Ararat Wind Farm

Round 2 Noise Compliance Testing

S2894C45

August 2019

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1 INTRODUCTION

Sonus has been engaged by GE Renewable Energy to conduct noise compliance testing in accordance with the Noise Compliance Testing Plan[1] (NCTP).

The NCTP requires two rounds of noise compliance testing. Within each round there is a staged methodology. Stage 1 is the primary method of NZS 6808:1998[2]. Where compliance cannot be confirmed in Stage 1 then the NCTP establishes additional test methods (Stage 2).

The first round of noise compliance testing was conducted in 2017 and was detailed in Sonus report "S2894C34". Compliance was demonstrated using Stage 1 and Stage 2 testing at the 19 dwellings in the vicinity of the Ararat Wind Farm where access was provided.

This report summarises the results of the second round of noise compliance testing for the Ararat Wind Farm at the dwellings where access has been provided.

2 CRITERIA

The applicable noise criteria are established in accordance with NZS6808:1998 with the exception of being considered over both the "all-time" (24 hours) and "night-time" (10pm to 7am) periods.

The noise criteria provided by NZS6808:1998 is an L_{A95} of 40 dB(A) or the measured background noise level plus 5 dB(A), whichever is the greater. The background noise level is determined in accordance with Section 4.5 of NZS6808:1998.

Sonus has conducted background noise level measurements at 19 dwellings in the vicinity of the Ararat Wind Farm between December 2015 and March 2016, immediately prior to construction of the wind farm. Details of the noise measurements and the measured background noise levels at each dwelling are summarised in Sonus report "S2894C30", dated June 2016.

The background noise monitoring regime commenced during construction of the Ararat Wind Farm. The construction activity did not affect the results due to the distances to the activity and the measurement process. An objective assessment which confirms the validity of the data is provided in Appendix A.

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1 Sonus document S2894C20 (dated July 2013), established in accordance with the relevant conditions of Ararat Rural City Council Permit No. 09/004799 and Northern Grampians Shire Council Permit No. 5.2009.94.1., and approved by the Minister for Planning.

2 New Zealand Standard *NZS 6808:1998 Acoustics – The assessment and measurement of sound from wind turbine generators.*

At the time of the background noise level measurements immediately prior to construction of the wind farm, access was not granted at two dwellings where the predicted noise level from the wind farm was greater than 35 dB(A) (AH8 and AH9). The 35 dB(A) is the trigger level for monitoring as required under the NCTP.

Sonus has previously conducted background noise level measurements at dwellings AH8 and AH9 in 2008 and 2009. There are obvious issues in reliance on data taken over 10 years ago, with the most significant being the potential for trees to mature and for background noise levels to increase accordingly. This increase could be incorrectly attributed to the wind farm. Notwithstanding, for the purposes of a conservative assessment, these data have been utilised in the absence of contemporary information.

In accordance with the legislative requirements at the time of the measurements, background noise levels at AH8 and AH9 were used to determine criteria based on wind speeds at 10m above ground level. The analysis of the background noise data has therefore been updated to correlate to wind speeds at the turbine hub height with the relevant assessment criteria updated accordingly (to align with the current assessment criteria). The following wind shear formula and wind speed power law have been used to determine the hub height wind speeds for each 10 minute measurement period, based on the measurements heights of approximately 36m and 48m.

$$\alpha = \text{Log}(v/v_{ref})/\log(z/z_{ref})$$

$$v = v_{ref} * (z/z_{ref})^{\alpha}$$

where, **V** is the wind speed at height **Z**;
$\mathbf{V}_{ref}$ is the reference wind speed at reference height $\mathbf{Z}_{ref}$;
α is the shear coefficient.

Based on the measured background noise levels, the relevant noise criteria at AH8 and AH9 have been determined (subject to the limitations noted above).

The relevant noise criteria at the other 19 dwellings and at AH8 and AH9 for the all-time and night-time periods are provided in Table 1 and Table 2, respectively. With the exception of AH8 and AH9, the criteria are as per the Round 1 testing.

Table 1: Criteria for "all time" period.

