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Lord Howe Island Renewable Energy Project

LORD HOWE ISLAND BOARD

Winter background noise monitoring

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Lord Howe Island Renewable Energy Project

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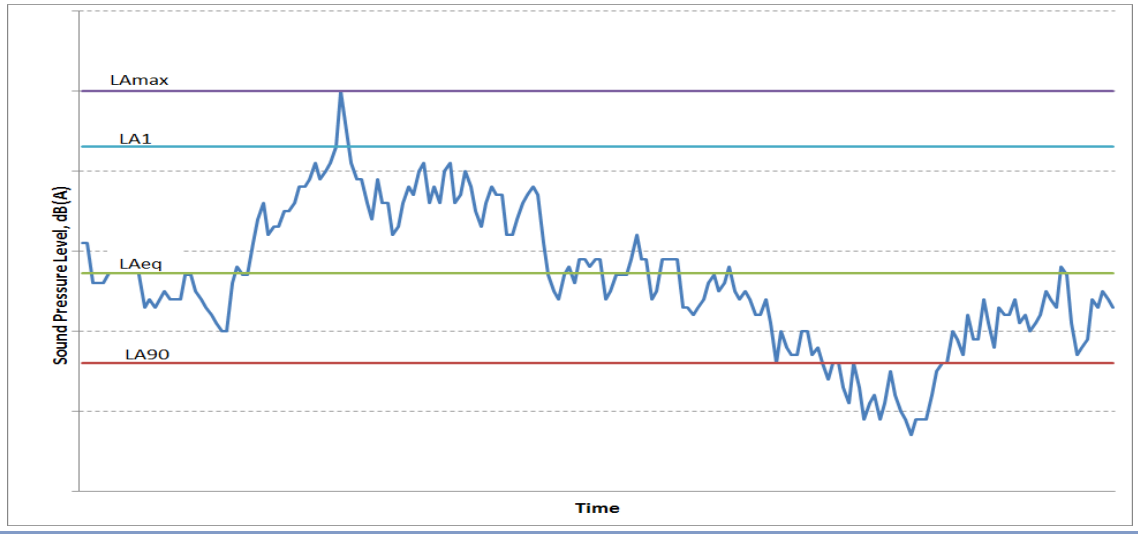
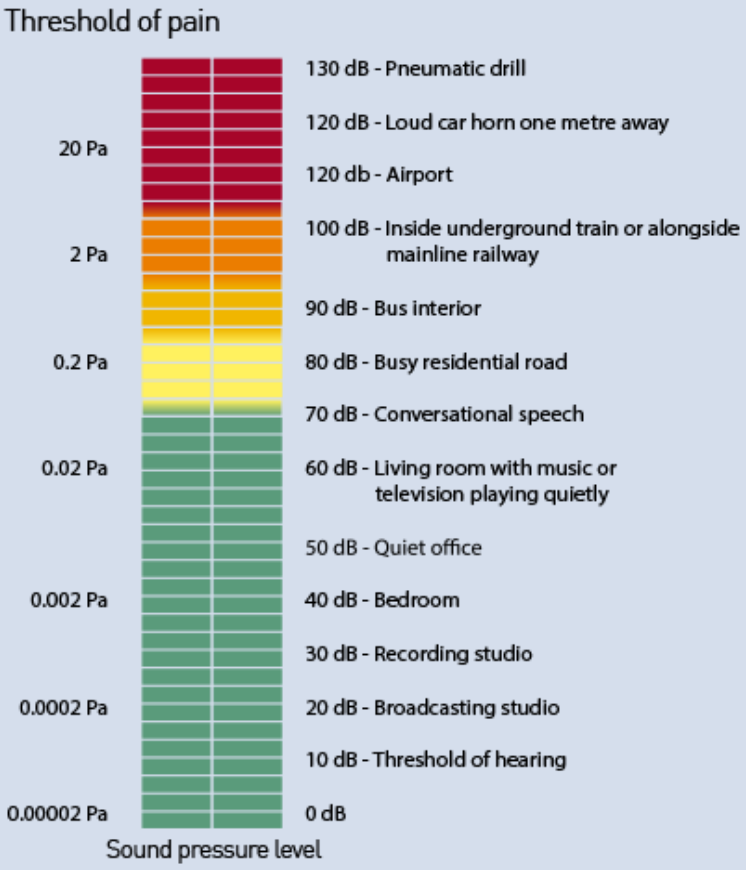
3	8/02/2016	LHIB comments	J Hutchison	J Hutchison	8/02/2016

Contents

Definition of terms

Assessment period	The period in a day over which assessments are made. In this case: • day (0700 to 2200 h), • night (2200 to 0700 h).
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
Decibel (dB)	A measure of sound equivalent to 20 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure, and 10 times the logarithm (to base 10) of the ratio of a given sound power to a reference power.
dB(A)	Unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.
Extraneous noise	Noise resulting from activities that are not typical of the area such as construction, and traffic generated by holiday periods or special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.
Feasible and reasonable measures	Feasibility relates to engineering considerations and what is practical to build; reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors: • noise mitigation benefits (noise reduction provided, people protected) • cost of mitigation (cost of mitigation versus benefit provided) • community views (aesthetic impacts and community wishes) • noise levels for affected land uses (existing and future levels)
Hub height	The hub height is the distance from the turbine platform to the rotor of a wind turbine and indicates how high the turbine stands above the ground, not including the length of the turbine blades.
Infrasound	Any sound whose frequency is below the range of normal human hearing (less than approximately 20 Hz).
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).
Low frequency noise	A noise with perceptible and definite content in the audible frequency range below 250 Hz.
Noise assessment criteria	A standard rule or test by which the acceptability of the nature and characteristics of noise may be judged or evaluated. Criteria are generally based on guidelines or standards developed by Government agencies (eg EPA) to protect the majority of people for the majority of the time from adverse impacts.
Noise level statistics	L_{A90} - The A-weighted sound pressure level exceeded 90% of the monitoring period. This is considered to represent the background noise. L_{Aeq} - The equivalent continuous A-weighted noise level—the level of noise equivalent to the energy average of noise levels occurring over a measurement period. L_{A1} – The A-weighted sound pressure level exceeded 1% of the monitoring period. L_{Amax} – The maximum A-weighted noise level associated with the measurement period. 

Predicted noise level	The L_{Aeq} wind farm noise level at a receiver predicted in accordance with AS4959
Receiver	Premises that may be affected by the noise source, other than premises on the same land as the noise source
Receiver catchment	A defined area in which all receivers are considered to experience similar levels of background noise and for which a single receiver would be representative of all
Sound Power Level	The A-weighted sound power level is a logarithmic ratio of the acoustic power output of a source relative to 10^{-12} watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.
Sound Pressure Level	This is the level of noise, usually expressed in dB(A), as measured by a standard sound level meter with a pressure microphone. The sound pressure level in dB(A) gives a close indication of the subjective loudness of noise. A technical definition for the sound pressure level, in decibels, is 20 times the logarithm (base 10) of the ratio of any two quantities related to a given sound pressure to a reference pressure (typically 20 µPa equivalent to 0 dB). Examples of typical sound pressure levels are shown below.  Source: https://www.osha.gov/dts/osta/otm/noise/health_effects/soundpropagation.html
Tonal noise	Noise with perceptible and definite pitch or tone
WTG	Wind Turbine Generator

Executive Summary

A hybrid renewable energy system is proposed on Lord Howe Island to reduce its reliance on imported diesel for electricity generation. In January 2015, the Lord Howe Island Board (LHIB) commissioned an assessment[1] of the potential for noise generated by two wind turbine generators (WTG) to result in adverse impacts on the community's amenity. The assessment consisted of background noise and meteorological monitoring, prediction of WTG noise on relevant receivers and recommendations for appropriate management.

The background noise monitoring component of the assessment found that wind in trees, the ocean and insects were the dominant sources of noise on the island. Considering insects are seasonal (active in the summer months), it was considered prudent to also establish background levels in the winter, where insects aren't as influential on noise levels, to ensure goals adopted for the management of wind turbine noise are representative of all times of the year.

This report covers the winter (August 2015) background measurement results, comparison with the summer background results from the original report[1] and an updated compilation of the results and recommendations.

Based on supplementary monitoring, a minor difference between summer and winter background noise levels was observed for the central, western and southern receivers at lower wind speeds. Eastern coastal receivers were found to experience a more substantial difference with lower background noise levels during the winter.

The predicted noise levels, taken from the previous assessment, show that the assessment criteria are not likely to be exceeded in either the summer or winter months, with the possible exception of Eastern coastal receivers where wind speeds at hub height of 12 m/s or above may result in a minor exceedance during winter nights. A summary of results is presented in Table ES-1.

