Dundonnell Wind Farm

Pre-Construction Noise Assessment

S5345C9A

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1 INTRODUCTION

A pre-construction noise assessment has been made of the proposed Dundonnell Wind Farm in Victoria, in accordance with the requirements of the relevant Conditions in the Planning Permit[1].

The relevant Conditions in the Planning Permit are the following:

> ***NOISE***
>
> ***Performance requirement***
>
> *11. Subject to condition 12, the operation of the wind energy facility must not result in wind farm sound levels that exceed the relevant base noise limit described below when measured in accordance with New Zealand Standard 6808:2010 Acoustics – Wind Farm Noise (the Standard):*
>
> *a. 40 dB LA90(min) at 'noise sensitive locations' (as defined in the Standard); or*
>
> *b. Any higher base noise limit that the wind farm operator and dwelling owner agree applies to a particular dwelling. This agreement must be in a form that runs with the land for the life of the wind energy facility.*
>
> *Where the background sound level plus 5 dB is greater than the relevant base noise limit, the noise limit will be the background sound level LA90(10min) plus 5 dB.*
>
> *12. Where special audible characteristics, including tonality, impulsive sound or enhanced amplitude modulation occur, as assessed in accordance with Appendix B of the Standard, the noise limit will be modified by applying a penalty of up to +6 dB LA90 in accordance with Section 5.4 of the Standard.*
>
> ***Noise compliance assessment***
>
> *Pre-construction assessment*
>
> *13. Before development of the wind energy facility commences, a pre-construction noise assessment, including a tonal audibility assessment, must be undertaken to reflect the final turbine layout and turbine model chosen. The pre-construction noise assessment shall be prepared by a suitably qualified and experienced independent acoustic engineer to demonstrate the wind energy facility will comply with the relevant noise limits specified in condition 11, and must be to the satisfaction of the responsible authority. All compliance reports must be publically available on the project website.*

This document summarises the pre-construction assessment, which includes the prediction of noise levels at noise sensitive locations from the final wind turbine generator (WTG) configuration (WTG layout and model selection), the comparison of the predicted noise levels with the relevant noise limits, and a tonal audibility assessment.

[1] Planning Permit No 2015/23858, issued on 30 June 2016.

2 FINAL WTG CONFIGURATION

The final WTG configuration consists of 80 Vestas V150-4.2MW WTGs with a hub height of 114m above ground level, located at the coordinates provided in Table 1.

Table 1: Coordinates of WTGs.

WTG ID	Coordinates (UTM WGS 84 Zone 54)		WTG ID	Coordinates (UTM WGS 84 Zone 54)		WTG ID	Coordinates (UTM WGS 84 Zone 54)	
	Easting	Southing		Easting	Southing		Easting	Southing
T001	673439	5809911	T048	672510	5807335	T087	674871	5805409
T002	677362	5809898	T050	670854	5807294	T088	670731	5805416
T003	673950	5809861	T051	675284	5807166	T090	671110	5805174
T004	676936	5809777	T052	671982	5807044	T094	671831	5804207
T006	676547	5809654	T054	671233	5807007	T095	671403	5804932
T008	674388	5809747	T055	673079	5809572	T096	671527	5804432
T009	673613	5809350	T056	673748	5806864	T097	672059	5803866
T010	677281	5809243	T057	672771	5806773	T101	671605	5803894
T012	672691	5809186	T058	674755	5806781	T103	671749	5803544
T013	674521	5808999	T059	676488	5806780	T104	676870	5809142
T014	674060	5808972	T060	676104	5806762			
T016	676545	5808807	T061	670768	5806744			
T017	677496	5808729	T062	675532	5806698			
T018	672620	5808482	T063	670228	5806686			
T019	672130	5808625	T065	674412	5806523			
T020	673640	5808532	T066	672193	5806473			
T021	677150	5808575	T067	673144	5806388			
T022	674312	5808443	T068	673891	5806247			
T023	673159	5808441	T069	671013	5806263			
T024	676738	5808330	T070	675880	5806259			
T025	671774	5808270	T071	673518	5806324			
T027	675199	5808162	T072	671504	5806238			
T029	673974	5808095	T073	669957	5806369			
T031	677567	5808002	T074	670662	5806094			
T032	675588	5808037	T075	674688	5806031			
T033	676032	5807966	T076	675521	5806036			
T034	672272	5807926	T077	671873	5806004			
T036	676978	5807708	T078	672435	5806099			
T038	673514	5807707	T080	675161	5805748			
T040	671627	5807627	T081	672806	5807864			
T041	673098	5807346	T082	674283	5805490			
T043	677291	5807477	T083	671199	5805692			
T044	676194	5807393	T084	670044	5805868			
T046	674553	5807362	T085	672249	5805592			
T047	676828	5807123	T086	671563	5805490			

3 NOISE SENSITIVE LOCATIONS

The noise sensitive locations surrounding the wind farm are listed in Table 2.

Table 2: Noise Sensitive Locations.

Dwelling ID	Coordinates (UTM WGS 84 Zone 54)		Stake-holder	Closest WTG	
	Easting	Southing		WTG ID	Distance, m
H1	669031	5806382	Yes	T073	926
H2	672687	5804696	Yes	T094	980
H3	667108	5804579	No	T084	3206
H5	673105	5798289	No	T103	5427
H6	670820	5798279	No	T103	5346
H8	676086	5801678	No	T087	3924
H9	677876	5801903	No	T087	4618
H10	680814	5799719	No	T070	8192
H11	677473	5798817	No	T087	7087
H12	681577	5801973	No	T043	6976
H13	681618	5802969	No	T043	6249
H14	682290	5804668	No	T043	5734
H15	682270	5805042	No	T043	5543
H16	680888	5804176	No	T043	4882
H17	679506	5804589	No	T043	3640
H18	680221	5807762	No	T031	2665
H19	680624	5810824	No	T002	3391
H20	679962	5810886	No	T002	2781
H21	676702	5812095	No	T002	2294
H22	677060	5814311	No	T002	4423
H23	677259	5815194	No	T002	5297
H24	677687	5816862	No	T002	6972
H25	672251	5815684	No	T001	5894
H26	670520	5815329	No	T001	6154
H27	668447	5813620	No	T012	6138
H28	667264	5813042	No	T025	6566
H29	663335	5808107	No	T073	6846
H31	663707	5803686	No	T084	6702
H32	663040	5804034	No	T084	7240
H33	662584	5803912	No	T084	7712
H35	662500	5802258	No	T084	8363
H36	661643	5804320	No	T084	8542
H37	662917	5802114	No	T084	8055
H39	666337	5803239	Yes	T084	4545
H40	667859	5802265	Yes	T101	4085
H41	668315	5805431	Yes	T084	1783
H42	672091	5801880	No	T103	1699
H43	672346	5801211	No	T103	2408
H44	673018	5801797	No	T103	2159
H46	673610	5803201	Yes	T097	1688
H47	674259	5804598	Yes	T082	892
H49	675515	5809154	Yes	T013	1006

Dwelling ID	Coordinates (UTM WGS 84 Zone 54)		Stake-holder	Closest WTG	
	Easting	Southing		WTG ID	Distance, m
H50	676372	5810735	Yes	T006	1054
H51	671667	5811042	Yes	T055	2038
H52	671547	5811153	Yes	T055	2201
H53	676191	5812660	No	T004	2978
H56	666056	5811177	Yes	T063	6130
H57	664585	5809240	Yes	T073	6091
H58	662781	5807078	No	T073	7211
H61	682427	5810972	No	T002	5177
H62	675853	5812054	No	T006	2452
H63	677018	5816534	No	T002	6644
H64	674257	5799633	No	T103	4646
H65	664009	5800534	No	T084	8054
H66	659271	5794818	No	T103	15226
H67	659128	5794722	No	T103	15399
H68	654047	5790668	No	T103	21890
H69	653387	5789716	No	T103	22987
H70	651395	5787972	No	T103	25628
H71	657660	5795091	No	T084	16416

Notes:

- A stakeholder is defined as a dwelling where the wind farm operator and dwelling owner agree that a higher base noise limit applies, in accordance with Condition 11b of the Planning Permit.
- The dwellings in Table 2 are shown on the figure in the Appendix.