Monitoring Location ID	$L_{A95,10}$ (dB(A)) at 85m Hub Height Integer Wind Speeds										
	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s	13 m/s	14 m/s
AH03	40	40	40	40	40	40	40	40	42	43	45
AH05	40	40	40	40	40	40	42	44	45	47	49
AH06	40	40	40	40	40	40	42	44	46	48	49
AH08	40	40	40	40	40	40	40	40	42	46	50
AH09	40	40	40	40	40	40	40	40	40	43	48
AH10	40	40	40	40	40	40	41	43	45	47	49
AH12	40	40	40	40	40	40	41	42	44	45	46
AH13	40	40	40	40	40	40	42	43	44	45	44
AH14	40	40	40	40	40	40	40	41	42	42	41
AH15	40	40	40	40	40	40	40	41	41	41	41
AH38	40	40	40	40	40	41	43	45	45	45	44
AH39	40	40	40	40	40	40	40	42	43	44	44
AH40	40	40	40	40	40	42	44	45	47	47	46
AH41	40	40	40	40	40	40	41	43	45	47	48
AH42	40	40	40	40	40	42	45	47	49	51	53
AH43	40	40	40	40	40	40	42	44	46	47	47
AH44	40	40	40	40	40	40	42	43	45	46	46
AH46	40	40	40	40	40	40	42	44	46	48	51
AH51	40	40	40	40	40	40	40	40	42	44	46
AH52	40	40	40	40	40	40	40	42	44	46	48
AH53	40	40	40	40	40	40	40	41	43	45	48

Table 2: Criteria for "night time" period.

Monitoring Location ID	$L_{A95,10}$ (dB(A)) at 85m Hub Height Integer Wind Speeds										
	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s	13 m/s	14 m/s
AH03	40	40	40	40	40	40	40	40	40	42	43
AH05	40	40	40	40	40	40	40	40	42	44	46
AH06	40	40	40	40	40	40	40	40	42	44	46
AH08	40	40	40	40	40	40	40	40	41	48	56
AH09	40	40	40	40	40	40	40	40	40	41	45
AH10	40	40	40	40	40	40	40	40	43	47	51
AH12	40	40	40	40	40	40	40	40	41	43	46
AH13	40	40	40	40	40	40	40	40	41	44	47
AH14	40	40	40	40	40	40	40	40	42	43	44
AH15	40	40	40	40	40	40	40	40	41	43	43
AH38	40	40	40	40	40	40	40	41	43	44	45
AH39	40	40	40	40	40	40	40	40	40	40	40
AH40	40	40	40	40	40	40	40	42	44	45	45
AH41	40	40	40	40	40	40	40	40	43	47	52
AH42	40	40	40	40	40	40	41	44	48	53	59
AH43	40	40	40	40	40	40	40	42	44	45	45
AH44	40	40	40	40	40	40	40	40	43	46	50
AH46	40	40	40	40	40	40	40	41	45	51	59
AH51	40	40	40	40	40	40	40	40	40	41	43
AH52	40	40	40	40	40	40	40	40	40	40	40
AH53	40	40	40	40	40	40	40	40	40	42	45

3 STAGE 1 TESTING

3.1 Testing Location

The NCTP requires the Stage 1 testing to be conducted at all non-stakeholder dwellings where the predicted noise level is at or above 35 dB(A), subject to access being granted.

The relevant non-stakeholder dwellings have been determined based on the predicted noise levels from the final turbine arrangement, as summarised in the Sonus report S2894C24, dated April 2014. A total of 21 dwellings were identified.

Access for the second round of compliance monitoring has been granted at 20 locations (refer Table 3), with the owners at AH46 (686992E 5876972N) denying access.

At each of the 20 dwellings, noise logging equipment was placed at the equivalent position to the background noise logging location (including the original 2008 / 2009 locations at AH8 and AH9). Generally, the position was on the wind farm side of the dwelling and at least 5m from the building facade to remove the effects of large reflecting surfaces. A photograph of the noise logging equipment at each dwelling is provided in Appendix B.