Table ES-1 Predicted noise levels compared with assessment criteria for summer and winter nights

Receiver catchment	Period	Wind speed at hub-height, m/s								
		4	5	6	7	8	9	10	11	12
Eastern coastal	Predicted noise level	31	31	31	38	40	41	48	49	50
	Criteria at night winter	44	45	46	47	48	48	48	48	48
	Criteria at night summer	49	50	51	51	52	53	54	55	57
Central / Joy's Shop area	Predicted noise level	25	25	25	32	34	35	42	43	44
	Criteria at night winter	41	41	42	43	44	45	46	47	48
	Criteria at night summer	40	43	44	45	44	44	45	46	48
Western coastal	Predicted noise level	27	27	27	34	36	37	44	45	45
	Criteria at night winter	39	41	42	43	45	46	47	47	48
	Criteria at night summer	41	42	42	43	43	44	45	46	48
Southern	Predicted noise level	16	16	16	24	26	26	34	35	35
	Criteria at night winter	42	42	43	44	45	46	47	48	48
	Criteria at night summer	40	43	44	45	44	44	45	46	48

[1] Jacobs, Wind Turbine Generator Noise Assessment, Rev 4, 23 April 2015

1. Introduction

1.1 Background

Lord Howe Island is developing a hybrid renewable energy system to reduce its reliance on imported diesel for electricity generation. The proposed system would consist of a solar (photovoltaic) farm of 450 kW, two wind turbine generators (WTG) of 275 kW each and battery storage.

In January 2015, the Lord Howe Island Board (LHIB) commissioned an assessment[2] of the potential for noise generated by the proposed WTGs to result in adverse impacts on the community's amenity. The assessment consisted of background noise and meteorological monitoring, prediction of WTG noise on relevant receivers and recommendations for appropriate management.

The background noise monitoring component of the assessment found that wind in trees, the ocean and insects were the dominant sources of noise on the island during the summer period. Considering insects are seasonal (active in the summer months), it was considered prudent to also establish background levels in the winter, where insects aren't as influential on noise levels, to ensure goals adopted for the management of wind turbine noise are representative of all times of the year.

Hutchison Weller was engaged to complete the winter background noise monitoring in line with the applicable standards and guidelines and prepare this supplementary monitoring report.

1.2 Wind farm noise guidelines

The NSW Department of Planning and Infrastructure (Planning and Infrastructure) released the *Draft NSW Planning Guidelines for Wind Farms* for consultation in December 2011. The document contains guidance on measurement and assessment of noise impacts from wind farms under the *Environmental Planning and Assessment Act 1979*. The draft guideline was developed with consideration of other guidelines used widely around Australia, including New Zealand; with methodologies and practices most closely following the South Australian EPA (2009) *Wind farms environmental noise guidelines* and Australian Standard AS4959 – *2010 Acoustics – Measurement, prediction and assessment of noise from wind turbine generators*.

Though the NSW guideline is in draft form, it adopts suitably stringent noise assessment criteria from other recognised and widely used guidelines. Therefore it will be referred to in this report.

Noise assessment criteria have been developed to account for a characteristic of wind farms where noise level from each WTG rises as the wind speed at the site increases and this increase is generally complemented by an equal or greater increase in the background noise level, which may substantially or even completely mask the WTG noise.

To protect the amenity of typically quiet, rural communities, and considering the wind speed at the subject site, the predicted equivalent noise level ($L_{eq,\ 10\ minute}$), adjusted for any excessive levels of tonality, amplitude modulation or low frequency, should not exceed the greater of:

35 dB(A)
OR
The background (L90) noise level by more than 5 dB(A)

This goal applies at all relevant receivers not associated with the wind farm and for wind speeds from cut-in to rated power of the WTG and each integer wind speed in between.

[2] Jacobs, Wind Turbine Generator Noise Assessment, Rev 4, 23 April 2015

1.3 Purpose

The purpose of this report is to establish the background noise levels for the night and day periods during the winter months and correlate these levels with wind speed at WTG hub height in line with the requirements of the NSW Draft *Planning Guidelines for Wind Farms* and AS 4959-2010.

This report should be read as an addendum to the previous assessment[3], which provides context on previous monitoring and findings.

This report details the methodologies and findings of the winter background noise monitoring, including:

- description of noise and meteorological monitoring locations and monitoring methods
- monitoring results and correlation with wind speed
- revised noise goals and comparison with previous report
- combined summary and recommendations

[3] Jacobs, Wind Turbine Generator Noise Assessment, Rev 4, 23 April 2015

2. Location description

2.1 Relevant receivers

A map showing the location of the proposed WTGs and the positions of relevant receivers in relation to the WTGs is provided in Figure 2-2. For the purpose of the previous assessment, the Island was divided into four receiver catchments, accommodating all relevant receivers. These are shown in Appendix A and include:

- Eastern coastal
- Central / Joy's Shop area
- Western coastal
- Southern

The majority of relevant receivers are northwest of the WTG location in the central and eastern coastal catchments. Receivers to the south are screened by the island's topography and are predicted to experience noise levels from the WTGs that are inaudible over existing background levels. For completeness, a number of these were included to provide a comprehensive assessment.

2.2 Prevailing wind

Considering the locations of relevant receivers to the WTG site, winds from the southeast would likely impact the greatest proportion of the island's population to the north and northwest of the WTG site. Easterly winds would also represent a risk of adverse impact to the Pinetrees Lodge to the west of the WTG site.

Wind speed and direction on Lord Howe Island is seasonal. During the summer months, winds are predominantly easterly and north-easterly, whilst south-westerly winds are typical in the winter months, as shown in the windroses derived from 10 years of historical data from the Bureau of Meteorology (BOM) station at the Lord Howe Island airport (Figure 2-1). Average wind speed ranges from 9–10 knots (~5 m/s) in January and March through to 13 knots (~6 m/s) in August.

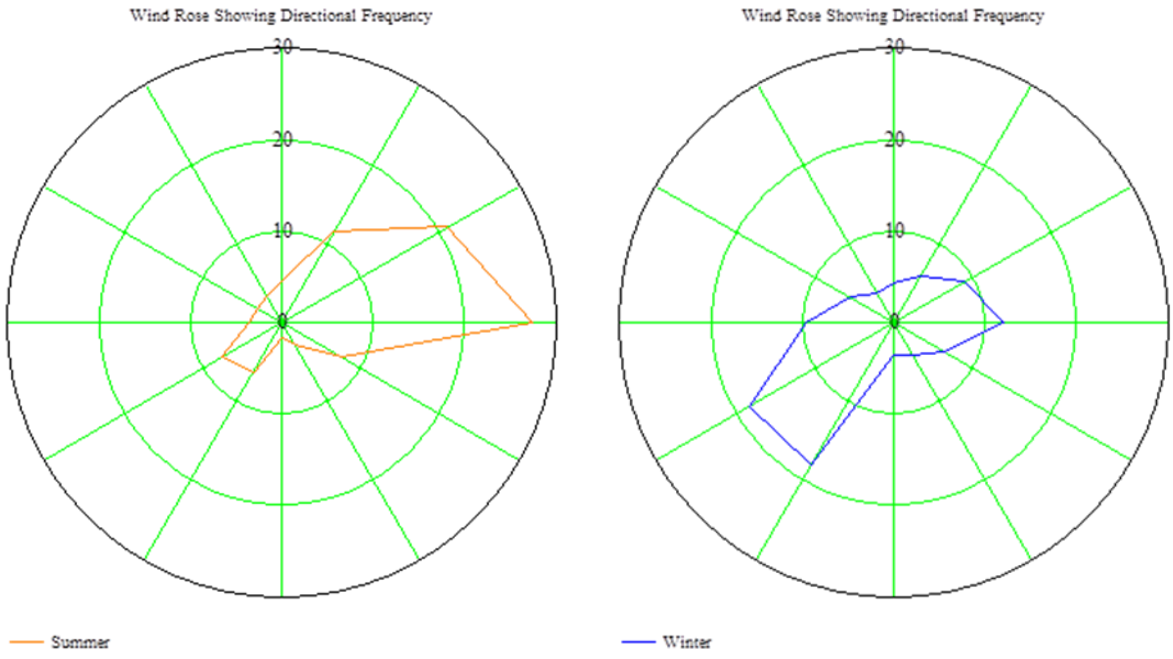


Figure 2-1 Wind roses for summer (left) and winter (right) (BOM 2015)

Figure 2-2 Lord Howe Island WTG locations and sensitive receivers for hub height wind speed12 m/s (source: Jacobs 2015)

3. Monitoring methodology

Background noise levels were measured at a single location within each receiver catchment concurrently with wind speed and direction over a period of approximately four weeks (3 August – 29 August 2015). Monitoring locations are described in Table 3-1.

In compliance with AS4959-2010 Acoustics – *Measurement, prediction and assessment of noise from wind turbine generators* (Standards Australia 2010) and the NSW Draft *Planning guidelines - wind farms* (Planning and Infrastructure 2011), monitoring was undertaken using Ngara environmental noise loggers, which are capable of collecting data between 10 Hz and 4000Hz and have a noise floor no greater than 20 dB(A) (the lowest noise level the instrument can measure). Loggers were placed within 30 m of sensitive non-associated receivers, on the side of the receiver towards the WTG site. The microphone was positioned 1.2 – 1.5 m above ground and at least 5 m from any reflecting surface, remote from any extraneous noise sources. Photographs of each monitoring location are provided in Appendix B. The locations were identical to those utilised in the summer monitoring work.

