monitoring at the reference locations is subject to approval of the property owners. Therefore, X21A has not been considered further in the noise compliance assessment.

3.2 Specific Criteria at Permit Reference Locations

Background noise levels for the purpose of determining specific noise criteria for each reference location were originally measured at the Planning Permit reference locations by Hayes McKenzie[1] in December 2004, prior to granting of the Planning Permit. Although noise criteria for the reference locations were established by Hayes McKenzie based on their measurements, the Planning Panel Report (May 2006) identified two shortcomings with the original noise data gathered by Hayes McKenzie.

- Firstly, the Panel deemed that the data gathered at T20A was unreliable; and
- Secondly, the Panel noted that the original background noise levels determined by Hayes McKenzie had been correlated with wind speeds measured by a single meteorological mast, at a height of 80m above ground level. This differs from the actual hub height of the wind turbines (84m), and it was furthermore considered that wind speed measurements from a single met mast may not adequately represent the wind speeds across the whole site, given the size of the site.

The Panel therefore recommended that additional monitoring be conducted at T20A, and 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 six permanent meteorological masts that would be used for post-construction noise testing.

As a result of the above findings, and a decision by the wind farm developer to establish noise criteria for locations in addition to the reference locations, a comprehensive set of background noise measurements were performed to update the background noise data and noise criteria, and address the issues identified with the original measurements. The updated background noise measurements were performed by AECOM during the period from August 2010 to January 2011, in the months prior to commencement of construction of the wind farm.

Details in relation to the measurement and determination of the updated background noise levels and noise criteria are presented in the report included in Appendix I.

It is noted that the updated background noise levels and criteria differ slightly from those determined by Hayes McKenzie. These differences are attributable to the following factors:

1) The updated background noise data has been correlated with the wind data from the permanent meteorological masts at the wind farm, which differ in position and height to the mast used by Hayes McKenzie.
2) The updated background noise data reflects changes in the background noise level due to vegetation growth, clearing of vegetation, and /or other changes to the properties and surrounding areas which occurred in the five to six year period which elapsed between the original background noise measurements and the updated background noise measurements.
3) The noise logger positions at each property were revised for the updated background noise measurements, to better represent the background noise levels at the dwellings and avoid potential sources of extraneous noise.

The updated background noise levels have been used to develop the noise criteria for this assessment. This information is presented in Section 7.2 with the noise compliance measurements.

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

4.0 Noise Measurement Methodology

4.1 Procedure

Environmental noise loggers were installed at the reference locations and configured in accordance with the requirements of NZS 6808:1998 and the Macarthur Wind Farm Planning Permit. In particular:

- Each noise logger was configured to measure 'A'-weighted, 'F' time-weighted $L_{95,10min}$ sound pressure levels;
- The microphone of each noise logger was set at a height between 1.2m and 1.5m above ground level, and a nominally 90mm diameter foam windscreen was placed over the microphone to reduce extraneous wind noise effects;
- The same noise logger position as previously used for the updated background noise monitoring was used for the noise compliance monitoring. Where practicable, the logger was located at least 5m from any significant vegetation and sound-reflecting structures, and within 10 m of the dwelling, on the side of the dwelling that would be most exposed to noise from the wind farm. However, for some of the reference locations, it was not practical to locate the logger within 10 m of the dwelling. Where the logger position deviates from the ideal position given above, the deviation is noted in Section 4.2 along with the reasons for the deviation.
- Noise monitoring was conducted over a concurrent period of nominally 4 weeks to provide a substantial data set on which to base the analysis. In accordance with Section 5.2.3 of NZS 6808:1998, a minimum of 1440 data points overall, equivalent to 10 days of continuous monitoring at 10 minute intervals, is recommended.

4.2 Noise Logger Positions at the Reference Locations

Details of the position where noise monitoring was conducted at each reference location are presented in Table 2. The site map in Appendix B shows the position of each reference location relative to the wind farm. Aerial photographs showing the position of the noise logger at each reference location are presented in Appendix E, along with photographs showing the installed noise logger.

Table 2 Noise Logger Positions at Reference Locations

Location ID	Address	Coordinates of Logger* (UTM WGS84 Zone 54H)		Approx Distance to Dwelling	Approx Distance to Nearest Turbine	Notes
		Easting	Northing			
P22A	221 Eastwoods Road, Macarthur, VIC 3286	599499	5786224	8m	1.5km	– The noise logger was installed at the same logger position as used for the updated background noise monitoring in September and October 2010. – It was noted that there had been growth of plants adjacent to the logger position since the updated background noise measurements were performed. Wind-induced noise from the additional vegetation may have resulted in higher background noise levels during windy periods of the noise compliance monitoring than compared with when the updated background noise measurements were performed. – It was also noted during our visits to the site that wind-induced noise from a row of trees approximately 40m to the east of the logger position typically dominated the noise environment at the logger position during periods of moderate to strong wind. – The battery of the noise logger at this reference location went flat unexpectedly during the fourth week of noise monitoring. Due to this, no noise data was logged at this reference location between 11:00pm on 2 March 2013 and 3:10pm on 7 March 2013.

Location ID	Address	Coordinates of Logger* (UTM WGS84 Zone 54H)		Approx Distance to Dwelling	Approx Distance to Nearest Turbine	Notes
		Easting	Northing			
Q15A	457 Eckersleys Road, Gerrigerrup, VIC 3289	600502	5793442	40m	1.6km	– The noise logger was installed at the same logger position as used for the updated background noise monitoring in November and December 2010. This location was further than 10m from the dwelling in order to avoid vegetation that would have potentially influenced the noise measurements in windy conditions. – The wind farm noise levels at the logger position would be representative of those within 10m of the dwelling as the distance from the wind farm to the logger was comparable to the distance from the wind farm to the dwelling. The effect of minor differences in position on the wind farm noise level received at 1.6km from the wind farm is insignificant. – During the two-week period between 22 February 2013 and 8 March 2013 the noise logger only gathered noise data intermittently. In order to capture 10 days of continuous noise monitoring data at this reference location, permission was sought from the landowner to extend the monitoring period by an additional two weeks until 27 March 2013. The landowner requested that the noise logger be removed on 22 March 2013 after only one week of additional monitoring, and we complied with this request. Further information regarding the equipment issues at this location is presented in Section 4.4.

Location ID	Address	Coordinates of Logger* (UTM WGS84 Zone 54H)		Approx Distance to Dwelling	Approx Distance to Nearest Turbine	Notes
		Easting	Northing			
T25A	842 Kangertong Road, Hawkesdale, VIC 3287	603615	5783646	5m	1.9km	– The noise logger was installed at the same logger position as used for the updated background noise monitoring in September and October 2010. – A water tank pump near to the logger position was noted to run intermittently for short periods. – Due to issues with the noise logger at Q15A and in order for noise monitoring to be undertaken concurrently, permission was sought from the landowner of T25A to extend the monitoring period by an additional two weeks until 27 March 2013. The landowner requested that the noise logger be removed on 22 March 2013 after only one week of additional monitoring, and we complied with this request.

Location ID	Address	Coordinates of Logger* (UTM WGS84 Zone 54H)		Approx Distance to Dwelling	Approx Distance to Nearest Turbine	Notes
		Easting	Northing			
V16A	926 Gerrigerrup Minhamite Road, Gerrigerrup, VIC 3289	605805	5792902	24m	700m	– The noise logger was installed at the same location as used for the original background noise monitoring conducted by Hayes Mackenzie in 2004. Updated background noise monitoring was not conducted at this reference location because it is subject to an agreement with the host landowner in accordance Condition 17 of the Planning Permit, this location, which restricts this reference location from being used as a dwelling. The noise criteria are therefore not actually applicable at this location. – This position was approximately 24m from the dwelling, and located the logger away from trees that are near to the dwelling. It was however noted on our visits to site during the monitoring period that noise from the trees dominated the noise environment at the measurement location during periods of moderate and strong wind. – The wind farm noise levels at the measurement location were considered to be representative of those within 10m of the dwelling. – At the time of the monitoring, livestock were grazing in the paddocks around this dwelling. A pen was constructed around the noise monitor to keep livestock from interfering with the equipment. – On each occasion when this site was visited during the compliance monitoring period it was found that sheep were sheltering in shade near to the dwelling. It is likely that noise from the sheep would have had some influence the noise measurements performed at this location, particularly during periods of lower wind speed. – Insect noise was also significant at this location, and noise from an old wind mill at the rear of the property was also audible.

* Coordinates from hand-held GPS receiver, typical accuracy +/- 3m. The noise logger positions were confirmed visually to be the same as the logger positions used for the updated background noise monitoring, or the original background monitoring in the case of V16A, using photographs from the background noise monitoring reports.

4.3 Number of Data Points

Section 5.2.3 of NZS 6808:1998 recommends that noise compliance monitoring should be based on a minimum of 1440 measured data points ($L_{A95(10min)}$ vs wind speed), equivalent to 10 days of continuous monitoring in 10 minute intervals. The standard does not separately specify a minimum number of night-time data points required, but the recommendation of 1440 overall data points implies that a minimum of 540 night-time data points would be required.

Table 3 below notes the number of data points used in the noise compliance assessment for each reference location. This shows that the number of data points used in the assessment at each reference location was more than the 1440 all-time and 540 night-time points required to comply with the recommendations of NZS 6808:1998.

Table 3 Number of Data Points Used in Analysis

Location ID	Monitoring Period		All-time Data (24 hours)	Night-time Data (10pm to 7am)
	Start	End		
P22A	8 February 2013	27 March 2013	5263	2025
Q15A	15 February 2013	22 March 2013	1723	657
T25A	15 February 2013	22 March 2013	4343	1735
V16A	8 February 2013	27 March 2013	5661	2171

A more detailed breakdown of the data points captured during the monitoring period for each reference location is presented in Appendix H.

4.4 Instrumentation

In accordance with Condition 23 of the Planning Permit, all acoustic instrumentation had been calibrated by a NATA[2] accredited laboratory, and held current certificates of calibration at the time of the monitoring. Details of the acoustic instruments used at each reference location are presented in Table 4. The calibration certificates for each instrument are presented in Appendix F.

The readings of the noise loggers were field-checked using a portable sound level calibrator at the beginning and end of the noise monitoring period, and at various intermediate times during the monitoring (typically weekly). At the time of all calibration checks the noise loggers were found to be reading the correct level.

Table 4 Instrumentation Details

Location ID	Instrument Description	Serial No.	Date of Last Laboratory Calibration*
P22A	Rion NL-21 Class 2 Environmental Noise Logger	676782	10 January 2013
Q15A	Larson Davis 831 Class 1 Environmental Noise Logger *(15 February 2013 to 22 March 2013)* Svan 957 Class 1 Environmental Noise Logger *(8 March 2013 to 22 March 2013)*	2375 27540	11 October 2012 21 October 2012
T25A	Rion NL-21 Class 2 Environmental Noise Logger	187448	28 May 2012
V16A	Rion NL-21 Class 2 Environmental Noise Logger *(8 February 2013 to 13 March 2013)* Svan 957 Class 1 Environmental Noise Logger *(15 March 2013 to 27 March 2013)*	409168 27552	21 November 2012 11 April 2012
-	Rion NC-74 Portable Sound Level Calibrator	35084189	22 May 2012

* In accordance with NATA guidelines, laboratory calibration of Sound Level Meters should be performed once every two years, and laboratory calibration of Sound Level Calibrators should be performed annually.

[2] National Association of Testing Authorities

The following additional points are noted regarding the instrumentation:

1) On 15 March 2013 the Larson Davis noise logger at Q15A was discovered to be measuring the sound levels only intermittently, due to a fault that is suspected to be associated with the microphone preamplifier or one of the connections between the sound level meter and the microphone preamplifier. Attempts were made to identify and rectify the issue on site, but due to the intermittent nature of the fault, the exact cause of the issue was unable to be found.