As discussed above, given that background noise measurements were not conducted at dwellings AH8 and AH9 immediately prior to construction of the wind farm, there is the potential that the noise environment will have changed. Noise logging equipment was therefore placed at an intermediate location between the closest wind turbine and dwellings to enable further analysis and data filtering to assist in determining compliance at these locations.

In addition to the noise logging, local wind speed logging (to determine the wind speed at the microphone as distinct to at the hub height of a turbine) was conducted at 9 locations, with rainfall data collected at 5 locations. The rainfall data and the measured wind speed at the microphone height were used to identify periods when data may have been adversely affected by weather. For locations where the local weather logging equipment was not deployed, data from the closest weather logger has been used in the analysis.

Table 3 provides the coordinates of the 20 noise testing locations for the Stage 1 testing, and includes the monitoring period at each location and the local weather logging details.

Table 3: Stage 1 noise testing locations.

No	Testing Location	Coordinates (WGS 84 Zone 54)		Monitoring Period	Wind Logger	Rain Logger
		Easting	Northing			
1	AH03	676173	5883809	4/9/2018 – 17/10/2018	AH53	AH9
2	AH05	677240	5877436	17/10/2018 – 28/11/2018	AH52	AH52
3	AH06	677508	5875847	4/9/2018 – 17/10/2018	AH53	AH9
4	AH8	680796	5872989	5/9/2018 – 17/10/2018	AH9	AH9
5	AH9	680740	5872799	5/9/2018 – 17/10/2018	AH9	AH9
6	AH10	684902	5873587	18/10/2018 – 28/11/2018	AH10	AH41
7	AH12	686435	5873123	5/9/2018 – 17/10/2018	AH9	AH9
8	AH13	686881	5873171	18/10/2018 – 28/11/2018	AH15	AH41
9	AH14	687352	5872154	5/9/2018 – 17/10/2018	AH14	AH40
10	AH15	687467	5872059	17/10/2018 – 28/11/2018	AH15	AH41
11	AH38	689658	5874816	4/9/2018 – 17/10/2018	AH40	AH40
12	AH39	689581	5874970	4/9/2018 – 17/10/2018	AH41 & AH39	AH41 & AH39
13	AH40	689599	5875129	4/9/2018 – 17/10/2018	AH41 & AH39	AH41 & AH39
14	AH41	687998	5876371	18/10/2018 – 28/11/2018	AH41	AH41
15	AH42	687930	5876332	4/9/2018 – 17/10/2018	AH42	AH42
16	AH43	687640	5876584	18/10/2018 – 28/11/2018	AH41	AH41
17	AH44	688176	5877160	4/9/2018 – 17/10/2018	AH42	AH42
18	AH51	681446	5881230	4/9/2018 – 17/10/2018	AH53	AH9
19	AH52	679501	5880515	17/10/2018 – 28/11/2018	AH52	AH52
20	AH53	679044	5879926	4/9/2018 – 17/10/2018	AH53	AH9

3.2 Data Collection

The noise levels (L_{A95}) at each location were measured continuously in 10 minute intervals over the monitoring periods using a NATA calibrated, Type 1 or Type 2 sound level meter with a noise floor of less than 20 dB(A). The sound level meters were calibrated before and after the background noise monitoring regime with a Type 1 calibrator and the microphones fitted with high wind speed weather proof windshields.

During the noise monitoring regime, hub height (85m) wind speed was monitored by GE Renewable Energy at the following meteorological masts located at the wind farm:

Table 4: Stage 1 mast locations.

Mast	Coordinates (WGS 84 Zone 54)	
	Easting	Northing
PMM01	679831	5878992
PMM02	680772	5878901
PMM03	684390	5875121
PMM04	680831	5873601

3.3 Data Analysis

At all locations noise data which were "adversely affected" by rain or wind on the microphone were removed. Data are considered to be adversely affected if rain occurred in a 10 minute period or where a wind speed greater than 5 m/s is exceeded for 90% of a 10 minute period.