4 ENVIRONMENTAL NOISE CRITERIA

The relevant noise performance requirements of the wind farm are provided by Condition 11 of the Planning Permit, which specifies the relevant base noise limits, and the background dependent noise limit if the background noise level is within 5 dB of the relevant base noise limit. In accordance with Condition 11, the base noise limit is 40 at non-stakeholder dwellings and the base limit agreed between the wind farm operator and the dwelling owner at stakeholder dwellings.

4.1 Base Noise Limits

Table 3 summarises the relevant base noise limits at the noise sensitive locations. The base noise limits at the stakeholder dwellings are those agreed between the wind farm operator and the dwelling owner.

Table 3: Base Noise Limit at Noise Sensitive Locations.

Dwelling ID	Coordinates (UTM WGS 84 Zone 54)		Stake-holder	Base Noise Limit, dB(A)
	Easting	Southing		
H1	669031	5806382	Yes	45
H2	672687	5804696	Yes	45
H3	667108	5804579	No	40
H5	673105	5798289	No	40
H6	670820	5798279	No	40
H8	676086	5801678	No	40
H9	677876	5801903	No	40
H10	680814	5799719	No	40
H11	677473	5798817	No	40
H12	681577	5801973	No	40
H13	681618	5802969	No	40
H14	682290	5804668	No	40
H15	682270	5805042	No	40
H16	680888	5804176	No	40
H17	679506	5804589	No	40
H18	680221	5807762	No	40
H19	680624	5810824	No	40
H20	679962	5810886	No	40
H21	676702	5812095	No	40
H22	677060	5814311	No	40
H23	677259	5815194	No	40
H24	677687	5816862	No	40
H25	672251	5815684	No	40
H26	670520	5815329	No	40
H27	668447	5813620	No	40
H28	667264	5813042	No	40
H29	663335	5808107	No	40
H31	663707	5803686	No	40
H32	663040	5804034	No	40
H33	662584	5803912	No	40
H35	662500	5802258	No	40

Dwelling ID	Coordinates (UTM WGS 84 Zone 54)		Stake-holder	Base Noise Limit, dB(A)
	Easting	Southing		
H36	661643	5804320	No	40
H37	662917	5802114	No	40
H39	666337	5803239	Yes	40
H40	667859	5802265	Yes	40
H41	668315	5805431	Yes	45
H42	672091	5801880	No	40
H43	672346	5801211	No	40
H44	673018	5801797	No	40
H46	673610	5803201	Yes	40
H47	674259	5804598	Yes	45
H49	675515	5809154	Yes	46
H50	676372	5810735	Yes	45
H51	671667	5811042	Yes	40
H52	671547	5811153	Yes	40
H53	676191	5812660	No	40
H56	666056	5811177	Yes	40
H57	664585	5809240	Yes	40
H58	662781	5807078	No	40
H61	682427	5810972	No	40
H62	675853	5812054	No	40
H63	677018	5816534	No	40
H64	674257	5799633	No	40
H65	664009	5800534	No	40
H66	659271	5794818	No	40
H67	659128	5794722	No	40
H68	654047	5790668	No	40
H69	653387	5789716	No	40
H70	651395	5787972	No	40
H71	657660	5795091	No	40

4.2 Background Dependent Noise Limit

Marshall Day Acoustics has conducted background noise monitoring at a selected number of dwellings at the planning stage, as summarised in the report *Dundonnell Wind Farm EES – Noise Impact Assessment*, Reference Rp001 R03 2012480ML, dated 2 September 2014. The locations include dwellings H2, H41, H49 and H52.

With the final proposed layout and agreements with stakeholders, compliance with the criteria at the Marshall Day background noise monitoring locations will not ensure that the relevant criteria are achieved at all dwellings. Therefore, Sonus has conducted background noise monitoring at four additional dwellings, H1, H18 and H46 and H62, as summarised in the report *Dundonnell Wind Farm – Background Noise Monitoring*, Reference S5345C6A, dated May 2018 (appended to this report). The dwellings were strategically selected such that compliance at these locations would demonstrate compliance at the other dwellings which do not have an agreement with the operator and are located further away from the wind farm.

Based on the background noise monitoring above, the background dependent noise limits were derived for each monitored dwelling, as summarised in Table 4.

Table 4: Derived Background Dependent Noise Limits.

Dwelling ID	Stakeholder	Noise Limit, dB(A), at Integer Hub Height Wind Speed, m/s									
		3	4	5	6	7	8	9	10	11	12
H1	Yes	45	45	45	45	45	45	45	45	45	45
H2	Yes	45	45	45	45	45	45	45	45	45	45
H18	No	40	40	40	40	40	40	41	43	45	47
H41	Yes	45	45	45	45	45	45	45	45	45	45
H46	Yes	40	40	40	40	40	40	41	43	44	46
H49	Yes	46	46	46	46	46	46	46	46	46	46
H52	Yes	40	40	40	40	40	40	40	40	41	43
H62	No	40	40	40	40	40	40	41	40	43	44

Notes:

1. The derived noise limits from the two monitoring regimes (in 2014 and 2017) reference wind speeds at different hub heights (ie 110m and 120.5m, respectively). To ensure a direct comparison between the predicted noise levels and the noise limits, standardisation of the noise limits to reference wind speeds at 114m hub height was conducted using a wind shear factor of 0.18 (average for the wind farm site). The process did not result in any significant change (less than 1 dB) to the noise limits provided in Table 4.
2. Since the Marshall Day Acoustic assessment in 2014, the agreed base noise limit at dwelling H49 has been amended to 46 dB(A), which is reflected in Table 4.

5 NOISE PREDICTION MODEL

5.1 Noise Propagation Model

The noise from the WTGs has modelled using the CONCAWE[2] propagation model within the SoundPlan noise modelling software. The CONCAWE noise propagation model is an internationally accepted noise propagation model that takes into account:

- the sound power level and position of the noise sources;
- the separation between the noise sources and receivers;
- the topography between the noise sources and receivers;
- the hardness of the ground;
- atmospheric absorption at different frequencies; and,
- meteorological conditions.

5.2 Noise Model Inputs

5.2.1 Meteorological Conditions

The CONCAWE system categorises the possible meteorological conditions into six categories, from Category 1 to Category 6. Category 1 is considered the "best-case" meteorological conditions (i.e., lowest noise level) while Category 6 is considered the "worst-case" meteorological conditions (i.e., highest noise level).