   In light of the above, a second noise logger was installed as a backup for the remainder of the noise monitoring period, to gather data in the event that the Larson Davis noise logger continued to operate intermittently. However, after removal of the noise monitoring equipment from Q15A at the request of the resident on 22 March 2013, it was discovered that the second logger had been reading approximately 15 to 20 dB above the actual level when subject to noise levels in the range of 35 to 45 dB(A), despite displaying the correct reading when checked with the portable sound level calibrator at a level of 94.0 dB(A). Furthermore, the electrical noise floor of the logger was found to be elevated to approximately 46 dB(A), which is almost 30 dB(A) higher than the 17 dB(A) noise floor quoted by the manufacturer for this instrument. As such, data from this second noise logger has been excluded from the analysis.

   From AECOM's preliminary inspections of both noise loggers the exact cause of the above problems was not able to be determined. Both noise loggers have subsequently been returned to their respective manufacturers for a detailed inspection. At the time of writing the findings of the manufacturers' inspections are still pending.

   Although the above problems were experienced, and then testing was discontinued at the request of the landowner, the minimum number of data points recommended by NZS 6808:1998 was still acquired – see Section 4.3.

2) At V16A, a different noise logger was used for the last two weeks of noise monitoring. This was because the noise logger was initially removed on 13 March 2013 after 5 weeks monitoring had been completed at this reference location, but due to the issues with the logger at Q15A, AGL requested that the noise logger be reinstalled at V16A on 15 March 2013 so that monitoring could continue concurrently with the extended monitoring period at Q15A. At the time when this decision was made, it was not practical to install the same noise logger back at V16A, due to it having already been redeployed at another residence where other operational noise monitoring of the wind farm was being undertaken. Therefore, an alternative noise logger was installed.

5.0 Meteorological Data

Meteorological data for the purpose of the noise compliance assessment was obtained from the permanent meteorological masts (met masts) located at the wind farm.

There are six permanent met masts at the wind farm, which are located at the positions given in Table 5, below. The positions of the met masts are also marked on the site map presented in Appendix B.

Table 5 Meteorological Mast Locations

Meteorological Mast ID	GPS Coordinates of Logger (UTM WGS84 Zone 54H)	
	Easting	Northing
M1	603659	5794791
M2	601520	5792228
M3	600644	5785321
M4	605928	5784988
M5	604870	5788838
M6	599468	5787226

The nature of the wind farm layout means that all the met masts are located at positions where they may be affected by the wake of the wind turbines for certain wind directions. The wind speed data used for the noise analysis was derived from a combination of the six met masts to ensure that all data used was not wake affected, as per the requirement of Section 4.5.4 of NZS 6808:1998.

The procedure used to determine wake free wind speed data for the noise compliance assessment was provided by the project's wind analyst, Garrad Hassan. A summary of this procedure is presented in Appendix G.

Each of the met masts comprises a range of sensors to measure wind speed, wind direction, temperature, humidity, and rainfall. The sensors are located on the masts as shown in Figure 2.

For the purpose of the noise compliance assessment, wind directions were determined from the wind vanes at approximately 82m above ground level (AGL), and the wind speeds at the each met mast were taken from one of the two cup anemometers located at 84m AGL (wind turbine hub-height). The particular anemometer that was used from each met mast at any given point in time was dependent on the wind direction at the time, so that the anemometer used was not within the wake of the met mast tower. Details of the anemometer selection method are presented in Appendix G.

All wind speed and direction data used for the noise compliance assessment was in terms of 10-minute averages. The measurement time intervals of the noise monitoring equipment were synchronised with the measurement intervals of the met masts.

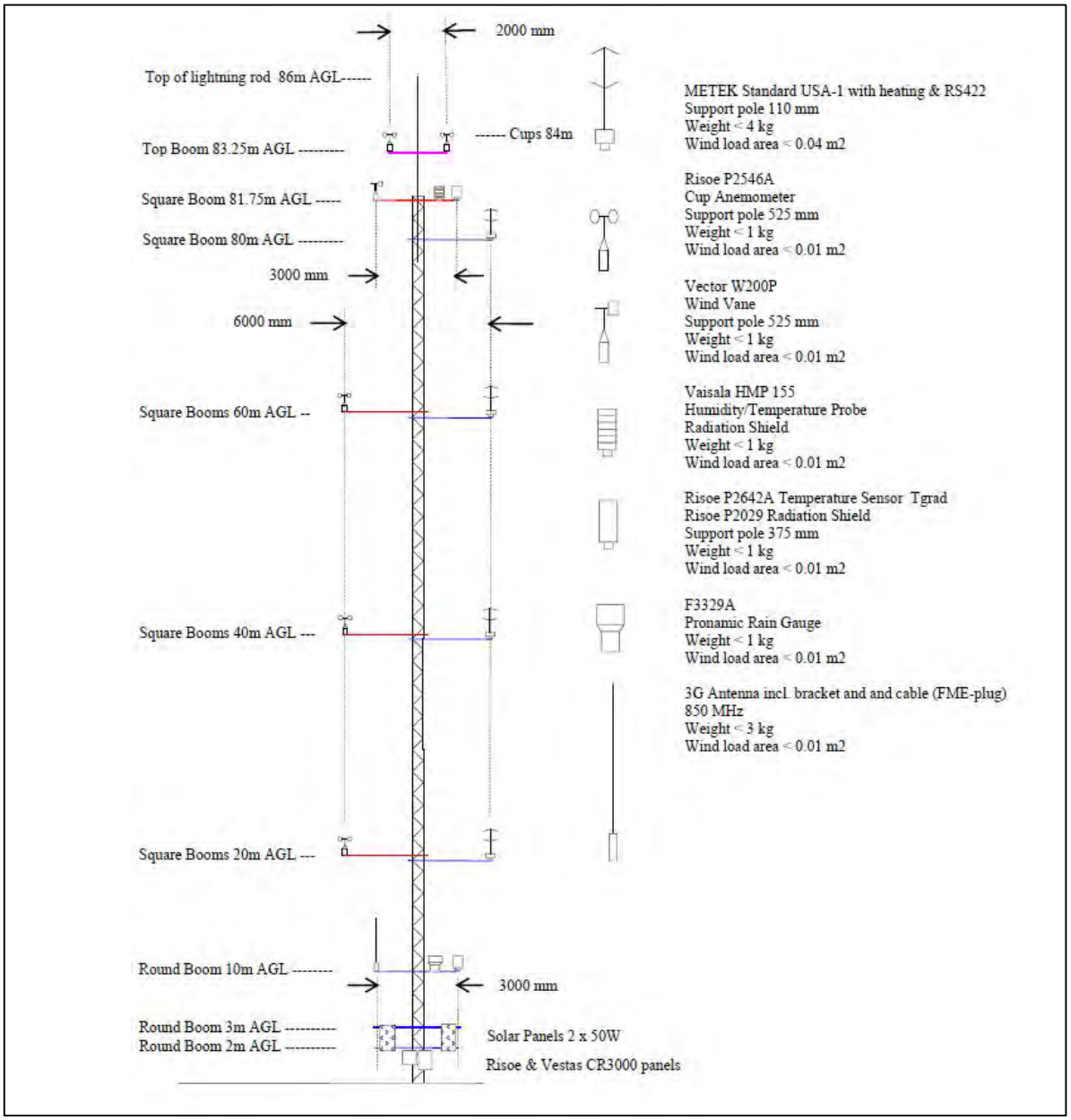


Figure 2 Meteorological Mast Sensors (Source: Vestas Macarthur Wind Farm Met Mast Installation Report, October 2012)

6.0 Wind Farm Operation Data

Wind farm operation data for the period of the monitoring was provided to AECOM by Vestas in the form of run-time logs indicating the number of seconds during each 10 minute period that each wind turbine at the wind farm was available to generate power.

This information was used to determine if the wind farm was operating normally, or if unrepresentative noise data needed to be excluded from the analysis, due to wind turbines in the vicinity of the reference locations not being available to operate (for example due to a fault or service shutdown).

AECOM understand that normal wind farm operations will typically involve some wind turbines being out of service, for one or more of the following reasons:

- Routine planned maintenance of the wind turbines;
- Routine planned maintenance of the electrical connection infrastructure (e.g. substation);
- Unplanned maintenance of the wind turbines in response to alarms or faults;
- Unplanned maintenance of the electrical connection infrastructure in response to alarms or faults;
- Constraints placed on energy exported to the electricity grid imposed by AEMO[3] as part of its obligation to retain security of supply of electricity across the state.

The exclusion of data that would therefore not be considered representative noise data for use in the noise compliance assessment at each reference location is discussed in Section 7.1.2.

The following operational events occurred during the noise compliance monitoring period between 8 February 2013 and 27 March 2013:

- Routine planned maintenance of the wind turbines;
- Relocation of the underground 33 kV reticulation cable in Section 20 of the wind farm to correct a defect. This occurred during the period from 7:00am on 14 March 2013 to 8:00pm on 15 March 2013, and resulted in wind turbines 61, 67, 68, 73, 76, 77, and 86 being off line during this period.
- A fault to wind turbine 68 (ring main unit would not close) meant that it remained off line after 8:00pm on 15 March 2013 until 5:20pm on 21 March 2013.

The above operational events have been accounted for in the noise compliance assessment for each reference location, in accordance with the procedure described in Section 7.1.2.

[3] The Australian Energy Market Operator

7.0 Analysis of Measurement Results

7.1 Analysis Methodology

7.1.1 General Procedure

As required by the Macarthur Wind Farm Planning Permit, the measured noise levels with the turbines operating were analysed separately for all-time and night time (10pm to 7am) periods.

In accordance with the methodology prescribed by NZS 6808:1998, regression analysis was used to determine the noise level at each reference location for each wind speed based on the $L_{95(10\ min)}$ noise level vs wind speed data pairs measured for each 10-minute interval during the noise monitoring period.

7.1.2 Data Exclusion

When one or more turbines making a significant contribution to the wind farm noise levels at the reference location were not operating, data for the corresponding period was not included in the assessment. The procedure used to determine these periods is explained below:

- The predicted noise contribution from each wind turbine at each reference location was extracted from the SoundPLAN noise model of the wind farm that was used to predict the noise emissions of the wind farm during the design phase.
- The predicted noise contributions from each of the wind turbines that were operational during each 10-minute interval were then summed together and compared to the predicted total noise level at the reference location under consideration.
- Where the difference between the predicted noise level with all wind turbines operating and the predicted noise level with only the actual operating turbines was equal to or greater than 0.5 dB(A), the data for that 10-minute period was excluded from the analysis.

Data periods where rain occurred were also excluded from the analysis due to the potential influence of extraneous noise from rain on the measurements.

Finally, the remaining data was screened for periods where extraneous noise had clearly influenced the noise measurement data. Wind turbines typically provide a constant noise source, with noise emissions increasing with increasing wind speed. Noise data that is affected by extraneous noise (such as from tractors and other farm machinery) is removed through the identification of obvious outliers and periods where there is poor correlation between the noise levels and the wind speed data. For example, large spikes in noise level during the day, during periods of constant wind conditions, would be typical of farm machinery operating in the area of the logger.

Exclusion of data due to extraneous noise was however kept to a minimum, so that the assessment remained conservative (i.e. would not erroneously skew the determined noise levels downwards in the event that extraneous noise was incorrectly identified).

A summary of the number of data points used for the analysis at each reference location, and the number of data points excluded, is presented in Appendix H.

7.1.3 Curve Fitting

Following the data exclusion process as outlined above, polynomial regression curves of up to third order were fitted to the data and the correlations between the regression curve and the wind speed versus noise level data were calculated by a least-squares regression formula. For determination of the average measured noise levels, the curve that was used was one with the highest coefficient of determination that provided a reasonable fit to the data.

The measured noise levels represent the combination of background noise and wind farm noise. As such, the measured noise levels would be higher than the noise levels due to the wind farm only.

Although NZS 6808:1998 allows for the measured noise levels to be adjusted to compensate for the influence of background noise when assessing the noise levels from the wind farm, such an adjustment has not been applied to the measured levels presented in this report. The approach of comparing the combined background noise and wind farm noise to the assessment criteria (as used in this report), is therefore conservative.