Sequential 10 minute $L_{A90,\,(10\ min)}$ background noise measurements were taken at each relevant receiver concurrently with 10 minute average speed and direction measurements on the wind farm site. Clocks on all monitoring equipment were set to match the time of the Lord Howe Island meteorological mast, which is set to Lord Howe Island Standard Time (half hour ahead of AEST).

Table 3-1 Background monitoring locations for noise and meteorology

Location	Easting, m	Northing, m	Elevation above sea level, m	Distance to closest WTG location, m	Distance to meteorological mast, m	Representative of:
M1 Cobby's House	507351	6510050	4.5	1600	1570	Southern coastal receivers
M2 Rear of Pinetrees	506697	6511462	5.5	480	580	West coastal receiver
M3 Pauli's House	507023	6511924	32.5	280	370	East coastal receivers
M4 Near Joy's shop	506522	6511939	13.5	680	800	Central island receivers
Main meteorological mast	507261	6511613	81 (mast base – anemometer heights included 10m, 30 m and 45 m)	100	n/a	n/a
Microphone-level meteorological station	506522	6511939	13.5	680	800	N/a

Noise was measured for wind speeds across the range at which the WTGs operate (cut in - 3.5 m/s to rated power - 12 m/s). Data were used to establish the correlation between the $L_{A90\ 10\ minute}$ background noise level and wind speed on the island during the entire 24-hour period as well as separate night and day periods.

4. Monitoring results

4.1 Summary of previous background noise monitoring

Previous monitoring, completed in January and February 2015 showed that, during the warmer months, the acoustic environment of Lord Howe Island is influenced by noise sources other than local wind conditions. Insect noise, particularly substantial during the day and evening, as well as ocean waves, provide a relatively constant background level. The background noise level was several decibels louder during the day than observed during the night when insects were not as prevalent, particularly at lower wind speeds.

Based on analysis of background noise levels and wind speed data for each relevant receiver, noise assessment criteria were derived from a 3rd order best fit regression line for night and day, since this presented the highest correlation coefficient. Derived noise assessment criteria for the warmer months are summarised in Table 4-1.

Table 4-1 Derived $L_{Aeq,\ 10\ minute}$ noise criteria for relevant receivers (summer monitoring period)

Receiver catchment	Period	Equation describing assessment criteria ($L_{Aeq,\ 10\ minute}$)	Wind speed at hub-height, m/s								
			4	5	6	7	8	9	10	11	12
Eastern coastal	All times	$y=-0.0819x^3 + 1.7872x^2 -11.47x+78.11$	56	55	56	57	59	60	60	59	56
	Night only	$y = 0.0205x^3 -0.4687x^2 +4.1876x+38.38$	49	50	51	52	52	53	54	55	57
Central	All times	$y = -0.0039x^3-0.0336x^2+1.6729x+40.64$	47	48	49	49	50	50	50	50	49
	Night only	$y = 0.0744x^3 - 1.8x^2 + 14.292x + 7.18$	40	43	44	45	44	44	45	46	48
Western coastal	All times	$y = 0.0028x^3-0.0609x^2+1.0317x+41.933$	45	46	47	47	48	48	49	50	50
	Night only	$y = 0.022x^3 - 0.474x^2 + 3.8983x + 31.17$	41	42	42	43	43	44	45	46	48
Southern island	All times	$y = -0.0089x^3+ 0.3021x^2-1.7583x+49.48$	47	48	49	49	50	50	50	50	49
	Night only	$y = -0.007x^3 + 0.1668x^2+0.0916x+39.67$	40	43	44	45	44	44	45	46	48

4.2 Winter background noise monitoring

Background noise monitoring was undertaken at the same four locations used in the previous assessment, as summarised in Table 4-2. Monitoring commenced on 3 August 2015 and continued until 29 August 2015. Winds were predominantly from the northwest requiring an additional two weeks of monitoring to satisfy the requirements of DP&I, AS 4959-2010 and SA EPA. That is, approximately 2,000 intervals, with at least 500 intervals in the worst-case direction.

A weather station was operated at one location (M4) to identify the wind speed at microphone height and to measure rainfall during the monitoring period. This allowed data collected during rain and at wind speeds (at microphone height) 6 m/s or greater to be excluded to avoid excessive wind- or rain-induced noise. A number of data points have been excluded due to rain and wind, or because the wind speed was either below cut-in or above the rated wind power of the WTG, as shown in Table 4-3.

During deployment of noise loggers, operator-attended monitoring was undertaken to characterise typical existing noise sources. Monitoring was performed with a dB01 'Duo' sound level meter during the day and night periods for 15 minutes in each location. A summary of observations and measured noise levels is provided in Table 4-2.

Table 4-2 Attended monitoring observations

Monitoring location	Recorded $L_{Aeq,15\ minute}$ noise parameters		Time	Observations
	L_{A90}	L_{Aeq}		
M1 Cobby's House	38.8	51.2	11:07 am	Conditions: Calm to light breeze (1 – 3 m/s) from NW, ~20°C Location: heavily vegetated with palms, 50 metres from the beach • Ocean is dominant noise source with continuous 39 – 40dB(A) • Slight breeze in trees 43-44 dB(A) • No insects audible
	50.6	54.5	11:14 pm	Conditions: light to moderate breeze (1 - 6 m/s) from northwest, partly cloudy, ~18°C. • When breeze light, waves on beach are dominant source ~49 dB(A). Windward side of island and waves choppy • Breeze strengthens and wind in trees increases to 61 dB(A)
M2 Rear of Pinetrees	39.5	53.5	11:50 am	Conditions: Calm to light breeze (1 – 3 m/s) from NW, ~20°C Location: Fewer palm trees but tall pine trees 'roar' in the wind, close to beach, large open space facing the WTG site • Surf noise is dominant ~39 – 40 dB(A) • Some hand tools used in resort ~52 dB(A) • Birds ~50 dB(A) • Breeze in trees ~45-48
	41	48	11:45 pm	Conditions: light to moderate breeze (1 - 6 m/s) from northwest, partly cloudy, ~18°C. • With moderate breeze, wind in trees dominant ~50 dB(A) • When calm to light breeze, waves dominate ~40 dB(A) • Power station inaudible • No insects
M3 Pauli's House	38.8	51.2	11:07 am	Conditions: Calm to light breeze (1 – 3 m/s) from NW, ~20°C • Dominant source is ocean noise ~39 – 40 dB(A) • Slight breeze in trees ~43-44 dB(A) • No insects
	45.2	49.3	10:46 pm	Conditions: light to moderate breeze (1 - 6 m/s) from northwest, partly cloudy, ~18°C. • When breeze strengthens, wind in tree dominates ~52-57 dB(A) • When calm to light, surf dominates ~44 – 47 dB(A) • Dome distant birds and frogs audible when breeze drops out
M4 Near Joy's shop	37.2	48.3	11:30 am	Conditions: Calm to light breeze (1 – 3 m/s) from NW, ~20°C • Open space, tree-fringed • Joy's shop nearby – no audible chillers • Surf dominant ~39-40 dB(A) • Cars idling from time to time at shop ~42 dB(A) • Traffic on middle beach road intermittent • Breeze in nearby trees
	41.9	50.6	10:21 pm	Conditions: light to moderate breeze (1 - 6 m/s) from northwest, partly cloudy, ~18°C. • Gusts in trees ~49 dB(A) • When wind drops, surf becomes the baseline noise source ~41 dB(A) • Distant birds

4.3 Winter data analysis

Measured L_{A90} noise levels over the monitoring period have been plotted against wind speed data at the proposed hub-height (55 m) to obtain a background noise level versus wind speed characteristic for each relevant receiver.

The line of best fit for data from each monitoring location has been determined using linear, second order (quadratic) and third order (cubic) polynomials. The correlation coefficient (R^2 value) for each line of best fit has been reported and the line with highest R^2 value used.

A summary of analysis for each relevant receiver is provided in Table 4-3. Graphs of the plotted measured data and regression lines for each monitoring location are provided in Appendix C.

Correlation coefficients for 24-hour data ranged from 0.23 to 0.38, which indicates that background noise levels, though increasing with wind speed, are not purely determined by local wind conditions. This is likely due to nearby waves on surrounding reefs, beaches and rocks, which influence the background noise level in most locations on the island. Insects were absent from the noise environment during the study.

Neither AS4959-2010 nor the Draft *Planning Guidelines – Wind Farms* recommend a minimum cut-off value for correlation; however AS4959 – 2010 recommends carrying out separate correlations at different times of the day and the Draft *Planning Guidelines – Wind Farms* requires day and night correlations to be considered.

Analysis of night time background noise versus wind data shows slightly weaker correlation, between 0.17 and 0.31.

Table 4-3 Long-term monitoring details

Location	Monitoring period	Noise logger serial no.	Total monitoring intervals	No. of valid data points		Best fit correlation coefficient, R^2, for all data			Best fit correlation coefficient, R^2, for	
				All	Night	Linear	2nd order	3rd order	Day 3rd order	Night 3rd order
M1 Cobby's	3 Aug 2015 – 29 Aug 2015	ARL Ngara 878000	2914	2319	833	0.23	0.23	0.23	0.26	0.17
M2 Pinetrees	3 Aug 2015 – 28 Aug 2015	ARL Ngara 8780A5	3330	2606	939	0.37	0.38	0.38	0.42	0.31
M3 Pauli's	3 Aug 2015 – 28 Aug 2015	ARL Ngara 8780A4	3581	2650	934	0.27	0.28	0.28	0.32	0.23
M4 Joy's shop	3 Aug 2015 – 29 Aug 2015	ARL Ngara 8780BA	3672	2733	961	0.26	0.26	0.27	0.33	0.18

5. Noise assessment criteria

When assessing the potential impact of WTG noise on the community, it is necessary to set a standard against which the nature and characteristics of this noise may be tested. Noise assessment criteria have been established for each relevant receiver, based on background noise levels and wind speeds in accordance with AS4959-2010 and the *Draft Planning Guidelines for Windfarms*.