For a conservative assessment, the noise model has considered meteorological conditions corresponding to Category 6 (night with no clouds and wind from the wind farm to the residence under consideration).

5.2.2 Noise Sources and Data

The noise modelling has been based on:

- 80 Vestas V150-4.2MW WTGs;
- a hub height of 114m above ground level;
- blades having serrated trailing edge; and,
- WTGs operated under Power Optimised Mode (PO1).

[2] CONCAWE The oil companies' international study group for conservation of clean air and water – Europe "The propagation of noise from petrochemical complexes to neighbouring communities"

The noise from the WTGs has been modelled based on:

- the overall sound power levels specified in Vestas Document *Performance Specification V150-4.0/4.2 MW 50/60 Hz*, Reference 0067-7067 V07, dated 13 November 2017;
- the one-third octave band spectrums detailed in Vestas Document *V150-4.0/4.2 MW Third octave noise emission*, Reference DMS 0067-4767 V03, dated 13 November 2017; and,
- the addition of +1 dB(A) to the sound power levels to account for uncertainty and to establish to the *guaranteed* sound power levels by Vestas.

The sound power levels input to the noise model are summarised in Table 5.

5.2.3 Other Input Parameters

Other model input parameters associated with the atmospheric absorption, ground absorption and shielding are summarised below:

- atmospheric conditions at 10°C and 80% relative humidity;
- acoustically soft ground (finite acoustic impedance); and,
- a maximum barrier attenuation from topography of 2 dB.

Table 5: 1/3 Octave Band Sound Power Levels for Vestas V150-4.2MW PO1 WTG with Serrated Trailing Edge Blades.

Hub Height Wind Speed	1/3 Octave Band Centre Frequency																							Overall
	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
3 m/s	64.1	67.5	70.6	73.2	75.5	77.7	79.3	80.6	81.6	82.3	82.6	82.5	82.1	81.4	80.4	78.9	77.3	75.2	72.8	70	67	63.5	59.6	55.6	92.1
4 m/s	63.9	67.3	70.6	73.3	75.6	77.8	79.5	80.8	81.8	82.5	82.8	82.8	82.4	81.7	80.6	79	77.3	75.2	72.7	69.8	66.6	63.1	59	54.9	92.3
5 m/s	65.8	69.3	72.5	75.2	77.5	79.8	81.4	82.7	83.8	84.4	84.7	84.7	84.3	83.5	82.5	80.9	79.1	77.1	74.5	71.6	68.5	64.9	60.8	56.7	94.2
6 m/s	69.1	72.6	75.8	78.5	80.8	83	84.6	85.9	87	87.6	87.9	87.9	87.5	86.7	85.7	84.1	82.3	80.3	77.7	74.8	71.7	68.1	64.1	59.9	97.4
7 m/s	72.9	76.3	79.5	82.1	84.4	86.5	88.2	89.5	90.4	91.1	91.4	91.3	90.9	90.2	89.2	87.6	85.9	83.8	81.3	78.4	75.4	71.8	67.8	63.8	100.9
8 m/s	76.4	79.8	82.9	85.5	87.8	90	91.6	92.9	93.8	94.5	94.8	94.7	94.3	93.6	92.5	91	89.3	87.2	84.8	81.9	78.8	75.3	71.3	67.2	104.3
9 m/s	78.1	81.5	84.6	87.2	89.5	91.6	93.2	94.5	95.4	96.1	96.4	96.3	95.9	95.2	94.1	92.6	90.9	88.9	86.4	83.6	80.5	77.1	73.1	69.1	105.9
10 m/s	78.2	81.6	84.7	87.2	89.5	91.6	93.2	94.4	95.4	96.1	96.3	96.3	95.9	95.2	94.2	92.6	91	88.9	86.5	83.7	80.7	77.2	73.3	69.3	105.9
11 m/s	78.5	81.8	84.8	87.3	89.5	91.6	93.2	94.4	95.4	96	96.3	96.3	95.9	95.2	94.2	92.7	91	89.1	86.7	83.9	81	77.6	73.8	69.9	105.9
12 m/s	78.7	81.9	84.9	87.4	89.6	91.6	93.2	94.4	95.4	96	96.3	96.2	95.8	95.2	94.2	92.7	91.1	89.2	86.9	84.1	81.2	77.9	74.1	70.3	105.9

6 NOISE PREDICTION RESULTS

The predicted noise levels at the dwellings where background noise monitoring was conducted and the comparison with the relevant noise limits are provided in Table 6.

Table 6: Predicted noise levels from wind turbine operation.

Dwelling ID	Noise Level, dB(A), at Integer Hub Height Wind Speed																			
	3 m/s		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	
	Limit	Prediction	*Limit*	Prediction	*Limit*	Prediction	*Limit*	Prediction	*Limit*	Prediction	*Limit*	Prediction	*Limit*	Prediction	*Limit*	Prediction	*Limit*	Prediction	*Limit*	Prediction
H1	*45*	28	*45*	28	*45*	30	*45*	34	*45*	37	*45*	40	*45*	42	*45*	42	*45*	42	*45*	42
H2	*45*	32	*45*	32	*45*	34	*45*	37	*45*	40	*45*	44	*45*	45	*45*	45	*45*	45	*45*	45
H18	*40*	18	*40*	18	*40*	20	*40*	23	*40*	27	*40*	30	*41*	32	*43*	32	*45*	32	*47*	32
H41	*45*	22	*45*	23	*45*	25	*45*	28	*45*	31	*45*	35	*45*	36	*45*	36	*45*	36	*45*	36
H46	*40*	24	*40*	24	*40*	26	*40*	29	*40*	33	*40*	36	*41*	38	*43*	38	*44*	38	*46*	38
H49	*46*	32	*46*	32	*46*	34	*46*	38	*46*	41	*46*	44	*46*	46	*46*	46	*46*	46	*46*	46
H52	*40*	21	*40*	22	*40*	23	*40*	27	*40*	30	*40*	34	*40*	35	*40*	35	*41*	35	*43*	35
H62	*40*	20	*40*	20	*40*	22	*40*	25	*40*	28	*40*	32	*41*	33	*40*	33	*43*	33	*44*	33

The predicted noise levels achieve the relevant noise limit at each dwelling over the entire wind speed range that was considered.

A noise contour map of the highest predicted noise level, at 11m/s hub height wind speed, is provided in the Appendix. The map shows five stakeholder dwellings (H1, H2, H47, H49 and H50) located within the 40 dB(A) contour. The highest predicted noise level at these dwellings is no greater than the established base noise limits of 45 dB(A) at H1, H2, H47 and H50; and 46 dB(A) at H49. All other dwellings are located outside the 40 dB(A) contour and therefore comply with the relevant noise limits.

7 TONAL AUDIBILITY ASSESSMENT

An objective assessment to identify potential audible tones has been conducted in accordance with the test method provided in Section B2.2 in Appendix B of the *New Zealand Standard 6808:2010 Acoustics – Wind Farm Noise*.

The method compares the noise levels (Z frequency weighted) in each one-third octave-band with the arithmetic mean of the noise levels in both adjacent bands. A potential audible tone is identified if the comparison shows a level difference that exceeds 15 dB between 25 Hz and 125 Hz (inclusive); 8 dB between 160 Hz and 400 Hz (inclusive); and 5 dB between 500Hz and 10000Hz.