7.2 Measured Noise Levels

The graphs on the following pages compare the measured 'all-time' and 'night-time' noise levels with the noise criteria determined for each reference location. Each graph shows each 10-minute data point measured with the wind turbines operating during the monitoring period as black dots. The polynomial fit-line to this data (i.e. the "average" noise level determined in accordance with NZS 6808:1998) is shown on the graph as an orange line. The updated background noise levels that were measured prior to construction of the wind farm are shown as light blue dots, behind the operational noise data, for information.

Tabulated noise levels and criteria for each integer wind speed are presented following the graphs for each reference location.

Note:

1) The normal mode of operation for the wind turbines at Macarthur Wind Farm is Noise Mode 0. This full power mode of operation was in effect throughout the compliance noise monitoring period. Based on data from Vestas' General Specification for the turbines, the maximum wind turbine sound power levels in this operating mode occur at a wind speed of 10 m/s. Any increases in the measured noise levels with wind speed above 10 m/s would therefore be a result of increasing background noise levels.

2) Based on data from Vestas' General Specification for the turbines, the wind turbine cut-in wind speed is 3 m/s. Data at wind speeds less than the cut-in wind speed is shown greyed-out in the following figures.

3) Background noise levels are not presented on the charts for V16A, as updated background noise levels were not measured at V16A, and the raw data from the original background noise levels measured by Hayes Mackenzie in 2004 was not available to AECOM to plot on the chart.

   Whilst operational noise levels have been measured at V16A, the dwelling has been decommissioned and the land is understood to be subject to a restrictive covenant preventing the development or construction of any dwelling in the future. The change in status of this particular land has been brought about through changed ownership from McKenry to Robertson (wind farm host landowner) since the Planning Permit was issued. Notwithstanding this, noise measurements have been conducted at this reference location and the results included for information only

7.2.1 P22A

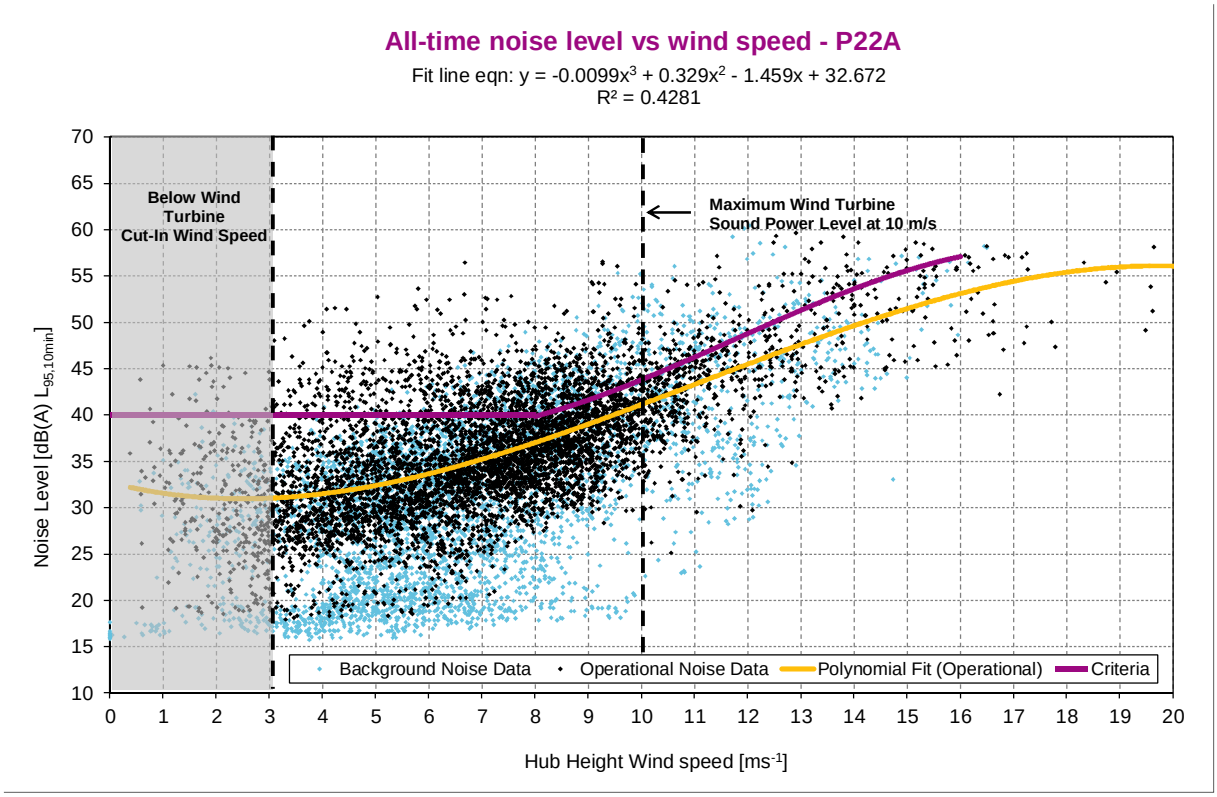


Figure 3 All-Time Monitoring Results – P22A

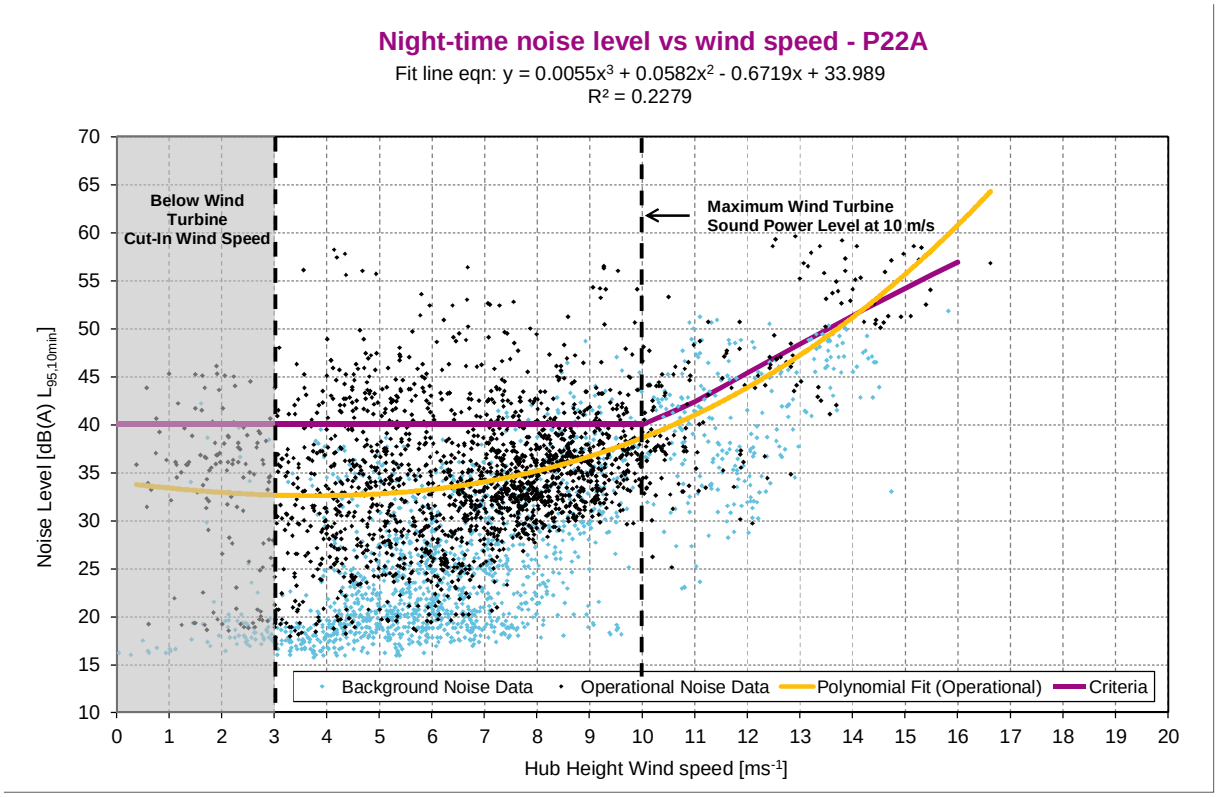


Figure 4 Night-Time Monitoring Results – P22A

Table 6 All-Time Monitoring Results – P22A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Background Noise Level [dB(A) L_{95}]	24	24	24	25	26	27	29	31	34	36	39	41	44	46	48	50	52
Criterion [dB(A) L_{95}]	n/a*	n/a*	n/a*	40	40	40	40	40	40	41	44	46	49	51	53	55	57
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**31**	**31**	**32**	**34**	**35**	**37**	**39**	**41**	**43**	**45**	**48**	**50**	**51**	**53**
Compliance	n/a*	n/a*	n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓**	✓**	✓**	✓**	✓**	✓**
Compliance Margin, [dB(A) L_{95}]	n/a*	n/a*	n/a*	9	9	8	6	5	3	2	3	**	**	**	**	**	**

Table 7 Night-Time Monitoring Results – P22A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Background Noise Level [dB(A) L_{95}]	20	19	19	20	21	23	24	27	29	32	34	37	40	43	46	49	52
Criterion [dB(A) L_{95}]	n/a*	n/a*	n/a*	40	40	40	40	40	40	40	40	42	45	48	51	54	57
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**33**	**33**	**33**	**33**	**34**	**35**	**37**	**39**	**41**	**44**	**47**	**51**	**56**	**61**
Compliance	n/a*	n/a*	n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓**	✓**	✓**	✓**	✓**	✓**
Compliance Margin, [dB(A) L_{95}]	n/a*	n/a*	n/a*	7	7	7	7	6	5	3	1	**	**	**	**	**	**

* The wind turbines do not operate at wind speeds of less than 3 m/s.

** The wind turbine sound power levels do not increase at wind speeds above 10 m/s. Noise level increases above 10 m/s are due to wind-induced extraneous noise.