With the exception of dwellings AH8 and AH9, the analysis of the data was conducted in accordance with the NCTP, as follows:

- Following removal of data affected by weather, the remaining noise data were correlated with wind speed data for each testing location, based on both the all-time and night-time periods; and,
- The wind farm noise contribution at the testing location was derived by logarithmically subtracting the background noise curve from the curve generated by the Stage 1 data correlation.

At dwellings AH8 & AH9 the background noise levels were used to conservatively establish assessment criteria. The post construction analysis did not subtract these background noise levels, but rather, additional data filtering was used to remove points where a higher noise level was measured at the dwellings than at the intermediate logger. These points (being where the measured noise level is higher further away from the wind farm) indicate that the data have been affected by other sources, such as wind in the trees.

The removal of these points therefore provides an indication of the windfarm noise level (albeit without the removal of background noise as the remaining data is still an unknown combination of wind farm noise and noise from wind in the trees and local sources) and has been used as a conservative Stage 1 method given the uncertainty associated with the previous background noise monitoring and changes in local conditions.

The wind speeds were taken from the wind mast closest to the relevant testing location. Table 5 provides the number of valid data points following removal of adverse data and identifies the wind mast which has been used for the correlations at each testing location.

Table 5: Number of valid data pairs and relevant wind mast.

No	Testing Location	Valid Data Points		Relevant Mast
		All-time	Night-time	
1	AH03	4116	1491	PMM01
2	AH05	3801	1263	PMM01
3	AH06	4114	1491	PMM01
4	AH08	3780	1405	PMM04
5	AH09	3860	1359	PMM04
6	AH10	4364	1496	PMM03
7	AH12	3804	1265	PMM03
8	AH13	3692	1206	PMM03
9	AH14	3802	1265	PMM03
10	AH15	3761	1234	PMM03
11	AH38	3852	1316	PMM03
12	AH39	3691	1191	PMM03
13	AH40	3689	1191	PMM03
14	AH41	3685	1206	PMM03
15	AH42	3856	1316	PMM03
16	AH43	3682	1206	PMM03
17	AH44	3857	1316	PMM03
18	AH51	4089	1481	PMM01*
19	AH52	3799	1263	PMM01
20	AH53	4088	1481	PMM01

** AH51 is closer to PMM02 (by 300m), however there is limited data available for PMM02, therefore PMM01 has been used*

3.4 Stage 1 Test Results

The resultant wind farm noise level (after the above data analysis) and criterion for each integer hub height wind speed from 4m/s to 14m/s are summarised in Table 6 and Table 7 for the all-time and night-time periods respectively. The wind speeds where the Stage 1 testing methodology cannot demonstrate compliance are highlighted in red in the following tables.

Table 6: Stage 1 noise levels and criteria (dB(A)) – "all-time" period.

Testing Location	4m/s		5m/s		6m/s		7m/s		8m/s		9m/s		10m/s		11m/s		12m/s		13m/s		14m/s	
	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results
AH03	40	27	40	25	40	26	40	27	40	29	40	31	40	34	40	38	42	41	43	45	45	48
AH05	40	30	40	32	40	34	40	35	40	36	40	37	42	37	44	38	45	39	47	40	49	41
AH06	40	30	40	30	40	31	40	33	40	34	40	36	42	38	44	40	46	42	48	43	49	44
AH08	40	26	40	28	40	30	40	32	40	34	40	36	40	38	40	39	42	41	46	42	50	43
AH09	40	25	40	28	40	30	40	32	40	34	40	36	40	38	40	40	40	41	43	43	48	44
AH10	40	26	40	27	40	28	40	29	40	31	40	32	41	34	43	35	45	37	47	38	49	38
AH12	40	28	40	30	40	33	40	35	40	36	40	37	41	39	42	40	44	41	45	43	46	45
AH13	40	30	40	30	40	31	40	32	40	33	40	34	42	36	43	37	44	38	45	39	44	40
AH14	40	23	40	25	40	28	40	30	40	32	40	34	42	35	43	37	44	38	45	39	44	41
AH15	40	25	40	26	40	26	40	27	40	29	40	30	40	31	41	33	41	34	41	35	41	35
AH38	40	26	40	28	40	30	40	31	40	33	41	35	43	37	45	39	45	40	45	43	44	45
AH39	40	25	40	26	40	27	40	28	40	30	40	32	40	33	42	35	43	35	44	36	44	35
AH40	40	27	40	28	40	29	40	31	40	33	42	35	44	36	45	38	47	39	47	39	46	38
AH41	40	25	40	26	40	28	40	30	40	31	40	33	41	35	43	36	45	38	47	39	48	39
AH42	40	25	40	28	40	31	40	34	40	37	40	39	41	41	43	42	45	44	47	44	48	45
AH43	40	24	40	26	40	28	40	30	40	32	40	34	42	35	44	37	46	37	47	38	47	38
AH44	40	24	40	26	40	28	40	30	40	32	42	34	45	36	47	38	49	39	51	40	53	41
AH51	40	29	40	29	40	29	40	30	40	31	40	32	40	34	40	35	42	36	44	37	46	38
AH52	40	30	40	32	40	33	40	35	40	37	40	38	40	39	42	40	44	41	46	40	48	40
AH53	40	31	40	29	40	28	40	29	40	31	40	33	40	36	41	38	43	40	45	40	48	41