The noise assessment criteria were derived from the 3rd order best fit regression line since this presented the highest correlation coefficient. Assessment criteria are summarised in Table 5-1 for day, night and 24-hour periods. Plotted noise criteria are shown in Appendix D. Criteria are relatively consistent between day and night periods for each location.

Table 5-1 Derived $L_{Aeq,\ 10\ minute}$ noise criteria for relevant receivers

Receiver catchment	Period	Equation describing assessment criteria ($L_{Aeq,\ 10\ min}$)	Wind speed at hub-height, m/s								
			4	5	6	7	8	9	10	11	12
Eastern coastal	All times	$y = -0.0064x^3+0.1056x^2+0.2876x+41.663$	44	45	46	47	47	48	49	49	49
	Day only	$y = -0.0094x^3+0.1984x^2-0.5041x+43.408$	44	45	45	46	47	48	49	49	50
	Night only	$y =-0.0018x^3-0.0605x^2+1.8027x+38.146$	44	45	46	47	48	48	48	48	48
Central	All times	$y = -0.0247x^3+0.5727x^2-3.1444x+45.168$	40	41	42	43	44	45	46	47	47
	Day only	$y = -0.0369x^3+0.8286x^2-4.6919x+47.793$	40	40	42	43	44	46	47	47	47
	Night only	$y = -0.0016x^3+0.0765x^2+0.042x+39.283$	41	41	42	43	44	45	46	47	48
Western coastal	All times	$y = -0.0239x^3+0.4972x^2-1.9803x+41.055$	40	41	42	43	45	46	47	48	48
	Day only	$y = -0.0395x^3+0.8699x^2-4.8014x+47.828$	40	41	42	43	45	46	47	48	47
	Night only	$y = 0.0008x^3-0.0904x^2+2.4113x+30.759$	39	41	42	43	45	46	47	47	48
Southern island	All times	$y = -0.0289x^3+ 0.6753x^2-3.8505x+47.73$	41	42	43	44	45	47	48	49	49
	Day only	$y = -0.0278x^3+0.6269x^2-3.2144x+45.5021$	41	42	43	44	46	47	48	49	49
	Night only	$y = -0.0261x^3+ 0.632x^2-3.9728x+49.021$	42	42	43	44	45	46	47	48	48

Noise criteria are intended to preserve the amenity on the island for residents and visitors, particularly during the night period, where activities such as sleep and relaxation rely on a quieter environment. WTG noise levels exceeding suitable levels at night may create annoyance.

Therefore, the recommendation in AS4959-2010 and the *Draft Planning Guidelines for Wind Farms* requirement to consider separate noise goals for the night period, has been adopted in this assessment and it is recommended to implement night noise criteria in each location. This approach was also adopted for the January 2015 monitoring work.

6. Comparison between winter and summer criteria and predicted WTG noise levels

A comparison is provided between noise criteria derived from background noise levels at night for the winter and summer monitoring surveys. Table 6-1 demonstrates that there is a minor difference between summer and winter noise levels for the central, western and southern receivers at lower wind speeds. Eastern coastal receivers were found to experience a more substantial difference with lower noise levels during the winter.

Predicted noise levels, from the previous assessment (Jacobs 2015), show that the derived criteria are not likely to be exceeded in either the summer or winter months at any location, with the possible exception of Eastern coastal receivers where wind speeds of 12 m/s or above at hub height, may result in a marginal (1 – 2 dB) exceedance of the night criteria during winter months. This level of exceedance is generally imperceptible and is considered to be a minor impact.

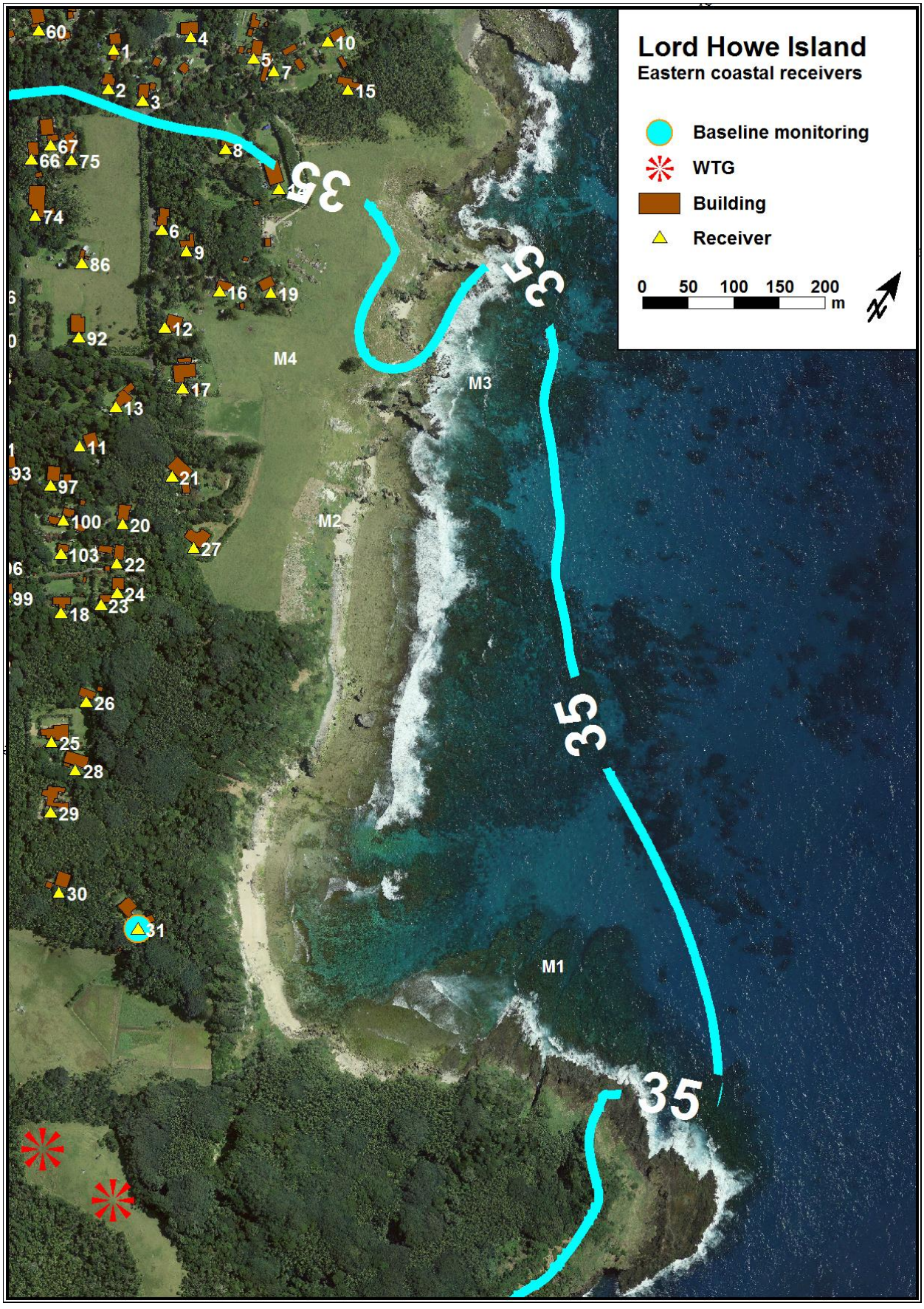
Table 6-1 Derived $L_{Aeq,\ 10\ minute}$ noise criteria, dB(A), for relevant receivers

Receiver catchment	Period	Wind speed at hub-height, m/s								
		4	5	6	7	8	9	10	11	12
Eastern coastal	Predicted noise level	31	31	31	38	40	41	48	49	50
	Criteria at night winter	44	45	46	47	48	48	48	48	48
	Criteria at night summer	49	50	51	51	52	53	54	55	57
Central / Joy's Shop area	Predicted noise level	25	25	25	32	34	35	42	43	44
	Criteria at night winter	41	41	42	43	44	45	46	47	48
	Criteria at night summer	40	43	44	45	44	44	45	46	48
Western coastal	Predicted noise level	27	27	27	34	36	37	44	45	45
	Criteria at night winter	39	41	42	43	45	46	47	47	48
	Criteria at night summer	41	42	42	43	43	44	45	46	48
Southern	Predicted noise level	16	16	16	24	26	26	34	35	35
	Criteria at night winter	42	42	43	44	45	46	47	48	48
	Criteria at night summer	40	43	44	45	44	44	45	46	48