7.2.2 Q15A

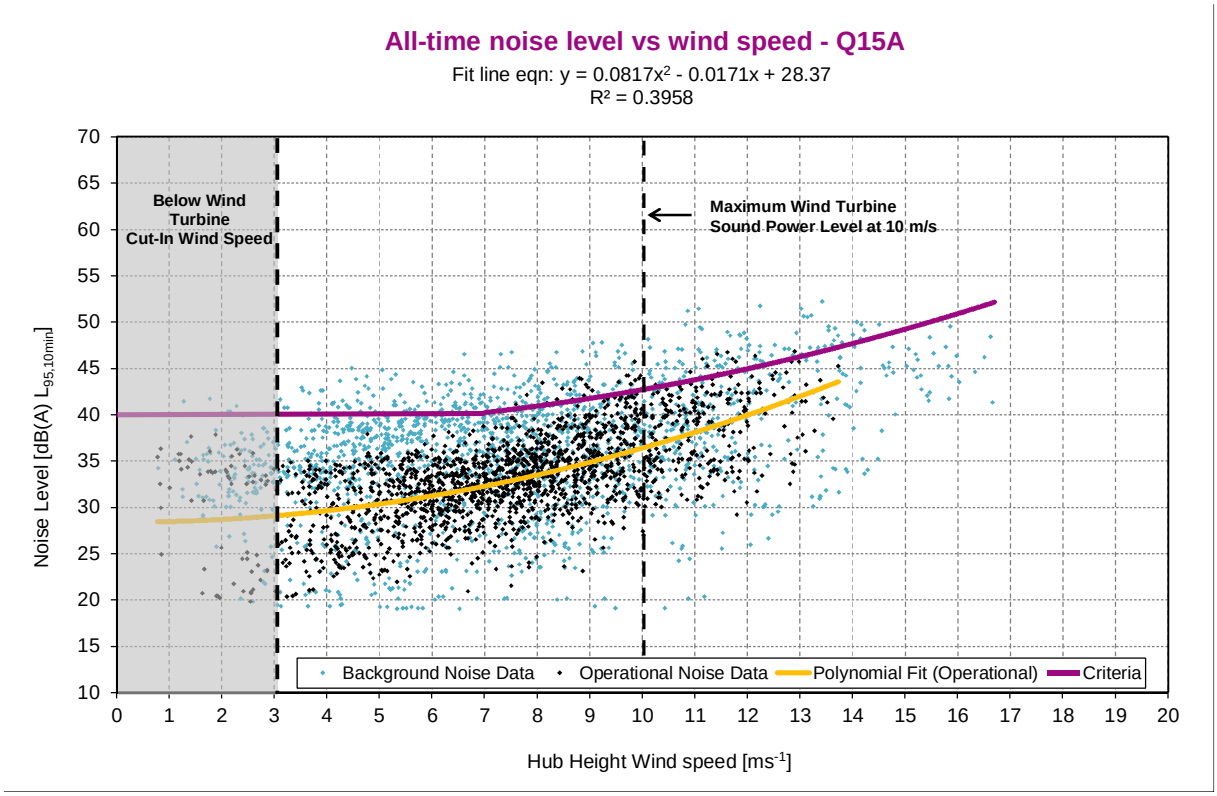


Figure 5 **All-Time Monitoring Results – Q15A**

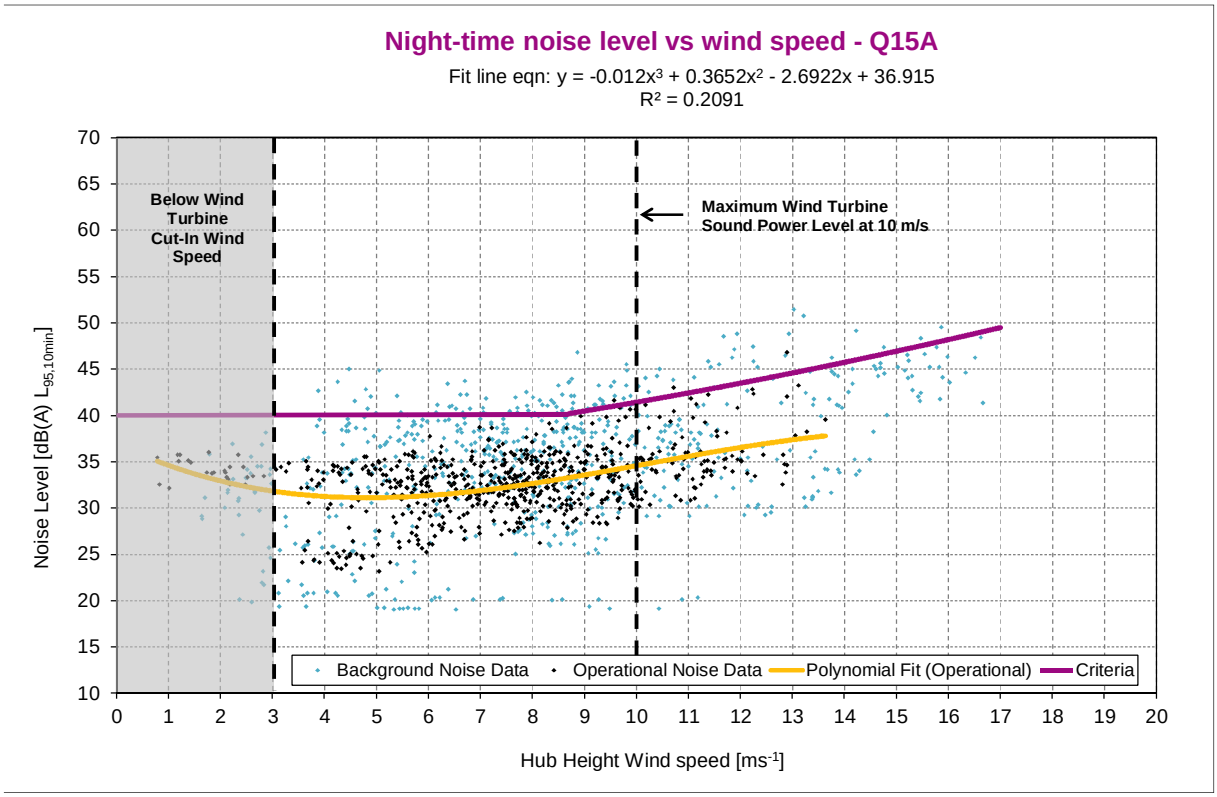


Figure 6 **Night-Time Monitoring Results – Q15A**

Table 8 All-Time Monitoring Results – Q15A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Background Noise Level [dB(A) L_{95}]	34	34	33	34	34	34	35	35	36	37	38	39	40	41	43	44	46	48
Criterion [dB(A) L_{95}]	n/a*	n/a*	n/a*	40	40	40	40	40	41	42	43	44	45	46	48	49	51	53
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**29**	**30**	**30**	**31**	**32**	**33**	**35**	**36**	**38**	**40**	**42**	**44**	**-**	**-**	**-**
Compliance	n/a*	n/a*	n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓**	✓**	✓**	✓**	✓**	✓**	✓**
Compliance Margin, [dB(A) L_{95}]	n/a*	n/a*	n/a*	11	10	10	9	8	8	7	7	**	**	**	**	**	**	**

Table 9 Night-Time Monitoring Results – Q15A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Background Noise Level [dB(A) L_{95}]	29	30	30	31	31	32	33	34	35	35	36	37	38	40	41	42	43	44
Criterion [dB(A) L_{95}]	n/a*	n/a*	n/a*	40	40	40	40	40	40	40	41	42	43	45	46	47	48	49
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**32**	**31**	**31**	**31**	**32**	**33**	**34**	**35**	**36**	**36**	**37**	**38**	**-**	**-**	**-**
Compliance	n/a*	n/a*	n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓**	✓**	✓**	✓**	✓**	✓**	✓**
Compliance Margin, [dB(A) L_{95}]	n/a*	n/a*	n/a*	8	9	9	9	8	7	6	6	**	**	**	**	**	**	**

* The wind turbines do not operate at wind speeds of less than 3 m/s.

** The wind turbine sound power levels do not increase at wind speeds above 10 m/s. Noise level increases above 10 m/s are due to wind-induced extraneous noise.

7.2.3 T25A

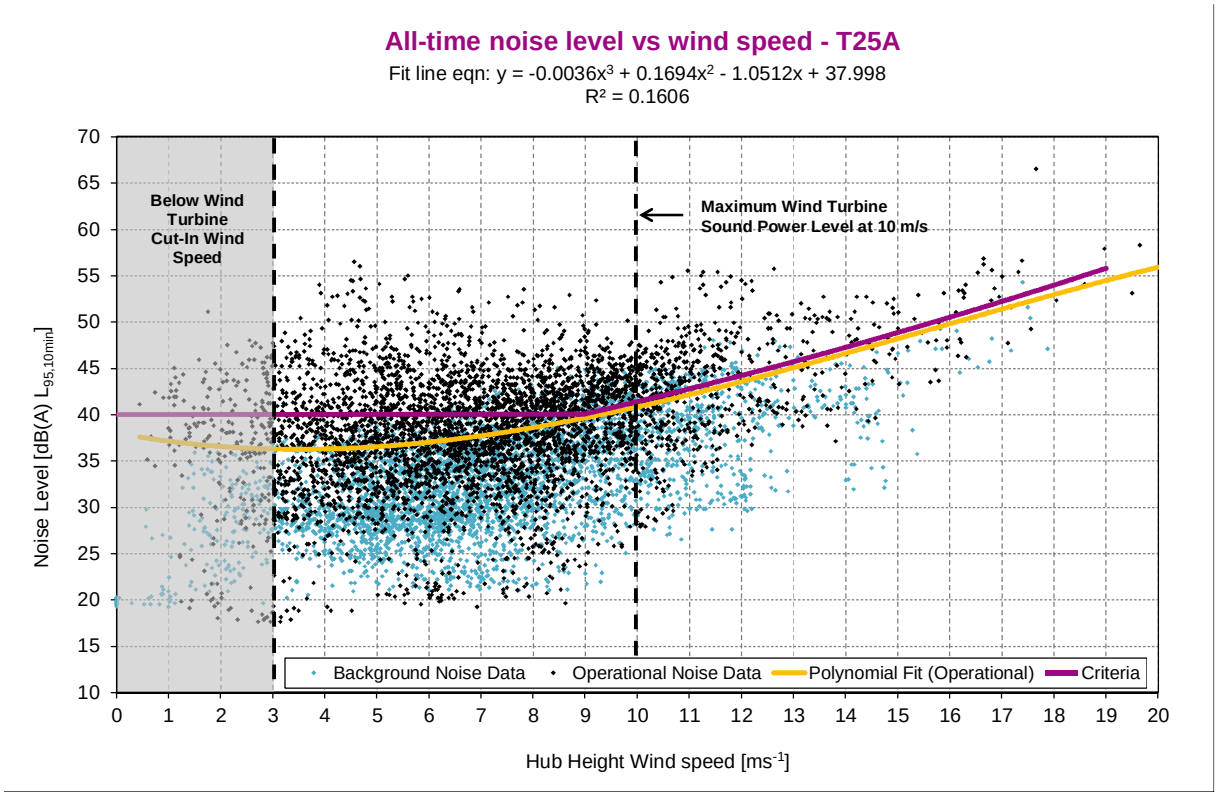


Figure 7 All-Time Monitoring Results – T25A

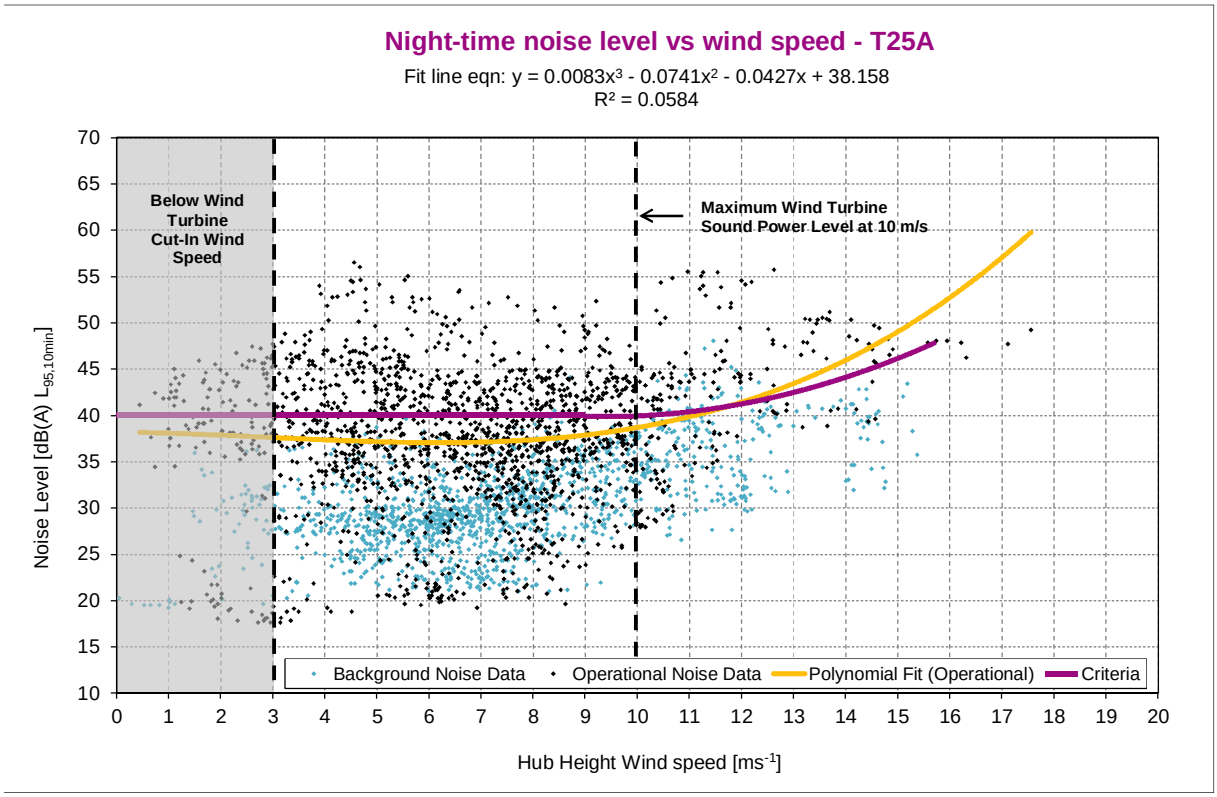


Figure 8 Night-Time Monitoring Results – T25A

Table 10 All-Time Monitoring Results – T25A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Background Noise Level [dB(A) L_{95}]	26	26	27	28	29	30	31	33	34	35	36	38	39	41	42	44	46	47	49	51
Criterion [dB(A) L_{95}]	n/a*	n/a*	n/a*	40	40	40	40	40	40	40	41	43	44	46	47	49	51	52	54	56
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**36**	**36**	**37**	**37**	**38**	**39**	**40**	**41**	**42**	**44**	**45**	**47**	**48**	**50**	**51**	**53**	**54**
Compliance	n/a*	n/a*	n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓**	✓**	✓**	✓**	✓**	✓**	✓**	✓**	✓**
Compliance Margin, [dB(A) L_{95}]	n/a*	n/a*	n/a*	4	4	3	3	2	1	0	0	**	**	**	**	**	**	**	**	**