Table 7: Stage 1 noise levels and criteria (dB(A)) – "night-time" period.

Testing Location	4m/s		5m/s		6m/s		7m/s		8m/s		9m/s		10m/s		11m/s		12m/s		13m/s		14m/s	
	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results	Noise Criteria	Stage 1 results
AH03	40	27	40	26	40	25	40	25	40	26	40	28	40	31	40	35	40	39	42	44	43	48
AH05	40	29	40	30	40	31	40	32	40	32	40	33	40	33	40	33	42	34	44	35	46	36
AH06	40	30	40	30	40	31	40	32	40	34	40	36	40	38	40	40	42	41	44	43	46	45
AH08	40	27	40	29	40	31	40	32	40	33	40	34	40	36	40	37	41	39	48	41	56	44
AH09	40	26	40	28	40	30	40	31	40	33	40	34	40	36	40	38	40	41	41	44	45	49
AH10	40	26	40	27	40	27	40	28	40	29	40	30	40	31	40	33	43	34	47	36	51	38
AH12	40	28	40	31	40	33	40	35	40	36	40	38	40	39	40	41	41	42	43	42	46	43
AH13	40	30	40	29	40	29	40	31	40	32	40	34	40	36	40	38	41	39	44	39	47	39
AH14	40	22	40	24	40	27	40	29	40	33	40	35	40	38	40	40	42	41	43	41	44	39
AH15	40	24	40	24	40	24	40	26	40	27	40	29	40	31	40	33	41	34	43	35	43	34
AH38	40	25	40	26	40	28	40	30	40	33	40	35	40	37	41	39	43	41	44	44	45	46
AH39	40	22	40	22	40	23	40	24	40	26	40	27	40	29	40	30	40	31	40	32	40	32
AH40	40	23	40	24	40	26	40	27	40	29	40	31	40	32	40	33	42	34	44	35	45	35
AH41	40	23	40	24	40	26	40	28	40	31	40	32	40	34	40	35	43	36	47	37	52	37
AH42	40	24	40	26	40	29	40	32	40	34	40	37	41	39	44	40	48	41	53	42	59	43
AH43	40	23	40	25	40	28	40	30	40	32	40	33	40	34	42	35	44	36	45	36	45	35
AH44	40	22	40	24	40	27	40	30	40	32	40	34	40	36	40	37	43	37	46	38	50	39
AH51	40	28	40	28	40	28	40	28	40	29	40	30	40	31	40	32	40	32	40	34	42	35
AH52	40	27	40	28	40	29	40	31	40	32	40	34	40	35	40	37	40	37	40	38	40	37
AH53	40	29	40	27	40	27	40	27	40	29	40	31	40	34	40	36	40	37	42	37	44	37

4 STAGE 2 TESTING

4.1 Stage 2 Testing Requirements

Based on the Stage 1 results in Table 5 and 6, Stage 2 testing is triggered at the dwellings, integer wind speeds and time periods summarised in Table 7.