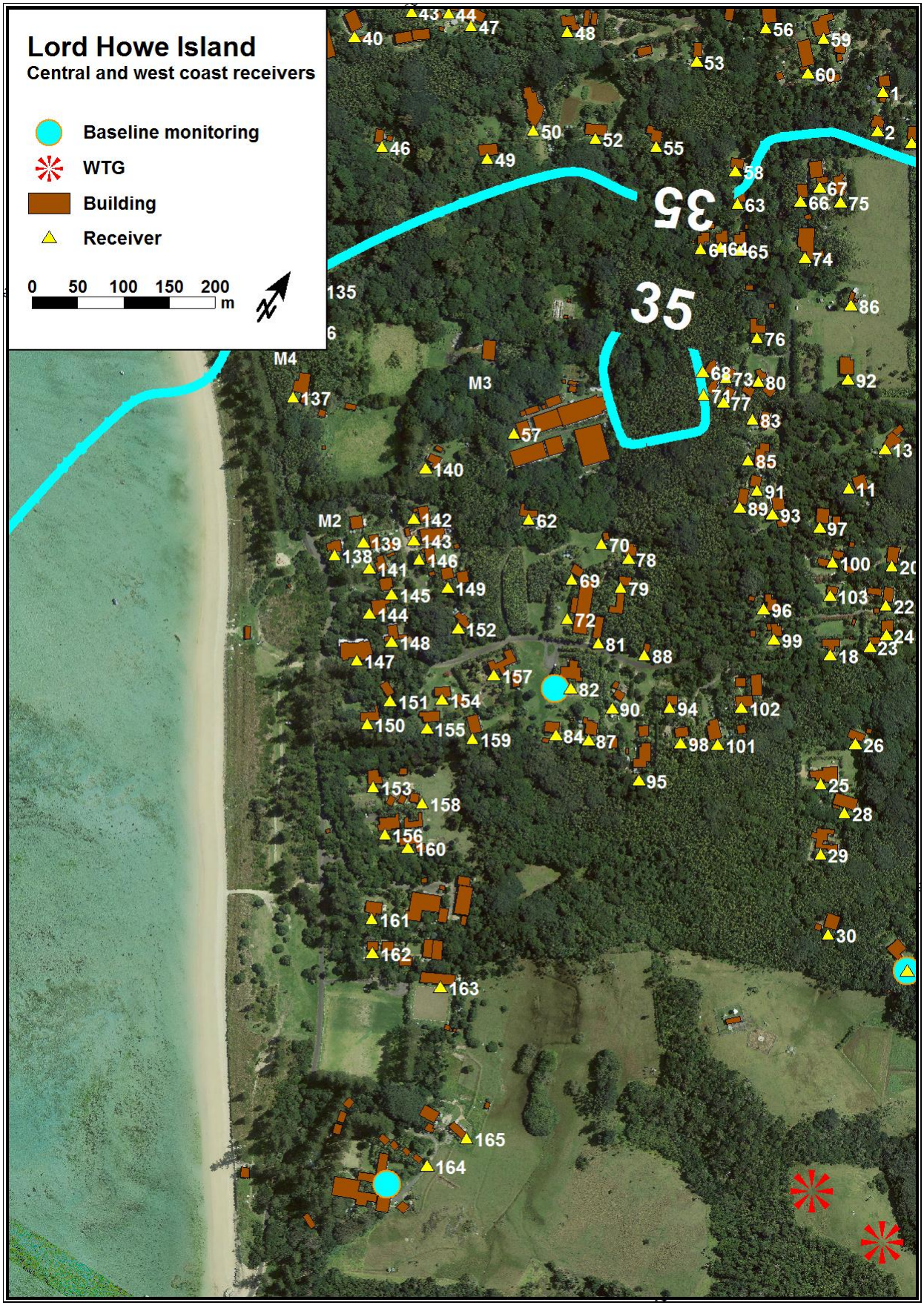
Upon commissioning, operational noise monitoring should be completed to confirm actual WTG noise emission levels and compliance with the assessment criteria.