Table 11 Night-Time Monitoring Results – T25A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Background Noise Level [dB(A) L_{95}]	25	26	26	26	27	28	29	30	31	32	33	35	36	38	39	41	43
Criterion [dB(A) L_{95}]	n/a*	n/a*	n/a*	40	40	40	40	40	40	40	40	40	41	43	44	46	48
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**38**	**37**	**37**	**37**	**37**	**37**	**38**	**39**	**40**	**41**	**43**	**46**	**49**	**53**
Compliance	n/a*	n/a*	n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓**	✓**	✓**	✓**	✓**	✓**
Compliance Margin, [dB(A) L_{95}]	n/a*	n/a*	n/a*	2	3	3	3	3	3	2	1	**	**	**	**	**	**

* The wind turbines do not operate at wind speeds of less than 3 m/s.

** The wind turbine sound power levels do not increase at wind speeds above 10 m/s. Noise level increases above 10 m/s are due to wind-induced extraneous noise.

7.2.4 V16A

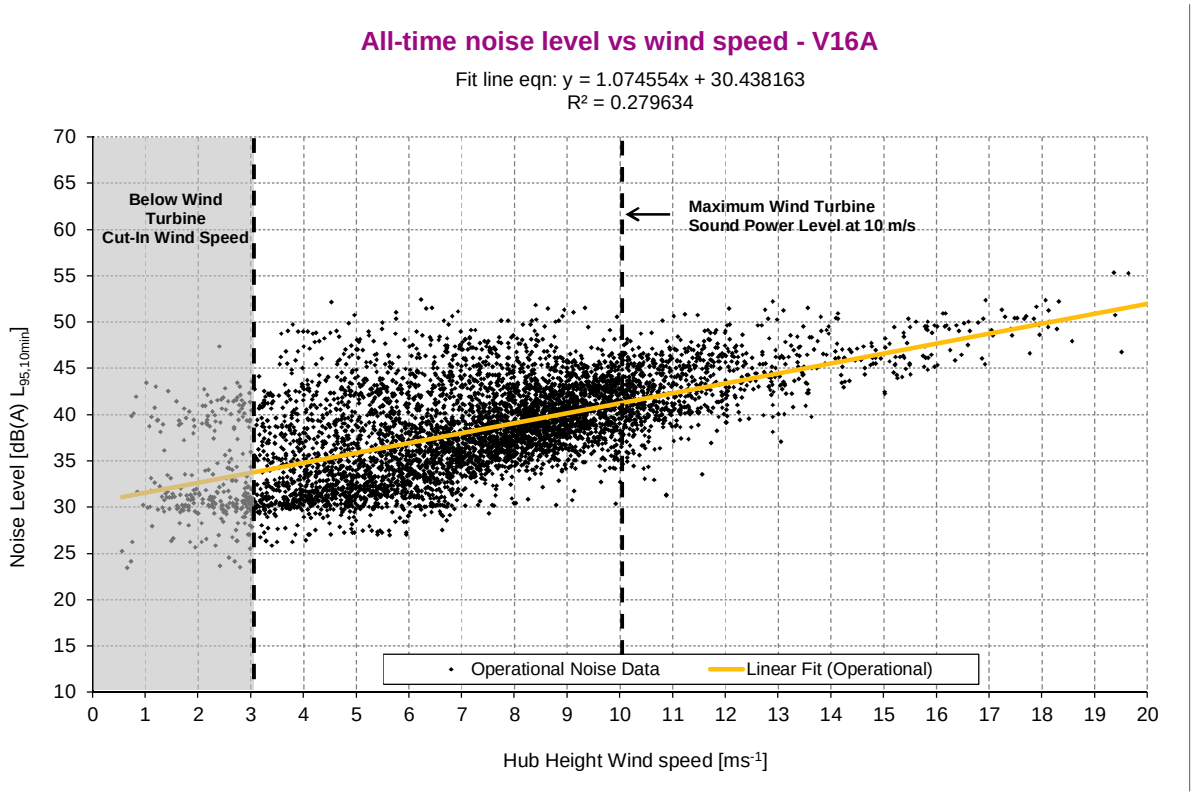


Figure 9 All-Time Monitoring Results – V16A

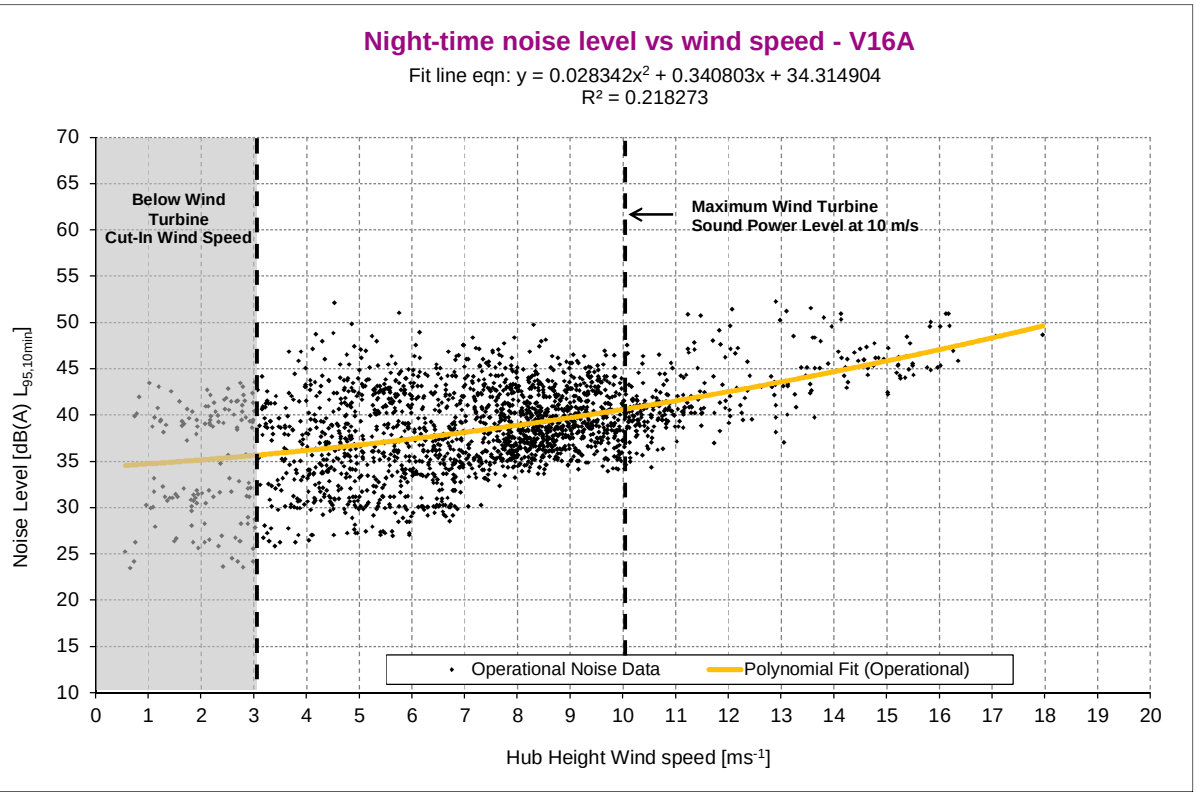


Figure 10 Night-Time Monitoring Results – V16A

Table 12 All-Time Monitoring Results – V16A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Background Noise Level [dB(A) L_{95}]***	-	-	-	28	28	29	30	31	33	35	37	40	42	45	48	51	54	57
Criterion [dB(A) L_{95}]****	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42****	**43****	**44****	**45****	**47****	**48****	**49****

Table 13 Night-Time Monitoring Results – V16A

Wind Speed at Hub Height [m/s]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Background Noise Level [dB(A) L_{95}]***	-	-	-	26	25	25	25	26	28	30	32	35	37	38	40	41	41	40
Criterion [dB(A) L_{95}]****	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Measured Noise Level with Wind Turbines Operating [dB(A) L_{95}]	**n/a***	**n/a***	**n/a***	**36**	**36**	**37**	**37**	**38**	**39**	**40**	**41**	**41****	**42****	**44****	**45****	**46****	**47****	**48****

* The wind turbines do not operate at wind speeds of less than 3 m/s.
** The wind turbine sound power levels do not increase at wind speeds above 10 m/s. Noise level increases above 10 m/s are due to wind-induced extraneous noise.
*** The background noise levels presented are the original background noise levels from the Hayes McKenzie Report (May 2005)
**** No criteria are applicable for this location as the dwelling has been decommissioned and the land is understood to be subject to a restrictive covenant preventing the development or construction of any dwelling in the future.

7.3 Discussion of Results

The planning permit requirement for Macarthur Wind Farm sets a noise limit for the wind farm of the greater of 40 dB(A) or 5 dB(A) above the background noise level when assessed in accordance with NZS 6808:1998. This limit is for the wind farm only noise, whereas, the assessment compares the combined background noise and wind farm noise levels to the assessment criteria. The approach taken in the assessment is therefore conservative because the combined background noise levels and wind farm noise levels would be higher than the wind farm noise levels alone, and in many cases the noise environment at the reference locations would have been dominated by the background noise.

Based on the graphs of the combined background noise and wind farm noise presented above, the results of the noise monitoring demonstrate that the wind farm is compliant with the noise criteria.

It is noted that the operational noise curve crosses the criteria curve for the night period at P22A and T25A, but the wind speeds where the curves cross are above 10 m/s. As 10 m/s is the wind speed where the wind turbines reach their maximum Sound Power Level the increases in noise level at wind speeds above 10 m/s would be related to wind-induced extraneous noise, rather than the wind farm. Subjective observations of the wind farm noise at those sites during the monitoring period support this conclusion.

It is also noted that the noise levels measured at P22A and T25A do not correlate particularly well with the wind speed. There is considerable scatter in the data, particularly at lower wind speeds, indicating that the measurements have been influenced by extraneous noise sources with no relationship to the wind speed. Despite the influence of extraneous noise, the noise levels at both reference locations are still complaint with the noise criteria.

8.0 Assessment of Special Audible Characteristics

8.1 Introduction

Pursuant to Conditions 16 b) and 25 of the Planning Permit, an assessment has been undertaken in accordance with NZS 6808:1998 to establish whether a penalty adjustment may be applicable for any special audible characteristics (SACs).

8.2 Special Audible Characteristics

Section 5.3.1 of NZS 6808:1998 defines SACs as being:

1) Clearly audible tones

2) Impulses; and

3) Modulation of sound levels.

Tones occur where the sound under consideration has energy concentrated at certain frequency (pitch), like a single note on a musical instrument.

Impulse sound, if present, would be heard as banging or thumping noises from the wind farm.