Table 4: Stage 2 testing requirements.

Dwelling	Time Period	Wind speeds, m/s
AH03	All-time (24 hour) Night-time	13, 14 NA
AH9	All-time (24 hour) Night-time	12 12, 13, 14
AH12	Night-time	11, 12
AH38	All-time (24 hour) Night-time	14 NA

Table 7 indicates Stage 2 testing is required at high wind speeds (11m/s and above) only.

4.2 Stage 2 Testing

Typically, the noise from a wind farm would increase with wind speed up to a maximum noise level (approximately 10m/s to 11m/s hub height wind speed) and then remain constant at subsequent higher wind speeds (due to the power generating capacity of the turbine being reached). However, the Stage 1 results for AH03, AH9, AH12 and AH38 show noise levels that continue to increase over the full wind speed range, indicating that the measured noise levels are influenced by local sources in the environment (such as wind in the trees) rather than the wind farm, particularly at the higher wind speeds.

To enable the noise contribution from the wind farm at high wind speeds to be determined, the Stage 2 testing comprised measuring the noise from the wind farm in the near field (close to a turbine where a high turbine noise to background noise level ratio can be achieved) to establish a reference noise emission curve for the turbines. The reference noise emission curve was then applied to the Stage 1 results to derive the noise level from the wind farm in the absence of wind in the environment. The noise from the wind farm at the dwellings will follow the reference noise emission curve at higher wind speeds in the absence of any other local noise sources in the environment.

Near Field Noise Measurements

The near field noise measurements were conducted in general accordance with the methodology of International Standard IEC 61400-11: 2012 *Wind turbine generator systems – Part 11: Acoustic noise measurements techniques* (IEC 61400), near turbine T61 (680834E 5873856N).

The measurements were conducted from 10 to 12 June 2019 and consisted of the following:

- A single microphone position, located approximately 115m southwest of turbine T61;
- continuous 10 second noise level measurements at the microphone and continuous 10 second wind speed measurements at hub height;
- 10 second nacelle yaw angle recordings to determine the wind direction; and
- a minimum of 180 measurements with the turbine operating over the range of wind speed of interest.

The noise and wind data were analysed to determine the periods when the noise measurements were downwind (± 15° of the nacelle centreline) of the turbine.

The remaining data points were plotted to produce the reference noise emission curve as shown in Figure 1.