Based on the one-third octave-band noise levels in Table 5, no potential audible tones were identified using the objective test method above.

8 CONCLUSION

A pre-construction noise assessment of the final WTG configuration for the proposed Dundonnell Wind Farm has been made in accordance with Conditions 11, 12 and 13 of the Planning Permit.

The assessment considered the final WTG configuration, consisting of the following:

- 80 Vestas V150-4.2MW WTGs;
- a hub height of 114m above ground level;
- blades with serrated trailing edge; and,
- WTGs operated under Power Optimised Mode (PO1).

The noise from the WTGs was predicted to the noise sensitive location using the CONCAWE noise propagation model, with sound power level (SWL) input based on the Vestas *Performance Specification* document and a +1dB addition for uncertainty, resulting in a maximum SWL of 105.9 dB(A).

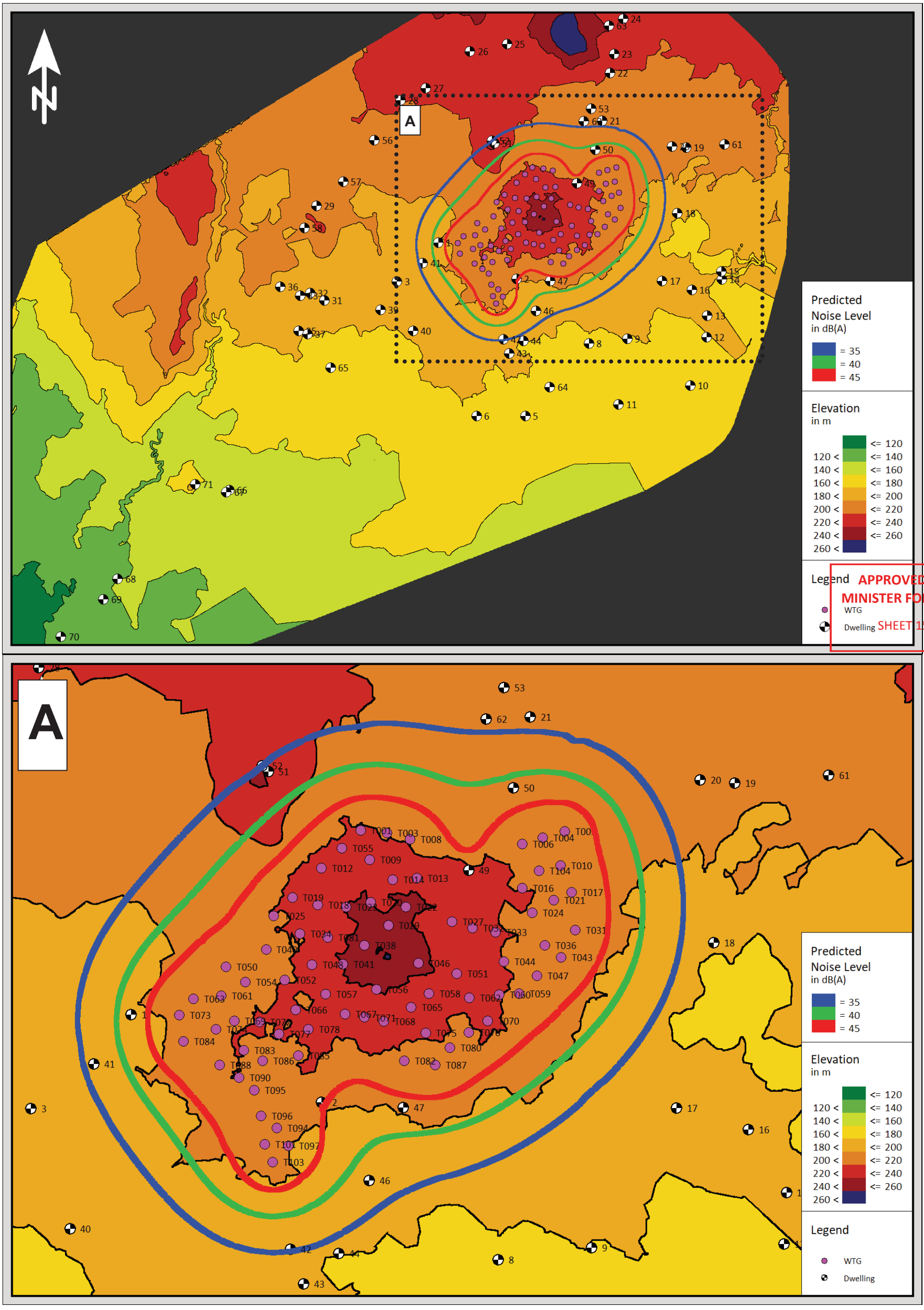
Based on the prediction, the noise levels at all noise sensitive locations surrounding the wind farm will be no greater than the established base noise limits of:

- 40 dB(A) at all non-stakeholder dwellings;
- 40 dB(A) at stakeholder dwellings H39, H40, H46, H51, H52, H56, and H57
- 45 dB(A) at stakeholder dwellings H1, H2, H41, H47 and H50; and,
- 46 dB(A) at stakeholder dwelling H49.

A tonal audibility assessment was conducted in accordance with the objective test method provided in Appendix B of the *New Zealand Standard 6808:2010 Acoustics – Wind Farm Noise,* which did not identify any potential audible tones from the proposed WTG.

Based on the above, the requirements of Conditions 11, 12 and 13 of the Planning Permit are satisfied.

APPENDIX: NOISE CONTOUR MAP (11M/S AT 114M HUB HEIGHT)



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Dundonnell Wind Farm

Background Noise Monitoring

S5345C6A

May 2018

sonus.

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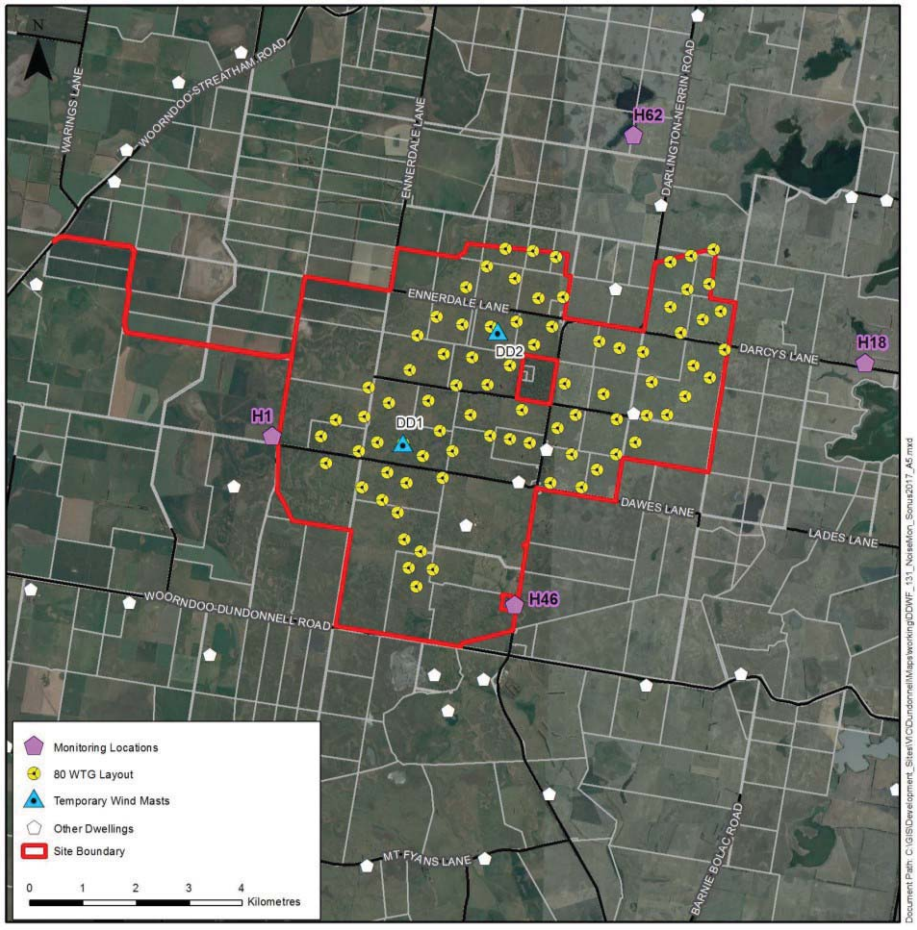
BACKGROUND