Appendix A. Relevant receivers map

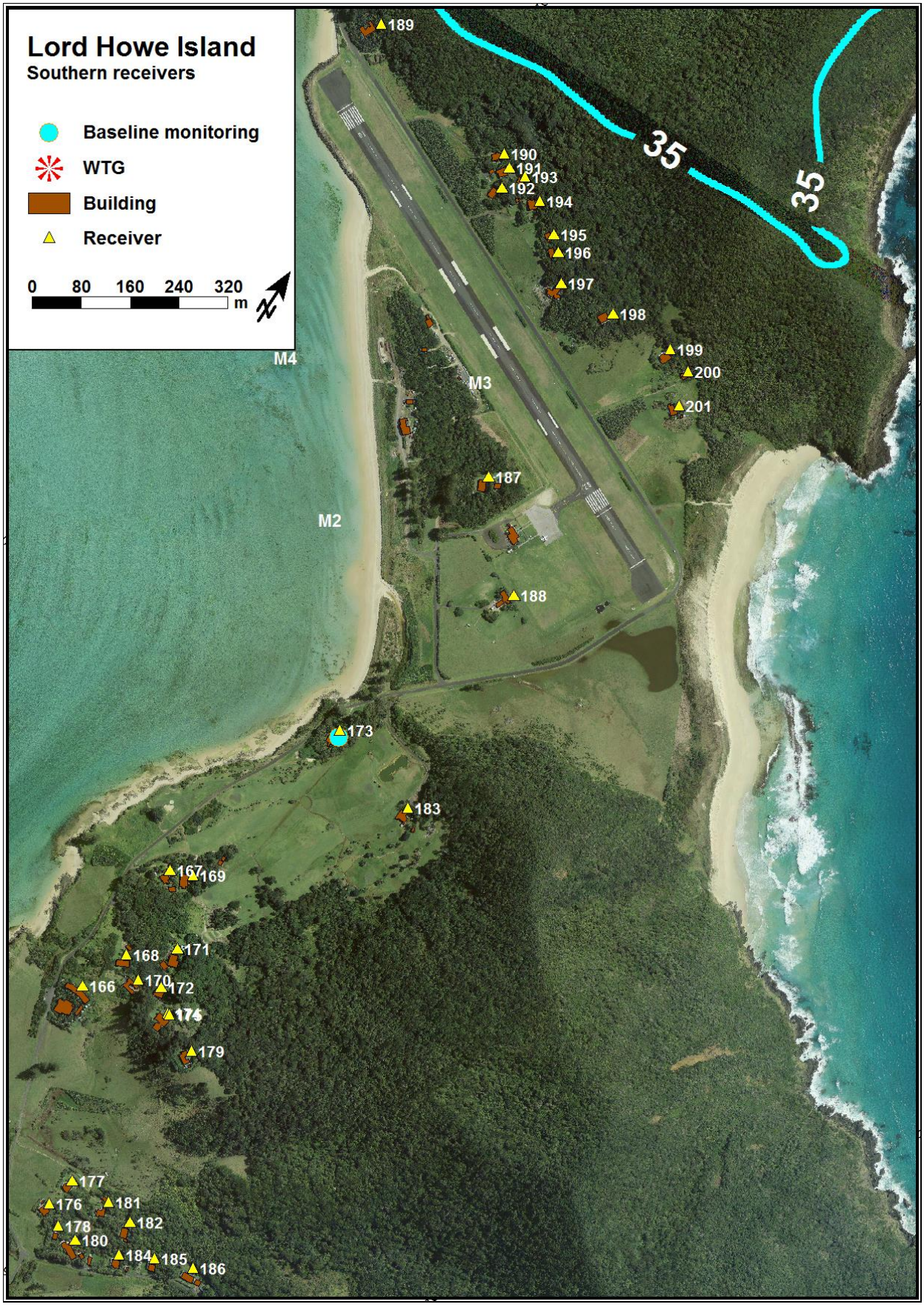
A.1 East coastal receivers



A.2 Central and west coastal receivers



A.3 Southern receivers

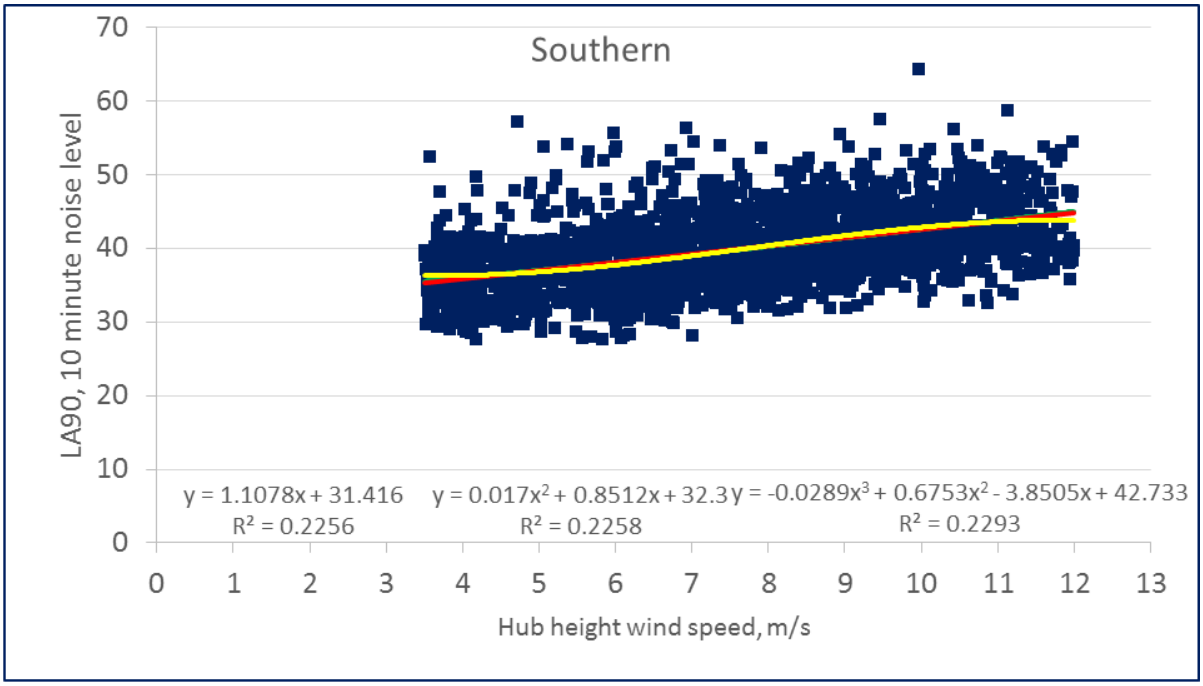


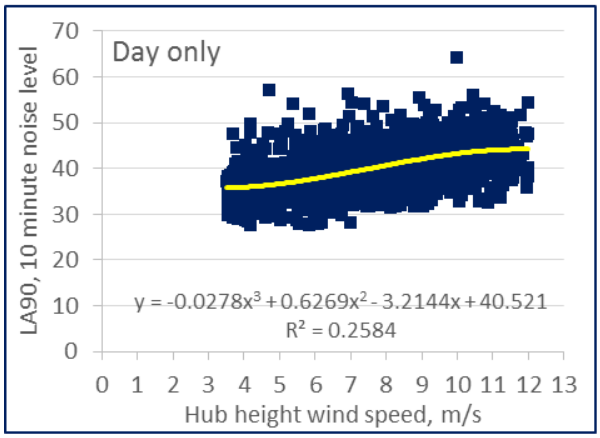
Appendix B. Photographs of background noise monitoring locations

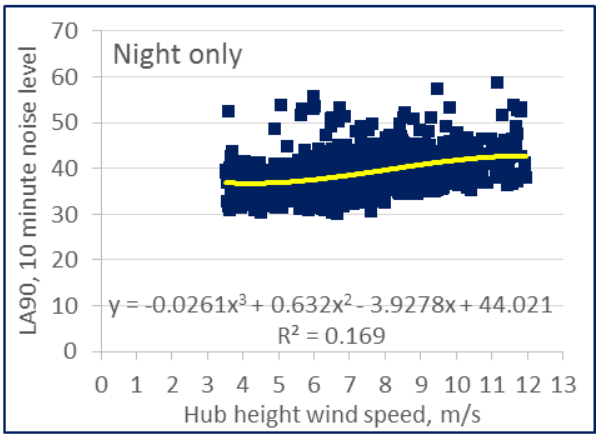
Monitoring location	Photograph of monitoring position	
M1 Cobby's House		
M2 Rear of Pinetrees		
M3 Pauli's House		
M4 Near Joy's shop		

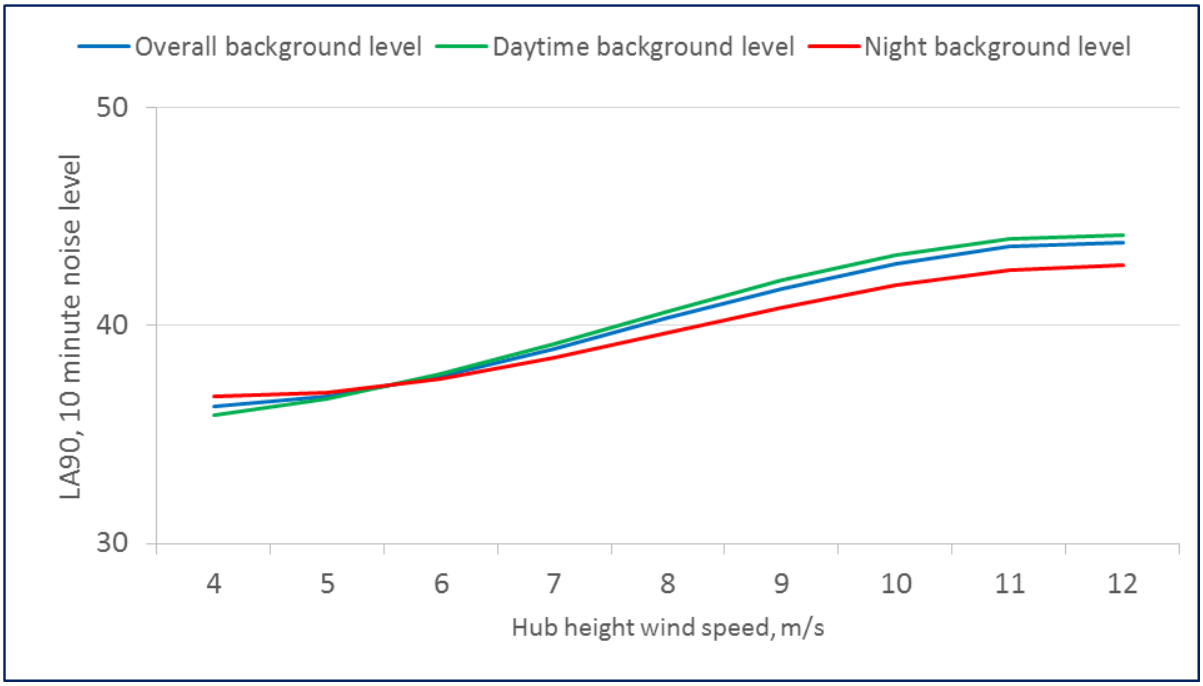
Appendix C. Background noise and wind data analysis