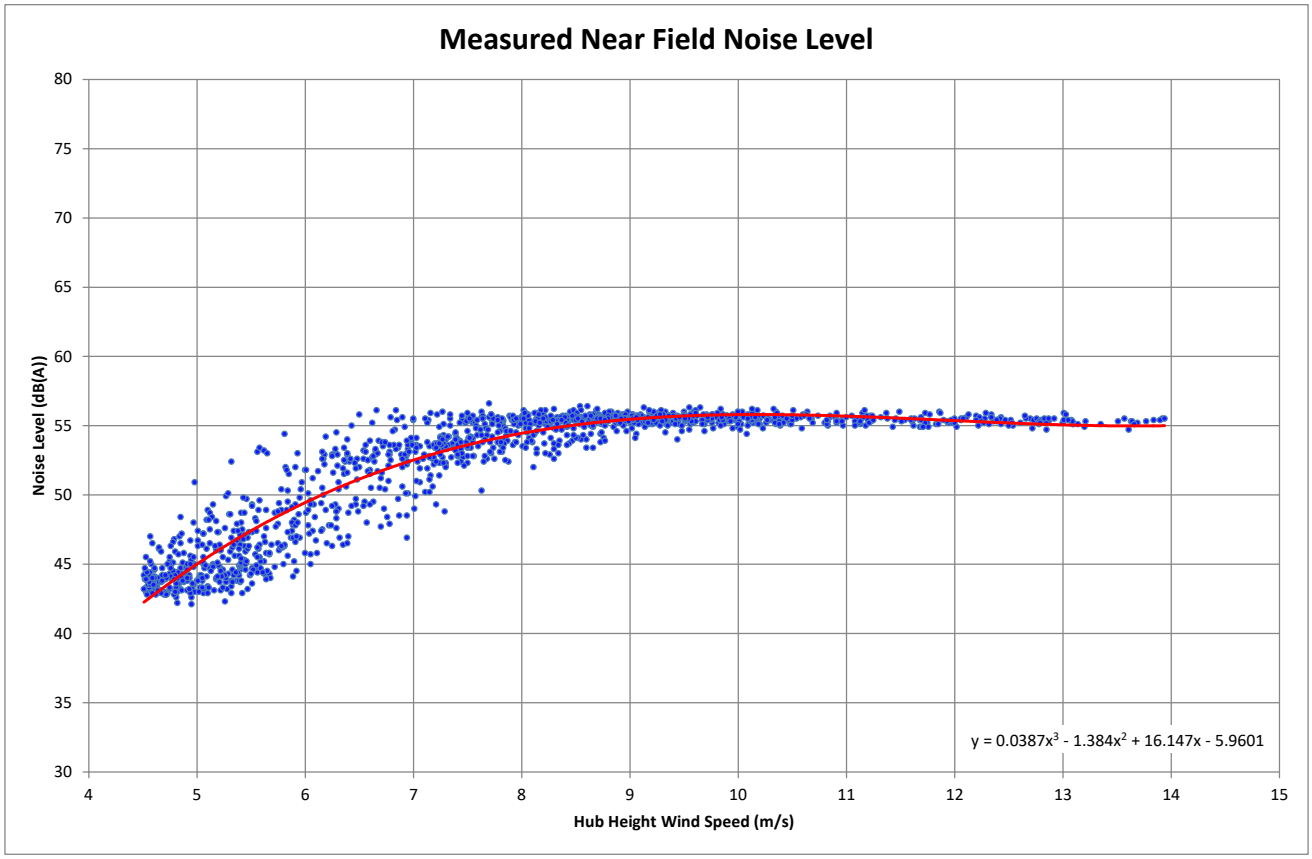

Figure 1: Noise emission curve turbine T61.

The graph confirms the noise from the Ararat Wind Farm increases with wind speed up to 10 m/s and then plateaus for higher wind speeds.

The graph results have been used to update the Stage 1 results for all wind speeds higher than 10 m/s to more accurately define the noise level from the wind farm without the influence of other noise sources in the environment.

The resulting graphs for the all-time and the night-time periods are provided in Appendix C and Appendix D respectively.

Tables 9 and 10 below provide an updated version of Tables 6 and 7 respectively to include the Stage 2 testing results.

Tables 6 and 7 highlight the measured noise level at 10m/s. The noise levels at integer wind speeds greater than 10m/s have been updated in accordance with the results of the Stage 2 testing, that is, to be no greater than the measured noise level at 10 m/s.

The Stage 1 and Stage 2 results demonstrate compliance at all dwellings subject to an assessment of special audible characteristics from the wind farm.

Table 6: Stage 2 noise levels and criteria (dB(A)) – "all-time" period.

Testing Location	4m/s		5m/s		6m/s		7m/s		8m/s		9m/s		10m/s		11m/s		12m/s		13m/s		14m/s	
	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results
Stage 2 Testing																						
AH03	40	27	40	25	40	26	40	27	40	29	40	31	40	34	40	34	42	34	43	34	45	34
AH09	40	25	40	28	40	30	40	32	40	34	40	36	40	38	40	38	40	38	43	38	48	38
AH38	40	26	40	28	40	30	40	31	40	33	41	35	43	37	45	37	45	37	45	37	44	37

Table 7: Wind farm noise levels and criteria (dB(A)) – "night-time" period.