Modulation of sound level (amplitude modulation) is where the sound from the wind farm exhibits a regularly varying level greater than that characteristic of 'normal' wind turbine operation. 'Normal' wind turbine operation is generally acknowledged as including some minor amplitude modulation due to 'swishing' noise from the blades. The noise limits prescribed by wind farm noise criteria generally take this minor amplitude modulation into account. Although NZS 6808:1998 does not specifically state this to be the case, it is clearly stated in the current version of the standard, NZS 6808:2010.

8.3 Assessment Procedure

In accordance with the requirements of Section 5.3.1 of NZS 6808:1998, subjective assessments of the wind farm noise were undertaken at each reference location, in order to determine if the noise from the wind farm exhibits any special audible characteristics that may require a penalty adjustment to be applied.

A minimum of five subjective assessments of the wind farm noise were undertaken at each reference location during the monitoring period. Each subjective assessment of the wind farm noise was conducted by a professional acoustic engineer (grade Member of the Australian Acoustical Society), as per the process below:

- An acoustic engineer listened to the sound at the reference location for a minimum period of 10 minutes;
- As far as practical, the listening position was the same as the noise logger position used for measurement of the 'A'-weighted sound pressure levels;
- The sounds at the reference location were noted, including any sound from the wind farm and any SACs due to the wind farm;
- The sound pressure levels during the subjective assessment were measured using a laboratory calibrated Bruel and Kjaer 2250 Class 1 Sound Level Meter (Serial Number 2600404). A copy of the calibration certificate for this Sound Level Meter is presented in Appendix F;
- The sounds present during the assessment were recorded to a wave file by the Sound Level Meter, to provide an audio record of the period, and to enable subsequent objective analysis if required;
- The local wind conditions at the reference locations during the assessment period were noted subjectively;
- The wind conditions at the wind farm were determined (after the assessment) from the relevant met mast data corresponding to the same time period as the assessment.

8.4 Summary of Findings

Subjective assessments of special audible characteristics were performed under a range of wind conditions covering wind speeds of approximately 2 to 16 m/s at hub height. The subjective assessments also covered winds from each general compass direction, meaning that downwind, upwind and crosswind conditions were considered for each reference location. Subjective assessments of the noise at V16A have not been considered, noting the restrictive covenant that is understood to apply to that reference location.

The wind farm noise was observed to be audible during at least one subjective assessment at each of P22A, Q15A and T25A. However, for the majority of the subjective assessments at these reference locations the wind farm noise was inaudible or only faintly audible.

No tones were audible during any of the subjective assessments at the reference locations considered.

Some minor amplitude modulation that is normally characteristic of wind farms was discernible at P22A and Q15A for short periods on some occasions. However, the level of amplitude modulation was not sufficient to attract a penalty.

In summary, special audible characteristics have not been determined to be present at any of the reference locations. Therefore, it is determined that no penalty adjustment for special audible characteristics is applicable.

9.0 Conclusion

The noise emissions from Macarthur Wind Farm have been assessed in accordance with the requirements of the Macarthur Wind Farm Planning Permit and the Standard, NZS 6808:1998 "*Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*".

Unattended noise compliance monitoring was undertaken during February and March, 2013 to determine the wind farm noise levels at the reference locations required in accordance with the Planning Permit.

At each reference location, the wind farm noise levels at each integer wind speed were measured to comply with the applicable noise criteria.

Pursuant to the Standard, subjective assessments of the wind farm noise were undertaken at each reference location during the monitoring period, in order to determine if the noise from the wind farm exhibits any special audible characteristics (SACs) that may require a penalty adjustment to be applied. A minimum of five subjective assessments, covering a representative range of wind conditions, were undertaken at each reference location.

Special audible characteristics have not been determined to be present at any of the reference locations. Therefore, it is determined that no penalty adjustment for special audible characteristics is applicable.

Based on the noise monitoring and assessments that have been conducted, as outlined in this report, the noise emissions from Macarthur Wind Farm comply with the acoustic requirements of the Macarthur Wind Farm Planning Permit.

Appendix A

Glossary of Terms

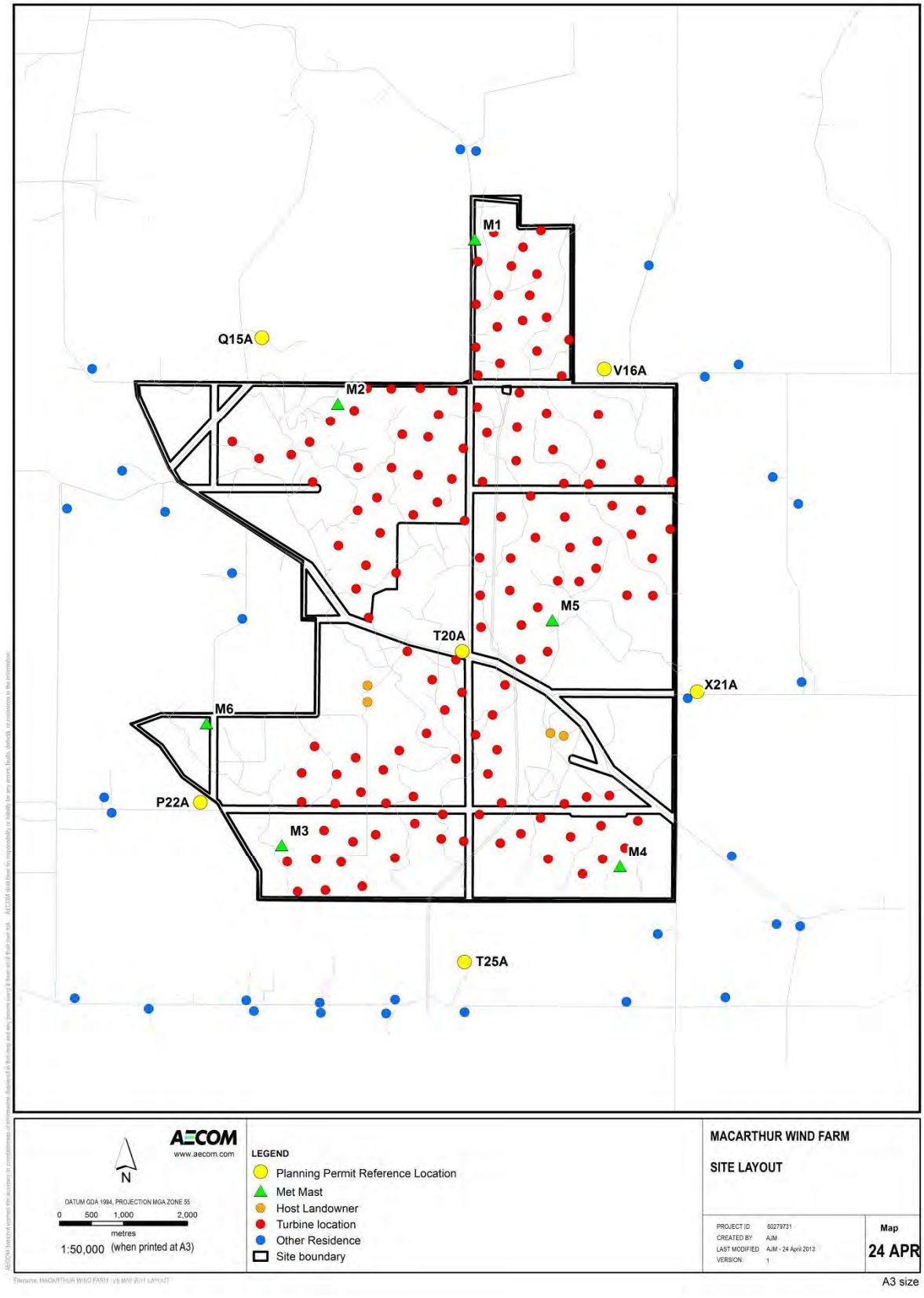
Appendix A Glossary of Terms

A-weighting	The A-weighting scale is used to adjust the sound pressure levels measured in decibels to more accurately reflect the subjective response of the human ear to sound. The human ear is less sensitive to low frequency (pitch) sounds than sounds of middle to high frequency. That is, low frequency sounds of the same decibel level are not heard as loud as high frequency sounds. A sound level meter replicates the human response of the ear by using an electronic filter which is called the A-weighting filter. A sound level measured with this filter switched on is denoted as dB(A).
dB(A)	The unit of A-weighted sound pressure level.
$L_{95(10min)}$	The A-weighted sound pressure level exceeded for 95% of a 10 minute measurement period. This descriptor is used to represent the background noise levels and the wind farm noise levels under NZS 6808:1998.
Sound Power Level	A measure of the total sound energy emitted by a source. Mathematically, it is ten times the logarithm to the base ten of the ratio of the sound power of a source to the reference sound power; where sound power is defined as the total sound energy radiated per unit time (W), and the reference sound power is $1x10^{-12}$ W. [Unit: Decibels]
Sound Pressure Level	A measure of the magnitude of a sound wave. Mathematically, it is twenty times the logarithm to the base ten of the ratio of the root mean square sound pressure at a point in a sound field, to the reference sound pressure; where sound pressure is defined as the alternating component of the pressure (Pa) at the point, and the reference sound pressure is $2x10^{-5}$ Pa. [Unit: Decibels]

Appendix B

Site Layout

Appendix B Site Layout



Appendix C

Wind Turbine Details

Appendix C Wind Turbine Details

The following tables provide general details of the wind turbines installed at Macarthur Wind Farm:

Table 14 General Details of Macarthur Wind Farm Wind Turbines

Make:	Vestas
Model:	V112 3MW
Rated Power Output	3 MW
Number of Blades:	3
Rotor Diameter:	112m
Hub Height:	84m
Rotational Speed	4.4 to 17.7 rpm
Rotational Direction	Clockwise
Cut-in Wind Speed*	3 m/s
Cut-out Wind Speed*	25 m/s

* Hub-height wind speed

Table 15 Sound Power Levels of Vestas V112 3MW, Operating Mode 0
(Source: Vestas General Specification, V112-3.0MW, IEC IIA, T05 Item No. 0004-7993 V02, dated 2009-12-03)

Conditions for Sound Power Level Measurement	**Standard: IEC 61400-11 Ed. 2, 2002 Wind shear: 0.16 Max. turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m^3 HH 94 m**
L_{wA} @ 3 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	95.0 4.3
L_{wA} @ 4 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	97.7 5.7
L_{wA} @ 5 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	102.5 7.2
L_{wA} @ 6 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	105.7 8.6
L_{wA} @ 7 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 10
L_{wA} @ 8 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 11.5
L_{wA} @ 9 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 12.9
L_{wA} @ 10 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 14.3
L_{wA} @ 11 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 15.8
L_{wA} @ 12 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 17.2
L_{wA} @ 13 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 18.6

Appendix D

Planning Permit Noise 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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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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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 E

Noise Monitoring Positions

P22A

Figure 11 Noise Logger Position at P22A (North at Top of Page, Wind Farm to East)

Figure 12 View to North at P22A

Figure 13 View to West at P22A

Figure 14 View to South at P22A

Figure 15 View to East at P22A

Figure 16 View to East at P22A with Macarthur Wind Farm in Distance

Q15A

Figure 17 Noise Logger Position at Q15A (North at Top of Page, Wind Farm to Southeast)

Figure 18 View to North at Q15A

Figure 19 View to West at Q15A

Figure 20 View to South at Q15A

Figure 21 View to East at Q15A

T25A

Figure 22 Noise Logger Position at T25A (North at Top of Page, Wind Farm to North)

Figure 23 View to North at T25A

Figure 24 View to West at T25A

Figure 25 View to South at T25A

Figure 26 View to East at T25A

V16A

Figure 27 Noise Logger Position at V16A (North to Top of Page, Wind Farm to West and South)

Figure 28 View to North at V16A

Figure 29 View to West at V16A

Figure 30 View to South at V16A

Figure 31 View to East at V16A

Appendix F

Calibration Certificates

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 39422**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00676782
Microphone Type:	UC-52	**Serial No:**	114116
Comments:	All tests passed for type 2. (See over for details)		
Owner:	AECOM Level 45,80 Collins Street Melbourne VIC 3000		
Ambient Pressure:	994 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	55 % ±5%
Date of Calibration:	10/01/2013	**Issue Date:**	10/01/2013
Acu-Vib Test Procedure:	AVP05 (SLM)		

CHECKED BY: ..... **AUTHORISED SIGNATORY:** .....