A Noise Impact Assessment for the Dundonnell Wind Farm was previously conducted by Marshall Day Acoustics and detailed in report Rp001 R03 2012480ML *"Dundonnell Wind Farm EES Noise Impact Assessment"* . The assessment included background noise monitoring at several locations.

Sonus has been engaged to conduct further background noise monitoring at several dwellings prior to construction of the wind farm, as generally depicted below (H1, H18, H46 and H62) and located at:

Table 1: Monitoring locations.

	Coordinates (UTM WGS84 54 H)	
	Easting	**Northing**
H1	669031m	5806382m
H18	680221m	5807762m
H46	673610m	5803201m
H62	675891m	5812051m



This report provides the methodology and results of the background noise monitoring regime.

NOISE MONITORING

The background noise monitoring was conducted between 29 August and 11 October 2017.

Location

A noise logger was positioned on the wind farm side of each dwelling, at an equivalent distance to major trees as the dwellings. A photograph of the noise monitoring equipment at each location is provided in Appendix A.

Equipment

The background noise was measured in 10 minute intervals with a *"Rion NL-52"* Type 1 sound level meter with a noise floor of less than 20 dB(A), calibrated at the beginning and end of the measurement period with a "*Rion NC74"* Calibrator. The microphones were positioned approximately 1.5 m above ground level and fitted with either "*Rion WS-15"* double layer all weather windshields or with a wind shield with a diameter of at least 150mm.

Hub Height Wind Speed

During the background noise monitoring, *Tilt Renewables Pty Ltd* measured the wind speed using two wind masts in 10 minute intervals. The following table provides the details of the wind masts;

Table 2: Respective Wind Mast Intervals for Monitoring locations.

Mast	Anemometer Heights
Mast 1	20m, 40m, 60m and 84m
Mast 2	26m, 43m, 55m and 71m

The background noise data was correlated with wind speeds at the two selected WTG hub heights of 91.5m and 120.5m. The wind speeds at hub height were calculated from the following power law wind profile model:

$$U = U_0 \left(\frac{h}{h_0}\right)^{\alpha}$$

where, U is the wind speed at height h;

U_0 is the reference wind speed at reference height h_o;

α is the shear coefficient.

The shear coefficient was estimated for each set of 10 minute average wind speeds using measurements at the two highest anemometer heights of each mast. Where a negative shear coefficient was calculated, the shear coefficient was set to zero.

The wind speed at hub height was determined for each 10 minute data point using the formula above, adapted as follows:

$$U_{91.5} = U_{84}\left(\frac{91.5}{84}\right)^{\alpha} \qquad U_{91.5} = U_{71}\left(\frac{91.5}{71}\right)^{\alpha}$$

$$U_{120.5} = U_{84}\left(\frac{120.5}{84}\right)^{\alpha} \qquad U_{120.5} = U_{71}\left(\frac{120.5}{71}\right)^{\alpha}$$

where

$U_{91.5}$ is the hub height wind speed;

$U_{102.5}$ is the alternative hub height wind speed;

U_{77} is the wind speed measured at the highest point on the wind mast, at 84m above ground level;

U_{84} is the wind speed measured at the highest point on the wind mast, at 77m above ground level;

α is the time-dependent shear coefficient profile determined for that particular data point from the instantaneous 60m, 84m, 55m and 71m data set.

Data Analysis

During the background noise monitoring period, wind speed and rainfall at the microphone height (approximately 1.5m above ground level) was measured using *"Rainwise"* wind speed and rainfall loggers. The rainfall and wind speed data were used to determine the periods when weather may have affected the background noise measurements and these data have been discarded. This includes periods where rainfall was measured and/or where the measured wind speed exceeded 5 m/s at the microphone for more than 90% of the measurement period.

Data below the approximate cut in wind speed or above the speed at rated power at each hub height were also removed.

Following the data removal procedure, the following number of points remained for each of the logging locations;

Location	Number of Data Points Remaining	
	91.5m Hub Height	120.5m Hub Height
H1	4655	4457
H18	4828	4645
H46	4726	4528
H62	4844	4661

Background Noise Correlation

The background noise data collected at each of the monitoring locations were correlated with the calculated wind speed at the proposed hub heights for each 10 minute period, based on the data from the nearest mast.

A least squares regression analysis of the data was undertaken to determine the line of best fit for the correlations. The data and the regression curves are shown in Appendix B.

Based on the line of best fit in Appendix B, the background noise level ($L_{A90,10min}$) can be determined for an integer hub height wind speeds.

Table 4 summarises the background noise level for each integer wind speed at the two proposed hub heights, between 3 and 13 m/s inclusive:

Table 3: Background Noise Levels at Additional Monitoring Location (dB(A))

	Wind Speed (m/s)		3	4	5	6	7	8	9	10	11	12	13
H1	**91.5m AGL**	$L_{A90,10min}$	31	30	29	30	31	32	33	35	37	39	41
H46	**91.5m AGL**	$L_{A90,10min}$	31	31	32	32	34	35	37	38	40	42	43
H62	**91.5m AGL**	$L_{A90,10min}$	33	32	32	33	34	35	36	37	39	40	41
H18	**91.5m AGL**	$L_{A90,10min}$	30	29	30	31	32	34	36	39	41	43	45

	Wind Speed (m/s)		3	4	5	6	7	8	9	10	11	12	13
H1	**120.5m AGL**	$L_{A90,10min}$	31	30	30	30	30	31	33	34	36	37	39
H46	**120.5m AGL**	$L_{A90,10min}$	32	31	31	32	33	35	36	38	39	41	41
H62	**120.5m AGL**	$L_{A90,10min}$	33	32	32	32	33	34	36	37	38	39	40
H18	**120.5m AGL**	$L_{A90,10min}$	30	29	29	30	32	34	36	38	40	42	42

Operational Noise Criteria

Based on the measured background noise levels, the criteria in Table 4 apply at any non-associated residence.