Testing Location	4m/s		5m/s		6m/s		7m/s		8m/s		9m/s		10m/s		11m/s		12m/s		13m/s		14m/s	
	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results	Noise Criteria	Stage 2 results
Stage 2 Testing																						
AH03	40	27	40	26	40	25	40	25	40	26	40	28	40	31	40	31	40	31	42	31	43	31
AH09	40	26	40	28	40	30	40	31	40	33	40	34	40	36	40	36	40	36	41	36	45	36
AH12	40	28	40	31	40	33	40	35	40	36	40	38	40	39	40	39	41	39	43	39	46	39
AH38	40	25	40	26	40	28	40	30	40	33	40	35	40	37	41	37	43	37	44	37	45	37

5 SPECIAL AUDIBLE CHARACTERISTICS

5.1 Tonality

Tonality testing has been conducted at AH9 and AH10.

The tonality testing was conducted in accordance with the NCTP as follows:

- For each 10 minute period, the equivalent sound level in each unweighted one third octave band was compared against the equivalent sound levels in the neighbouring one third octave bands;
- Where the noise level exceeded the level in both adjacent bands by more than the values in the table below and there was no evidence (such as an audio recording) that the tone is from a source unrelated to the wind farm, the 10 minute interval was deemed to exhibit tonality and a 5 dB(A) penalty added to the measured noise level in that 10 minute interval, prior to correlating the noise data with the corresponding wind data as detailed above.

One Third Octave Band	Level Difference
25-125 Hz	15 dB
160-400 Hz	8 dB
500-4000Hz	5 dB

The one third octave band data associated with the Round 2 Stage 2 testing has been analysed to determine the periods when a tone was measured, in accordance to the above. The data exhibited a range of tones which were further analysed to determine the source of tone. Review of audio recordings indicated that the sources of the tones were from trucks, cars and animals rather than from the wind farm.

Notwithstanding, a penalty has conservatively been applied to the wind farm at the residences during times when a tone has been measured and the correlations compared to that prior to application of a penalty. The difference in noise level for each integer wind speed has been compared and is less than 1 dB(A) at any wind speed.

Based on the above and the requirements of the NCTP, the wind farm does not exhibit any tonal characteristic which would require assessment at other dwellings or a penalty to be applied to the windfarm noise levels provided in the previous sections.

5.2 Amplitude Modulation

The NCTP references the "interim test method" provided in NZS6808:2010 to test for amplitude modulation. The test method consists of the following:

- Measurements of noise level:
  - at the dwelling with the highest predicted noise levels;
  - at the integer wind speed where the difference between the predicted noise level and the project criteria is the least;
  - under a downwind condition for at least 50% of the measurement period;
  - over a minimum interval of 2-minutes with the wind farm operational;
  - with at least 5 measurement intervals where the modulation of the wind farm was audible;
- Review of the overall noise level time trace for modulation at the blade pass frequency;
- Assess whether the typical peak to trough values exceed 5 dB. The noise from the wind farm exhibits amplitude modulation the values exceed 5 dB;
- Apply 5 dB penalty to the wind farm noise level for the wind conditions under which the modulation occurs.

Noise level measurements (100 millisecond intervals) have been conducted at AH9 to determine amplitude modulation in accordance with the above. Five samples of 2 minute data corresponding to the periods with 11 m/s wind speed have been analysed.

Audio recordings during these periods have been analysed and determined to include both wind farm and local insect sources. The time trace of the noise level during these samples show modulation at approximately 1 Hz (the approximate blade pass frequency), with typical peak to trough values in the order of 1.5 to 2 dB, which is below the 5 dB criterion.

Based the above, the wind farm does not exhibit significant amplitude modulation other than that typically expected from an operating wind farm and therefore a penalty is not applicable.

6 CONCLUSION

The second round of noise compliance testing has been conducted for the Ararat Wind Farm in accordance with the NCTP.

The Round 2 Stage 1 tests confirmed that the noise from operation of the wind farm complied with the established noise criteria at 16 of the 20 surrounding dwellings. Due to the conservative limitations of the Stage 1 testing, compliance could not be determined at higher wind speeds at 4 dwellings.

Stage 2 testing was conducted at the 4 dwellings, being AH03, AH09, AH12 and AH38, which confirmed that the wind farm achieved compliance at all 20 dwellings.

The testing also confirmed that no penalties were applicable for special audible characteristics of tonality and amplitude modulation.