C.1 Southern receivers

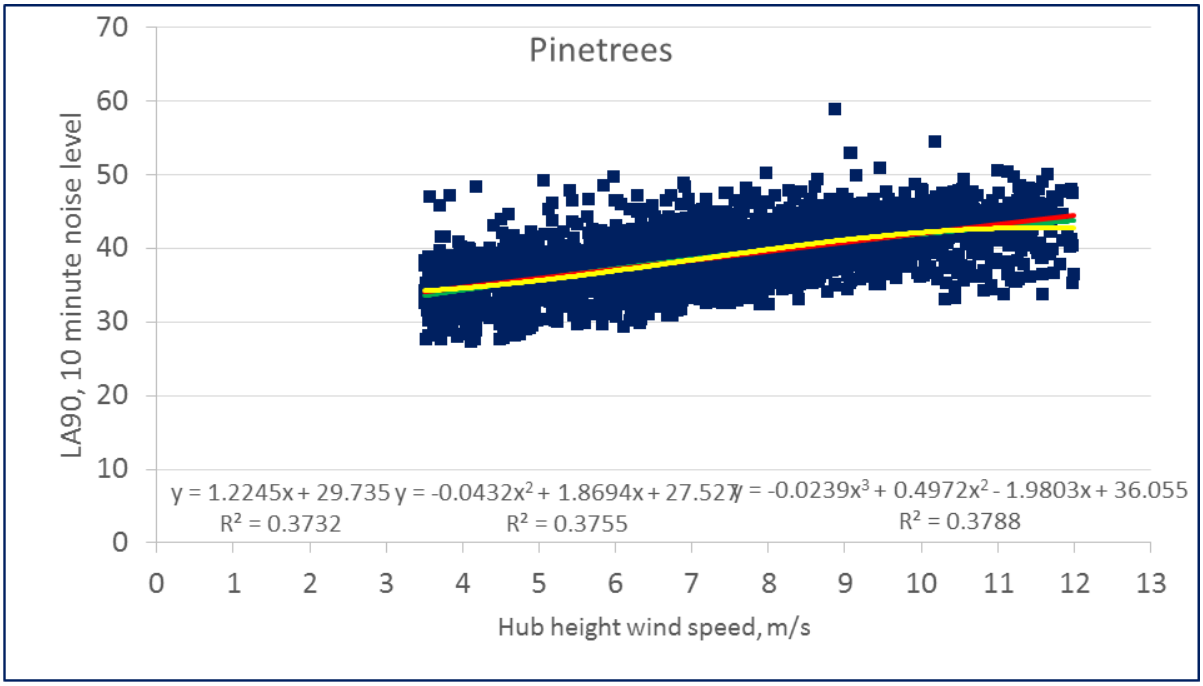


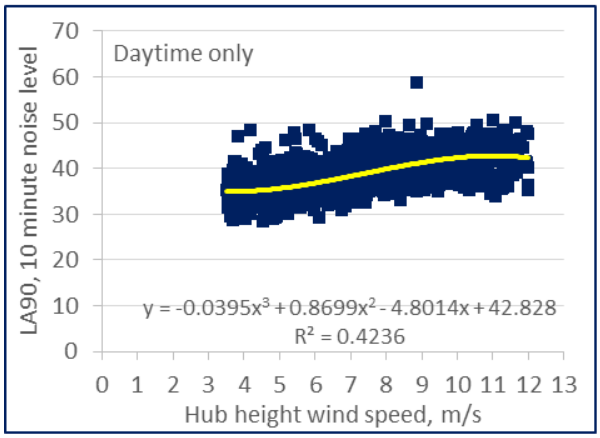


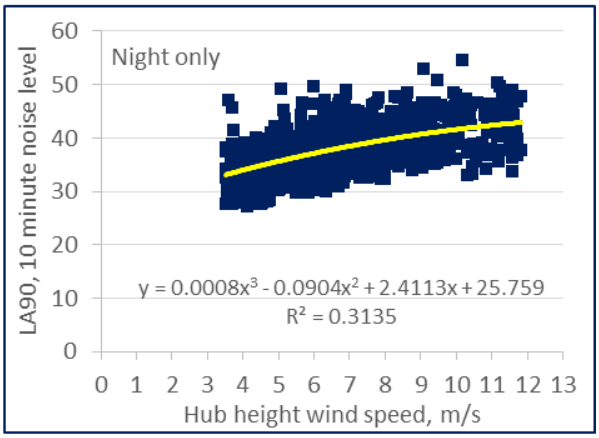


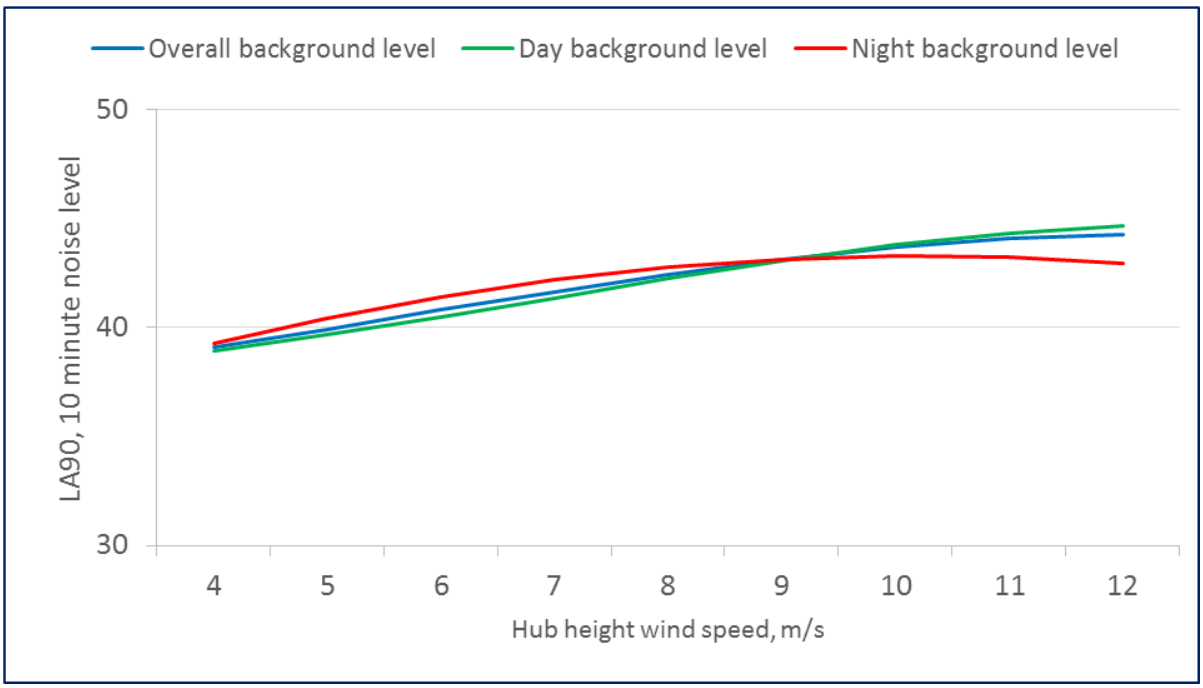


C.2 Western coastal receivers

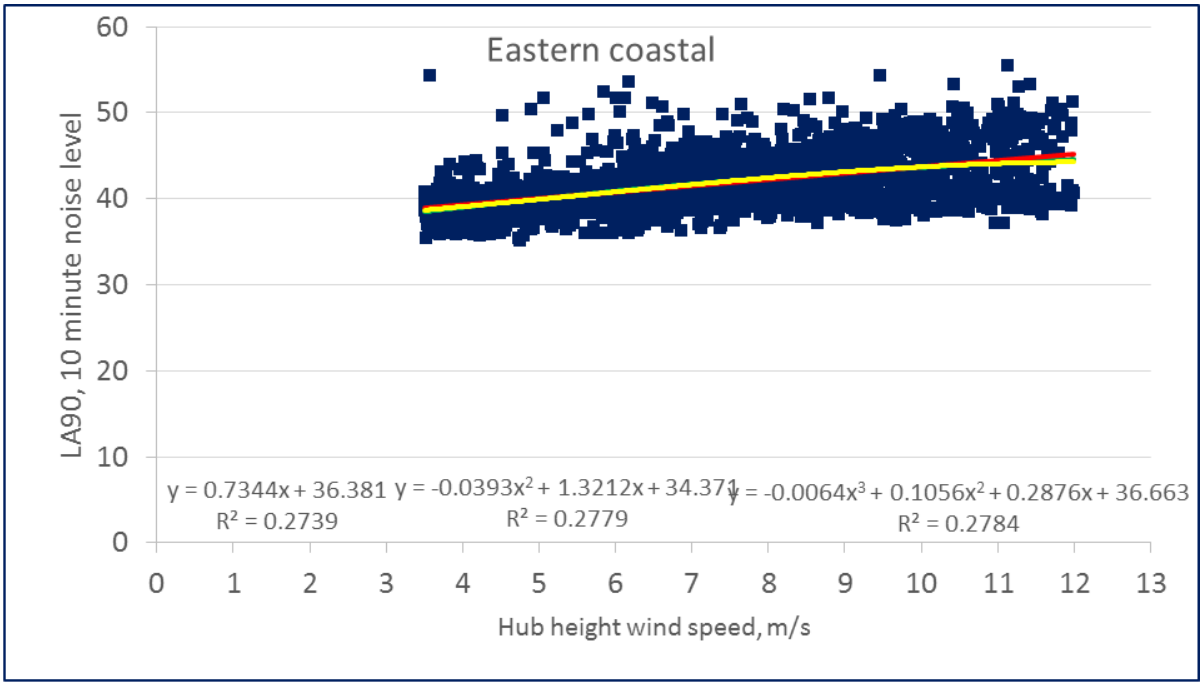


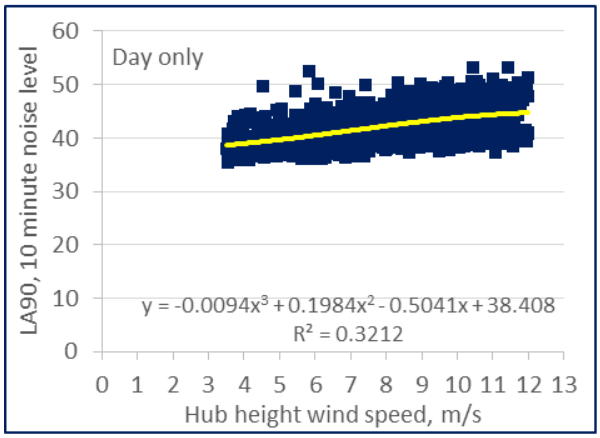


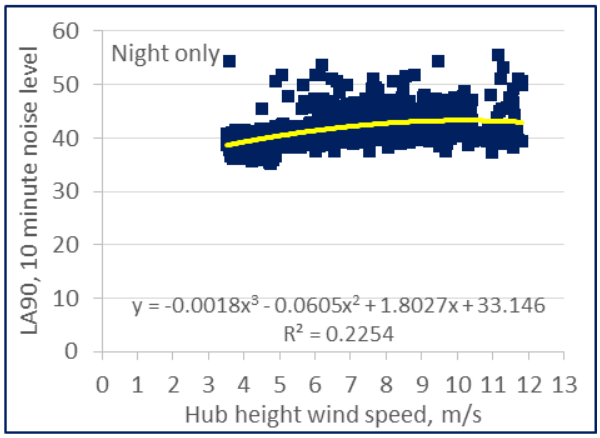