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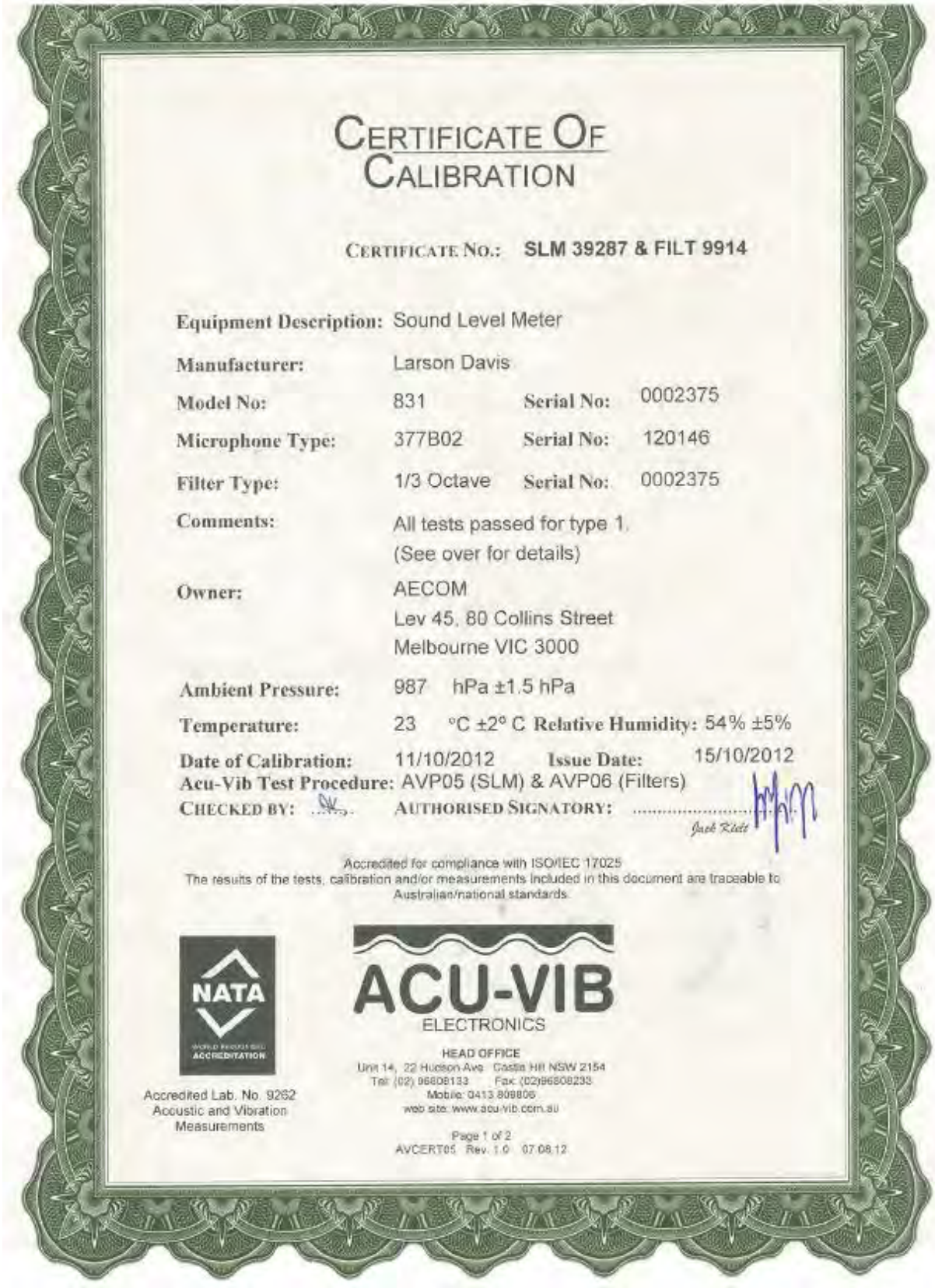

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 39287 & FILT 9914

Equipment Description:	Sound Level Meter		
Manufacturer:	Larson Davis		
Model No:	831	**Serial No:**	0002375
Microphone Type:	377B02	**Serial No:**	120146
Filter Type:	1/3 Octave	**Serial No:**	0002375
Comments:	All tests passed for type 1. (See over for details)		
Owner:	AECOM Lev 45, 80 Collins Street Melbourne VIC 3000		
Ambient Pressure:	987 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	54% ±5%
Date of Calibration:	11/10/2012	**Issue Date:**	15/10/2012

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters)

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CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 39306 & FILT 9927**

Equipment Description:	Sound and Vibration Analyzer		
Manufacturer:	Svantek		
Model No:	Svan-957	**Serial No:**	27540
Microphone Type:	40AZ	**Serial No:**	101859
Filter Type:	1/3 Octave	**Serial No:**	27540
Comments:	All tests passed for type 1. (See over for details)		
Owner:	AECOM Level 45,80 Collins Street Melbourne VIC 3000		
Ambient Pressure:	1002 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	30% ±5%
Date of Calibration:	21/10/2012	**Issue Date:**	22/10/2012
Acu-Vib Test Procedure:	AVP05 (SLM) & AVP06 (Filters)		

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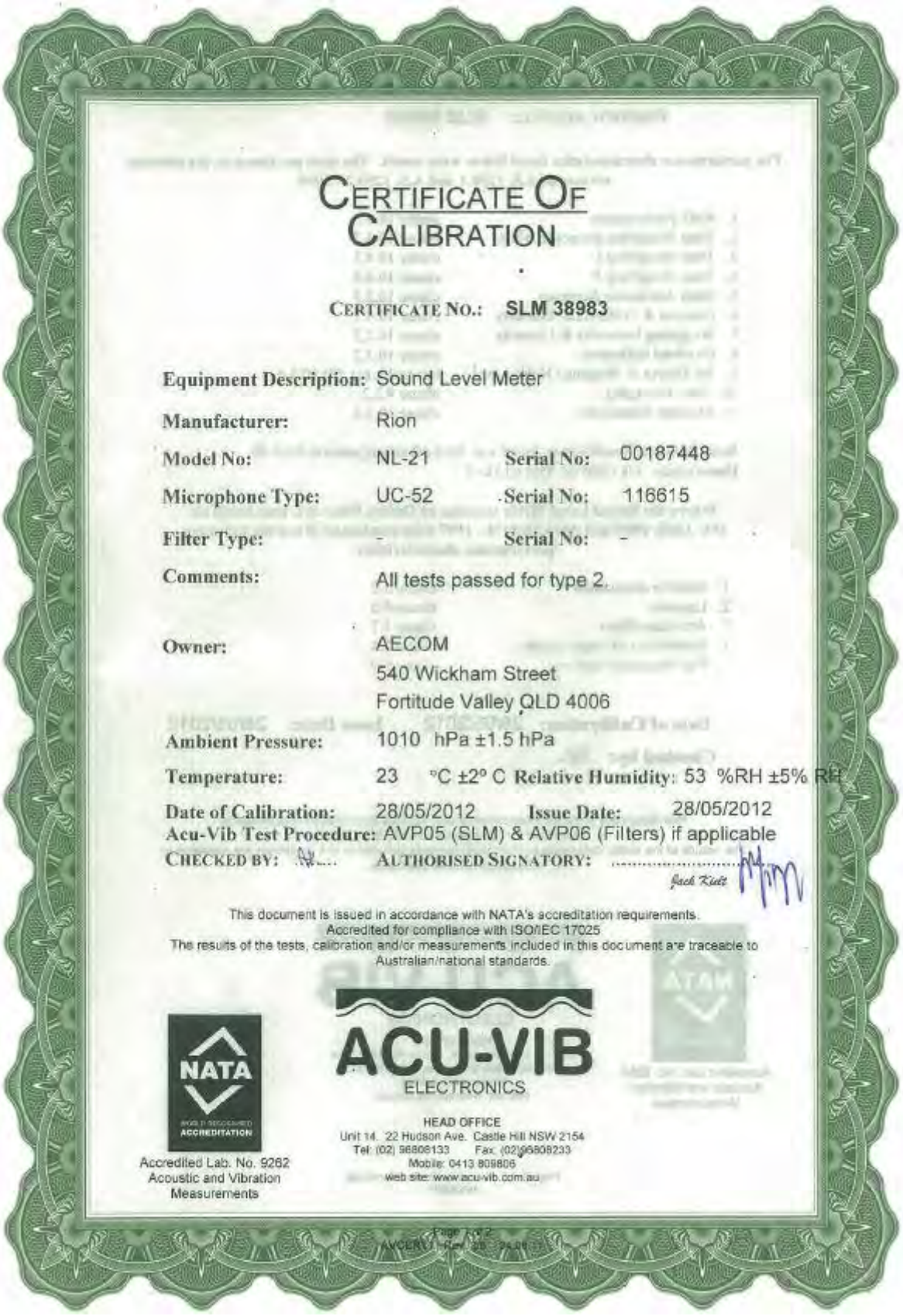

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 38983

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00187448
Microphone Type:	UC-52	**Serial No:**	116615
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		
Owner:	AECOM 540 Wickham Street Fortitude Valley QLD 4006		
Ambient Pressure:	1010 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	53 %RH ±5% RH
Date of Calibration:	28/05/2012	**Issue Date:**	28/05/2012

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

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CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 39358**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00409168
Microphone Type:	UC-52	**Serial No:**	128702

Comments: All tests passed for type 2.
(See over for details)

Owner: AECOM
Level 1, 21 Stokes Street
Townsville QLD 4810

Ambient Pressure: 994 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 53 % ±5%

Date of Calibration: 21/11/2012 **Issue Date:** 26/11/2012

Acu-Vib Test Procedure: AVP05 (SLM)

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CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 38905 & FILT 2726

Equipment Description:	Sound Level Meter		
Manufacturer:	Svantek		
Model No:	Svan-957	**Serial No:**	27552
Microphone Type:	7052E	**Serial No:**	50541
Filter Type:	1/3 Octave	**Serial No:**	27552
Comments:	All tests passed for type 1.		
Owner:	AECOM 540 Wickham Street Fortitude Valley QLD 4006		
Ambient Pressure:	1017 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	54 %RH ±5% R
Date of Calibration:	11/04/2012	**Issue Date:**	12/04/2012
Acu-Vib Test Procedure:	AVP05 (SLM) & AVP06 (Filters) if applicable		