Table 4: Criteria (dB(A)) with Reference to Hub Height Wind Speed

Dwelling	Wind Speeds (m/s) at 91.5m AGL										
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
H1	40	40	40	40	40	40	40	40	42	44	46
H46	40	40	40	40	40	40	42	43	45	47	48
H62	40	40	40	40	40	40	41	42	44	45	46
H18	40	40	40	40	40	40	41	44	46	48	50
All other non-associated residences	The higher of 40 dB(A) or the existing background noise level (LA90 (10-minute)) plus 5 dB(A)										

Dwelling	Wind Speeds (m/s) at 120.5m AGL										
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
H1	40	40	40	40	40	40	40	40	41	42	44
H46	40	40	40	40	40	40	41	43	44	46	46
H62	40	40	40	40	40	40	41	42	43	44	45
H18	40	40	40	40	40	40	41	43	45	47	48
All other non-associated residences	The higher of 40 dB(A) or the existing background noise level (LA90 (10-minute)) plus 5 dB(A)										

Appendix A: Photograph of logger at additional monitoring locations

Dwelling H1

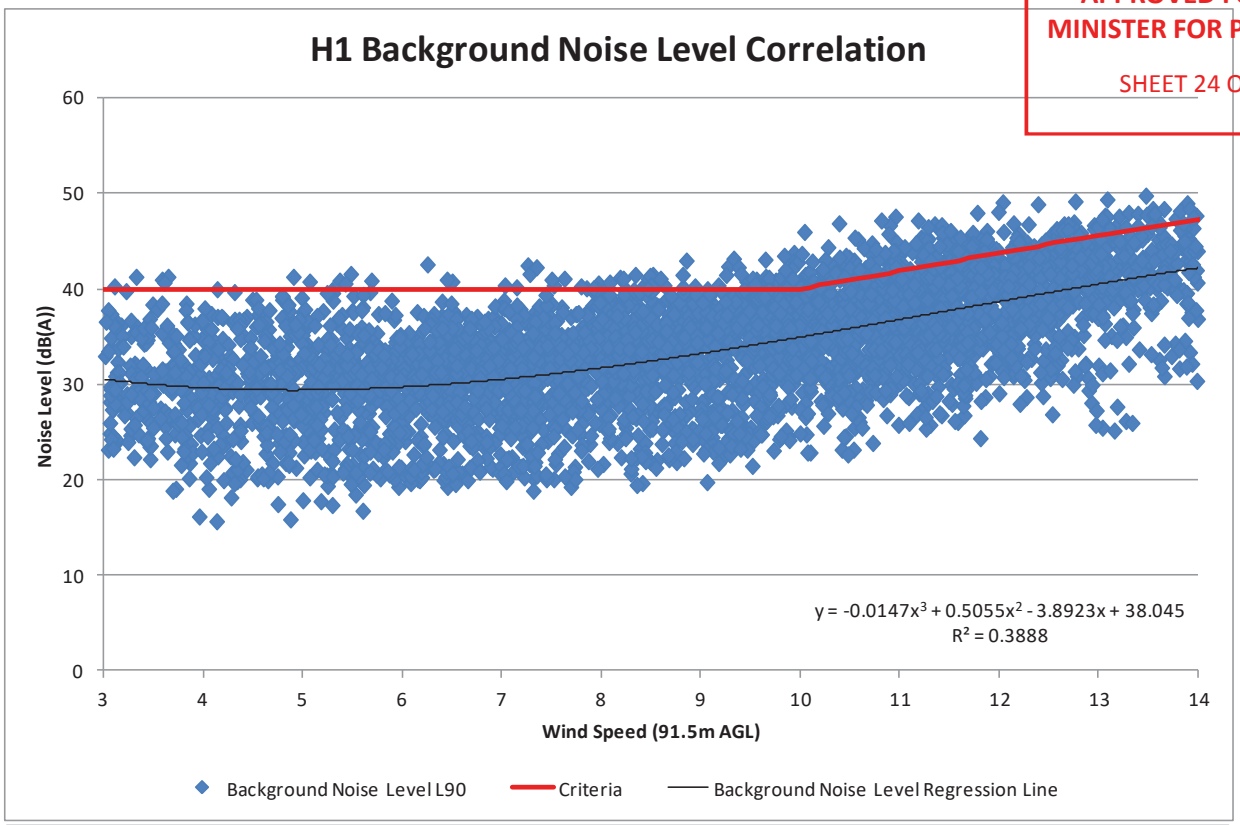
Dwelling H18

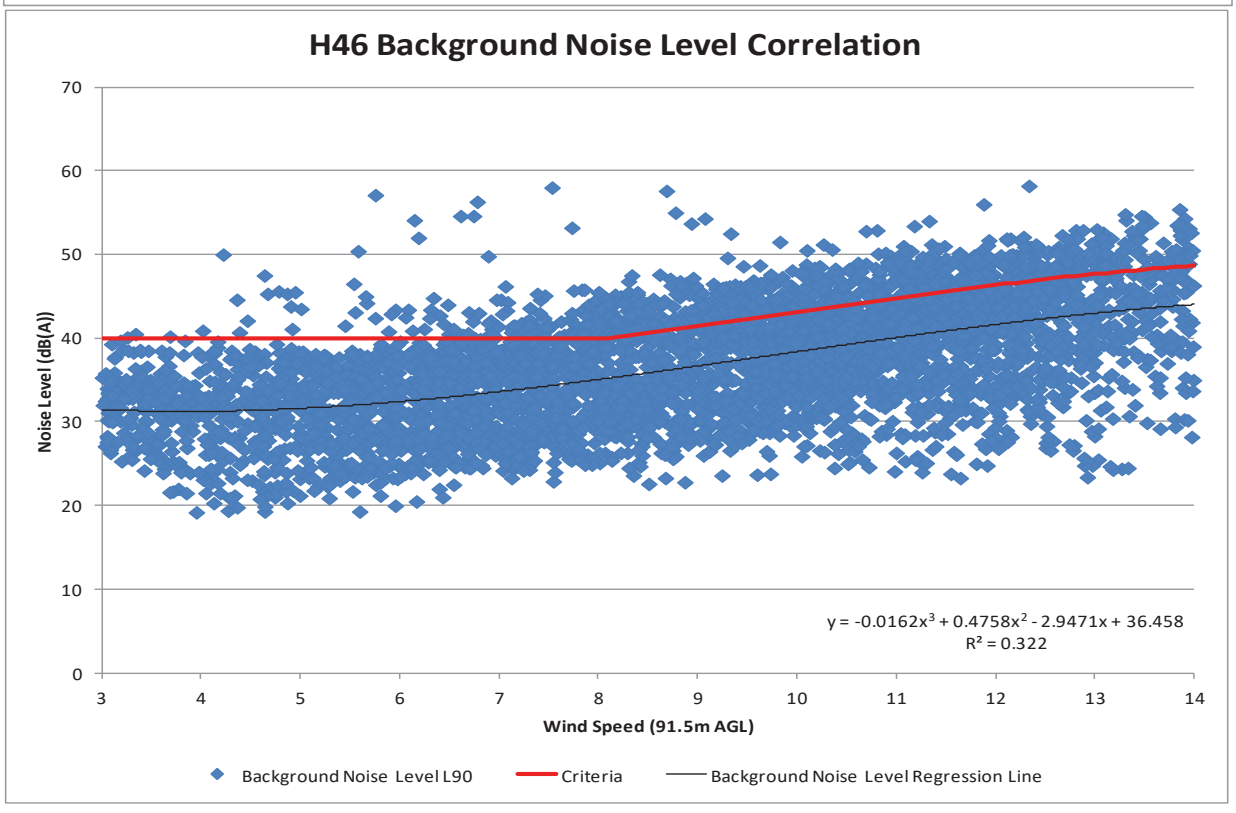
Dwelling H46

Dwelling H62

Appendix B: Background noise and wind speed correlation for additional monitoring location

91.5m Hub Height





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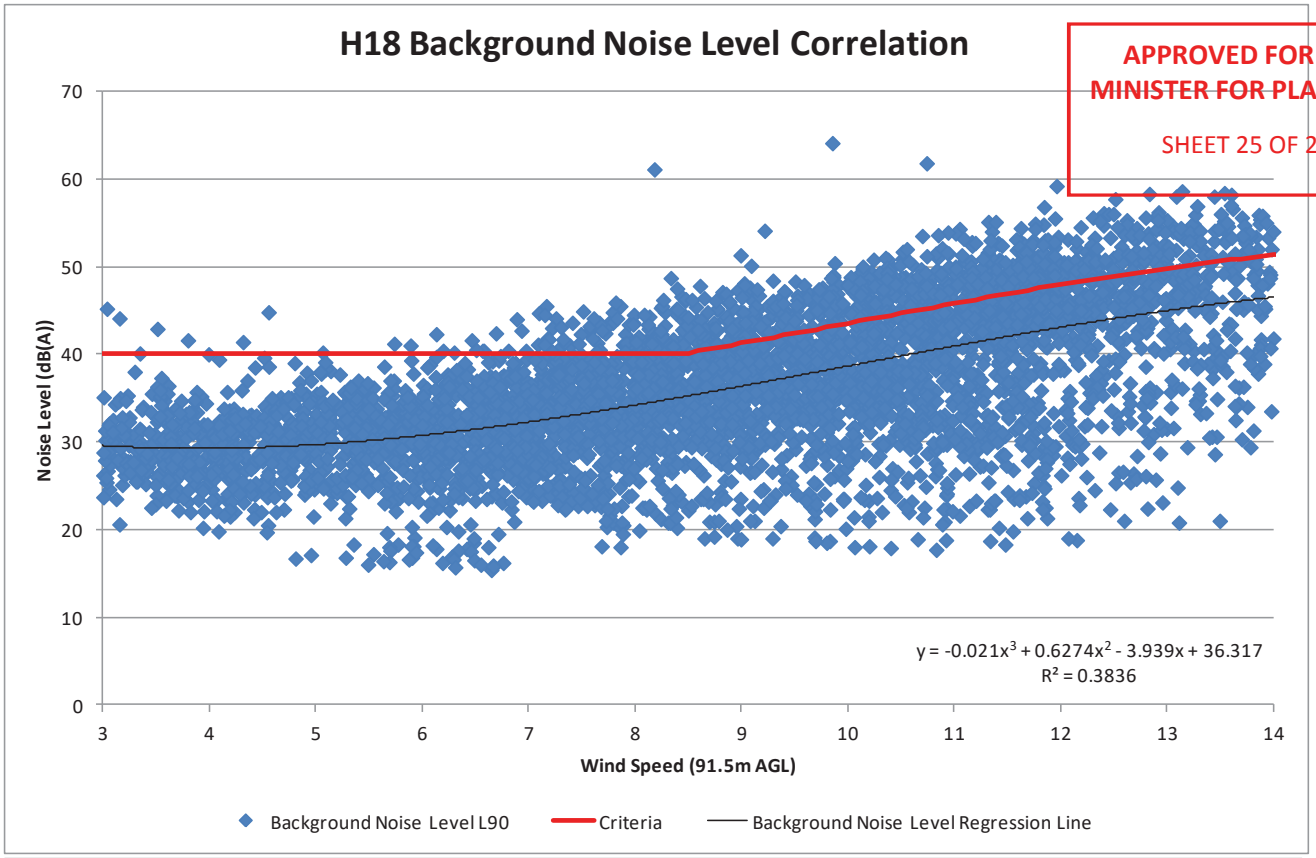
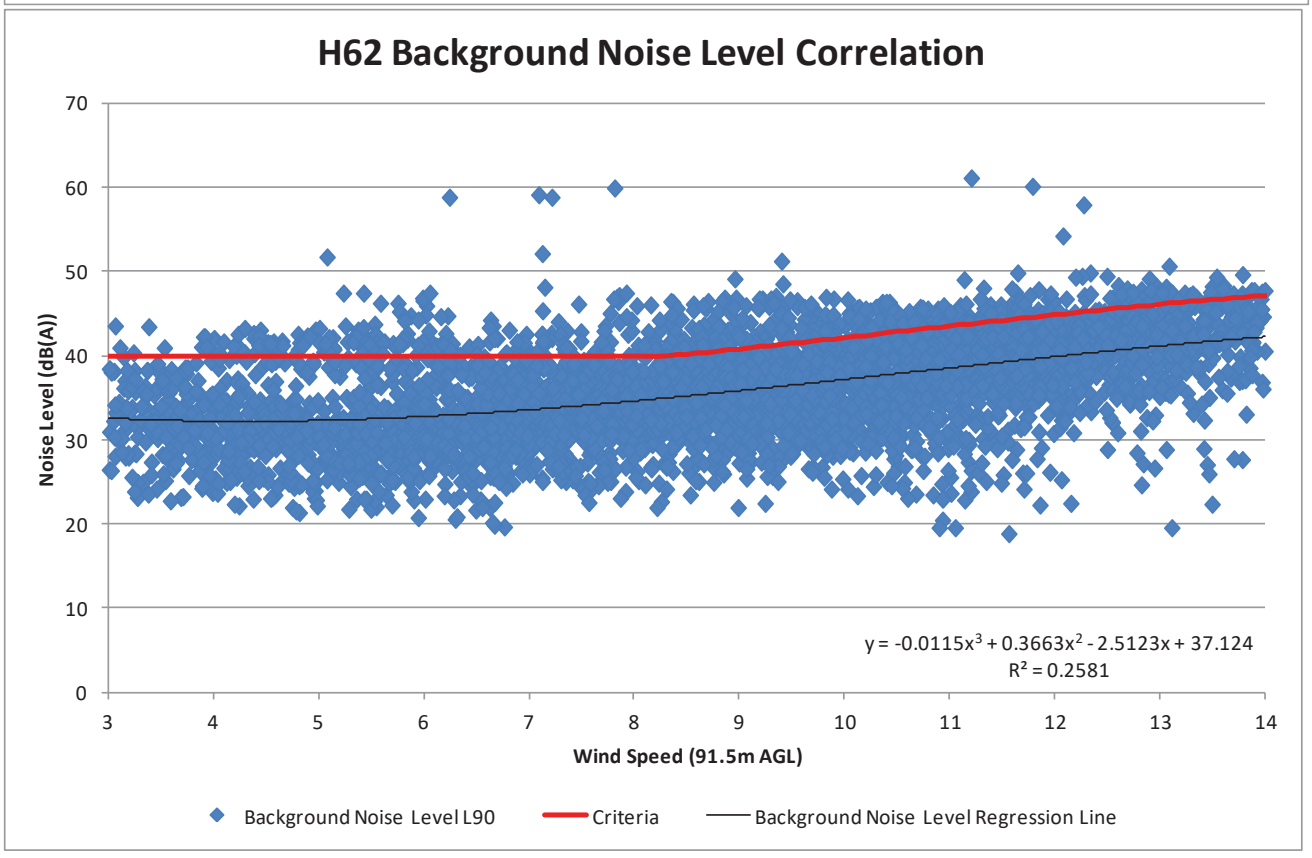