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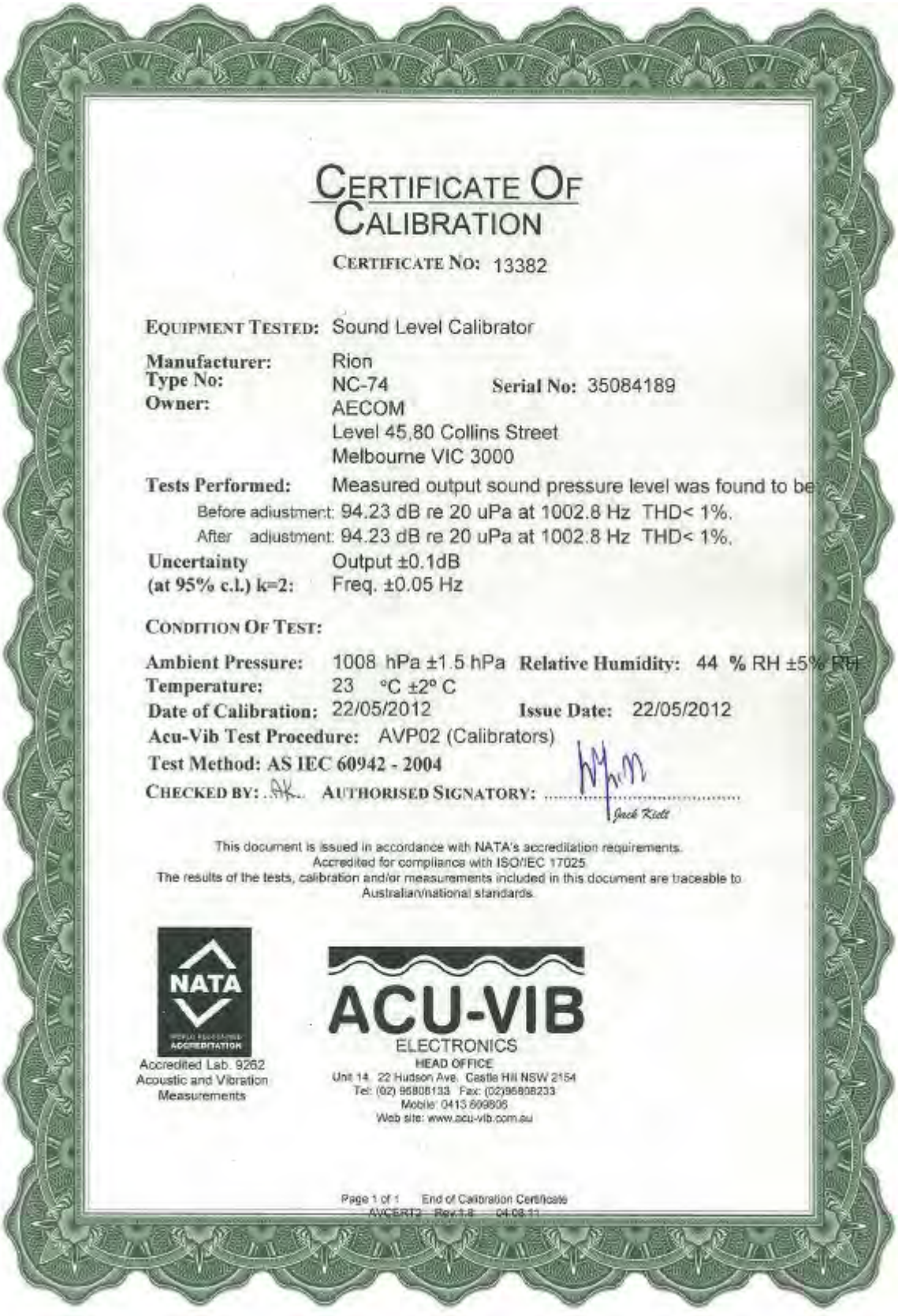

CERTIFICATE OF CALIBRATION

CERTIFICATE NO: 13382

EQUIPMENT TESTED: Sound Level Calibrator

Manufacturer: Rion
Type No: NC-74 **Serial No:** 35084189
Owner: AECOM
Level 45,80 Collins Street
Melbourne VIC 3000

Tests Performed: Measured output sound pressure level was found to be:
Before adjustment: 94.23 dB re 20 uPa at 1002.8 Hz THD< 1%.
After adjustment: 94.23 dB re 20 uPa at 1002.8 Hz THD< 1%.

Uncertainty (at 95% c.l.) k=2: Output ±0.1dB
Freq. ±0.05 Hz

CONDITION OF TEST:

Ambient Pressure: 1008 hPa ±1.5 hPa **Relative Humidity:** 44 % RH ±5% RH
Temperature: 23 °C ±2° C
Date of Calibration: 22/05/2012 **Issue Date:** 22/05/2012
Acu-Vib Test Procedure: AVP02 (Calibrators)
Test Method: AS IEC 60942 - 2004
CHECKED BY: ... **AUTHORISED SIGNATORY:** .....
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CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 38984 & FILT 3762**

Equipment Description:	Sound Level Meter		
Manufacturer:	B & K		
Model No:	2250	**Serial No:**	2600404
Microphone Type:	4189	**Serial No:**	2603666
Filter Type:	1/3 Octave	**Serial No:**	2600404
Comments:	All tests passed for type 1		

Owner: AECOM
Level 45,80 Collins Street
Melbourne VIC 3000

Ambient Pressure: 1017 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 47 %RH ±5% RH

Date of Calibration: 30/05/2012 **Issue Date:** 31/05/2012

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: **AUTHORISED SIGNATORY:** Jacob Riedt

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Appendix G

Method for Determining Wake-Free Wind Data

Appendix G Method for Determining Wake-Free Wind Data

Met Mast Selection and Wind Speed Determination

The nature of the wind farm layout means that all the met masts are located at positions where they may be affected by the wake of the wind turbines for certain wind directions.

To maintain consistency with the background noise curves, and satisfy the requirements of Section 4.5.4 of NZS 6808:1998, the wind data must be wake free.

The wind speed data used for the noise analysis was derived from a combination of the six met masts to ensure that all data used was not wake affected. A procedure for deriving wake free wind data was recommended by the project's wind analyst, Garrad Hassan, and selection of the wind data was undertaken in accordance with that procedure.

The procedure can be summarised as follows:

- A lead met mast is selected from either M1, M4 or M6, based on whichever of those masts is the closest to the reference location;
- The wind direction measured at the lead met mast is used to determine whether the mast was in the wake of the wind turbines for any particular time interval.
- For periods where the lead mast is determined to be in the wake of the wind turbines, wind speed data is taken from an alternative met mast that is not in the wake of the wind turbines for that particular wind direction.
- A directional correlation ratio that has been derived between the two met masts is then applied to adjust the wind speed from the alternative met mast to the equivalent wind speed at the lead met mast.
- In this manner, a composite times series of wind speed data from wake free met masts is synthesised and related back to the lead met mast location.

The lead met masts used for each reference location were as follows:

Table 16 Lead Met Mast for Each Noise Monitoring Location

Location ID	Lead Met Mast
P22A	M6
Q15A	M1
T25A	M4
V16A	M1

The alternative masts and directional correlation ratios used to avoid wake affects in each wind direction and relate the data back to the lead mast position were as follows:

For lead met mast M1:

Table 17 Meteorological Masts Used for Wind Speed Data

Wind Direction as Measured at Met Mast M1	Met Mast Used for Wind Speed Data
Greater than or equal to 70 degrees and less than 218 degrees	Met Mast M4
Greater than or equal to 218 degrees or less than 20 degrees	Met Mast M1
Greater than or equal to 20 degrees and less than 70 degrees	Met Mast M6

Table 18 Wind Speed Correction Factors M4 to M1

Wind Direction as Measured at Met Mast M1	Correction Factor applied to M4 Wind Speeds
Greater than or equal to 70 degrees and less than 75 degrees	0.988592
Greater than or equal to 75 degrees and less than 105 degrees	1.097402
Greater than or equal to 105 degrees and less than 135 degrees	1.076224
Greater than or equal to 135 degrees and less than 165 degrees	1.061829
Greater than or equal to 165 degrees and less than 195 degrees	1.068266
Greater than or equal to 195 degrees and less than 218 degrees	1.000269

Table 19 Wind Speed Correction Factors M6 to M1

Wind Direction as Measured at Met Mast M1	Correction Factor applied to M4 Wind Speeds
Greater than or equal to 20 degrees and less than 45 degrees	1.056619
Greater than or equal to 45 degrees and less than 70 degrees	1.020335

For lead met mast M4:

Table 20 Meteorological Masts Used for Wind Speed Data

Wind Direction as Measured at Met Mast M4	Met Mast Used for Wind Speed Data
Greater than or equal to 70 degrees and less than 218 degrees	Met Mast M4
Greater than or equal to 218 degrees and less than 340 degrees	Met Mast M3
Greater than or equal to 340 degrees or less than 70 degrees	Met Mast M6

Table 21 Wind Speed Correction Factors M4 to M3

Wind Direction as Measured at Met Mast M4	Correction Factor applied to M3 Wind Speeds
Greater than or equal to 218 degrees and less than 225 degrees	1.056454
Greater than or equal to 225 degrees and less than 255 degrees	1.023231
Greater than or equal to 255 degrees and less than 285 degrees	1.054981
Greater than or equal to 285 degrees and less than 315 degrees	1.085166
Greater than or equal to 315 degrees and less than 340 degrees	0.993236

Table 22 Wind Speed Correction Factors M6 to M4

Wind Direction as Measured at Met Mast M4	Correction Factor applied to M6 Wind Speeds
Greater than or equal to 340 degrees and less than 345 degrees	1.015667
Greater than or equal to 345 degrees or less than 15 degrees	1.064022
Greater than or equal to 15 degrees and less than 45 degrees	0.983088
Greater than or equal to 45 degrees and less than 70 degrees	0.999326

For lead met mast M6:

Table 23 Meteorological Masts Used for Wind Speed Data

Wind Direction as Measured at Met Mast M6	Met Mast Used for Wind Speed Data
Greater than or equal to 70 degrees and less than 175 degrees	Met Mast M4
Greater than or equal to 175 degrees or less than 70 degrees	Met Mast M6

Table 24 Wind Speed Correction Factors M4 to M6

Wind Direction as Measured at Met Mast M6	Correction Factor applied to M4 Wind Speeds
Greater than or equal to 70 degrees and less than 75 degrees	1.000303
Greater than or equal to 75 degrees and less than 105 degrees	1.00651
Greater than or equal to 105 degrees and less than 135 degrees	0.97507
Greater than or equal to 135 degrees and less than 165 degrees	1.028481
Greater than or equal to 165 degrees and less than 175 degrees	0.987351

Method for Determining the Anemometer to be Used

On each met mast there are two cup anemometers at 84m above ground level (hub-height). These anemometers are referred to as Cup 1A and Cup 1B.

The two cup anemometers on each met mast are located 180 degrees apart with respect to the met mast tower, and as such, at any given time one of the anemometers will be in the wake of the met mast and the other will be free from the wake of the met mast. The wind speed was therefore taken from whichever of the two cup anemometers was not in the wake of the met mast at each point in time.

Based on met mast information provided by Vestas, the following table shows the wind directions at each met mast for which each cup anemometer is not in the wake of the met mast:

Table 25 Cup Selection Table

Meteorological Mast ID	Wind Directions (WD) not Waked by Met Mast, degrees	
	Cup 1A	Cup 1B
M1	0 ≤ WD < 45 and 225 ≤ WD < 360	45 ≤ WD < 225
M2	0 ≤ WD < 60 and 240 ≤ WD < 360	60 ≤ WD < 240
M3	0 ≤ WD < 60 and 240 ≤ WD < 360	60 ≤ WD < 240
M4	60 ≤ WD < 240	0 ≤ WD < 60 and 240 ≤ WD < 360
M5	60 ≤ WD < 240	0 ≤ WD < 60 and 240 ≤ WD < 360
M6	0 ≤ WD < 30 and 210 ≤ WD < 360	30 ≤ WD < 210

Appendix H

Summary of Data Points Used for Analysis

Appendix H Summary of Data Points Used for Analysis

The following tables present a summary of the data points used in, and excluded from, the analysis of the measured noise levels:

Table 26 Number of All-Time Data Points

Location ID	1 - Available Noise Data Points	2 - Data Points excluded due to Non-Operational Wind Turbines	3 - Additional Data Points excluded due to Rain	4 - Additional Data Points excluded due to Extraneous Noise	5 - Total Data Points used for All-Time Analysis
P22A	6079	794	22	0	**5263**
Q15A	1999	262	3	11	**1723**
T25A	5030	612	52	23	**4343**
V16A	6589	878	66	0	**5661**

Table 27 Number of Night-Time Data Points

Location ID	5 - Total Data Points used for All-Time Analysis	6 - Day-time Data Points Excluded	7 - Total Data Points used for Night-Time Analysis
P22A	5263	3238	**2025**
Q15A	1723	1066	**657**
T25A	4343	2608	**1735**
V16A	5661	3490	**2171**

Appendix I

Background Noise Monitoring Report