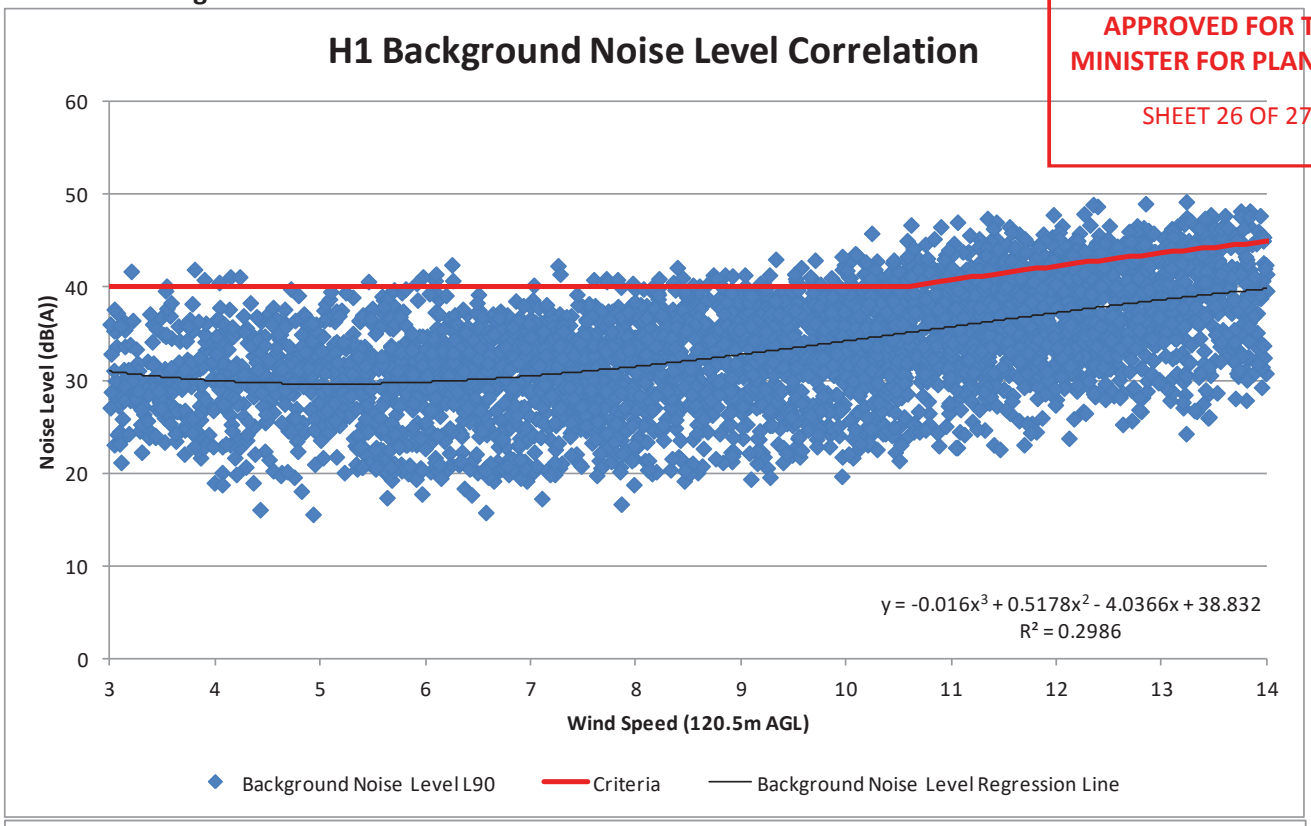
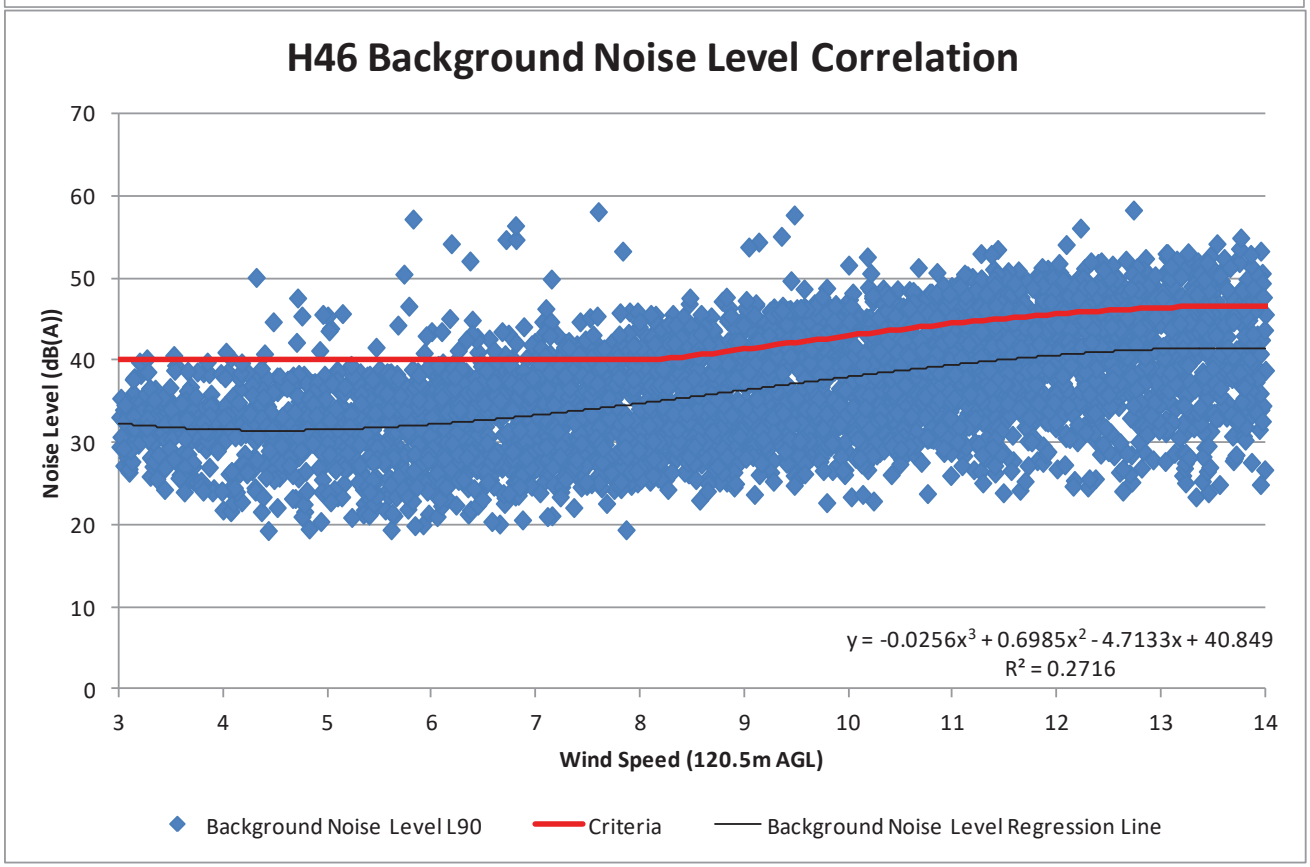




120.5m Hub Height





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