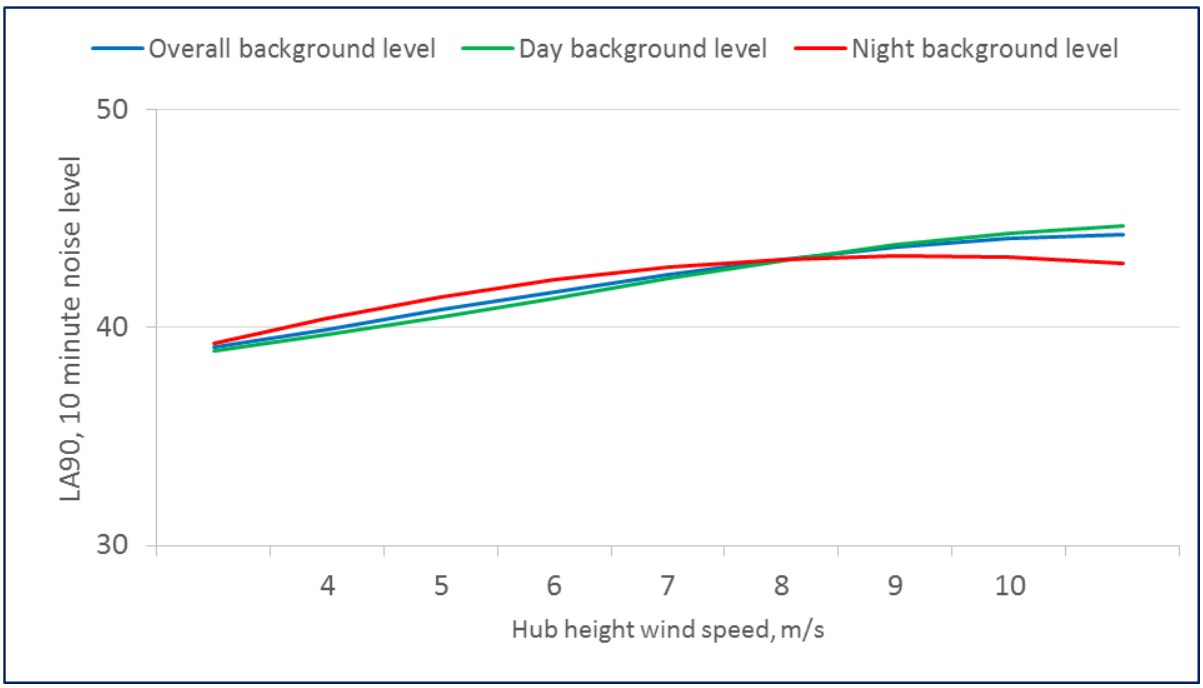


C.3 Eastern coastal receivers

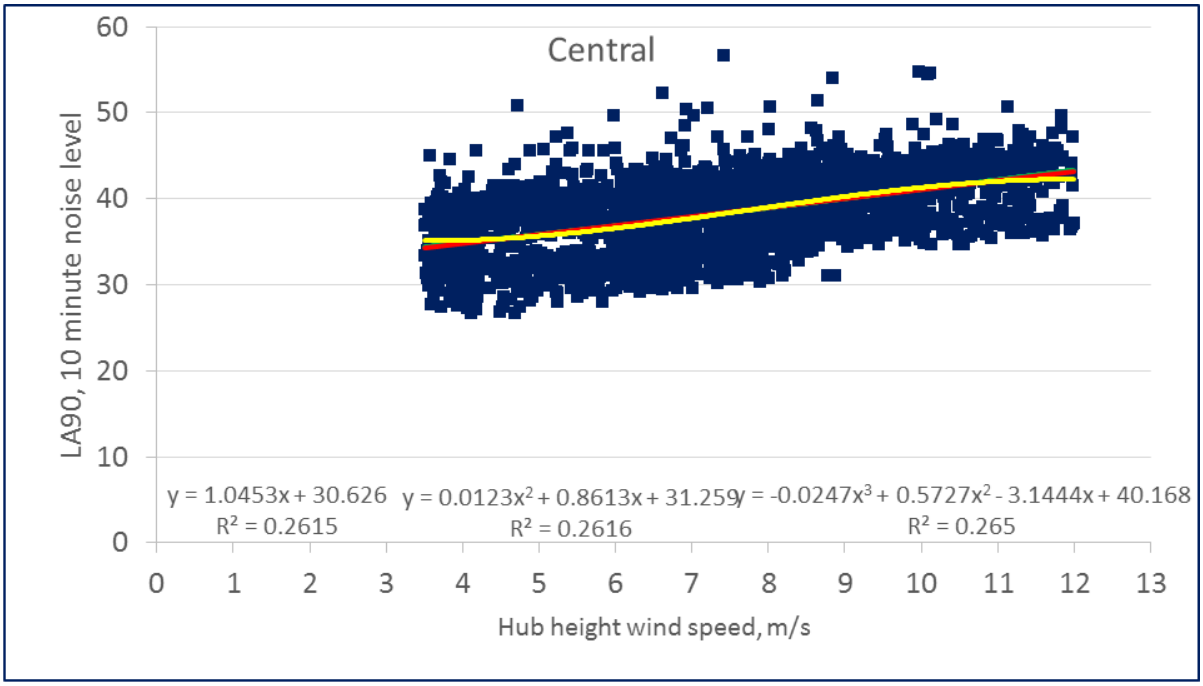


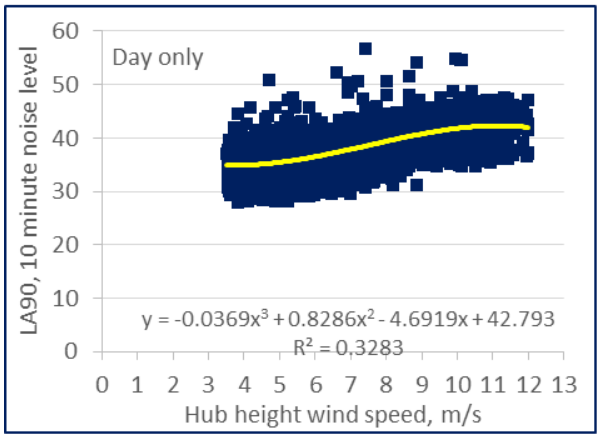


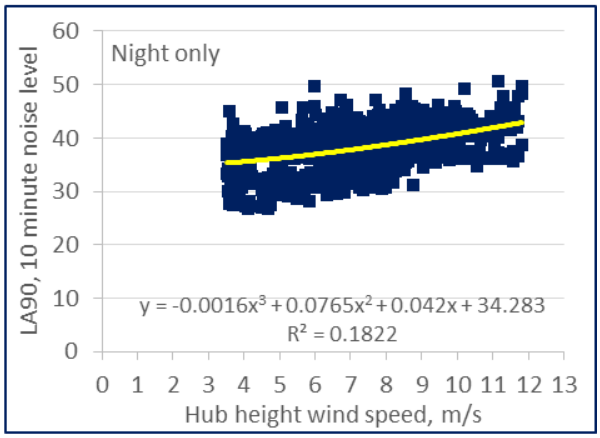


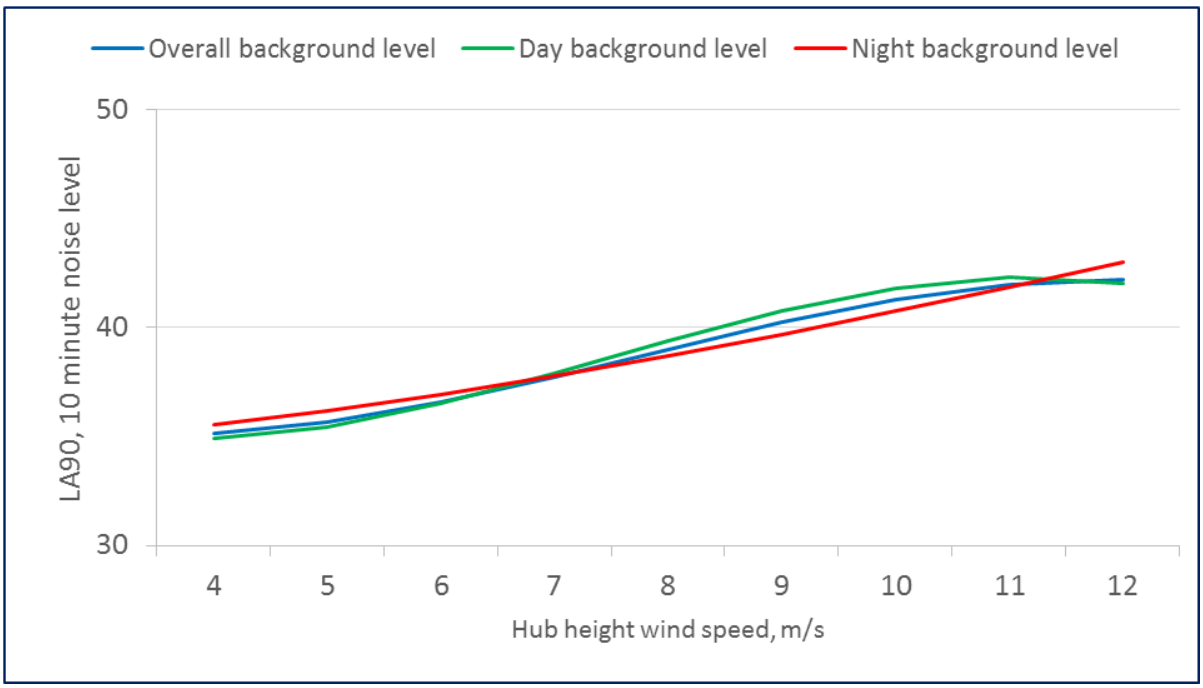


C.4 Central receivers









Appendix D. Derived noise criteria

Figure 6-1 Derived noise criteria for eastern coastal receivers

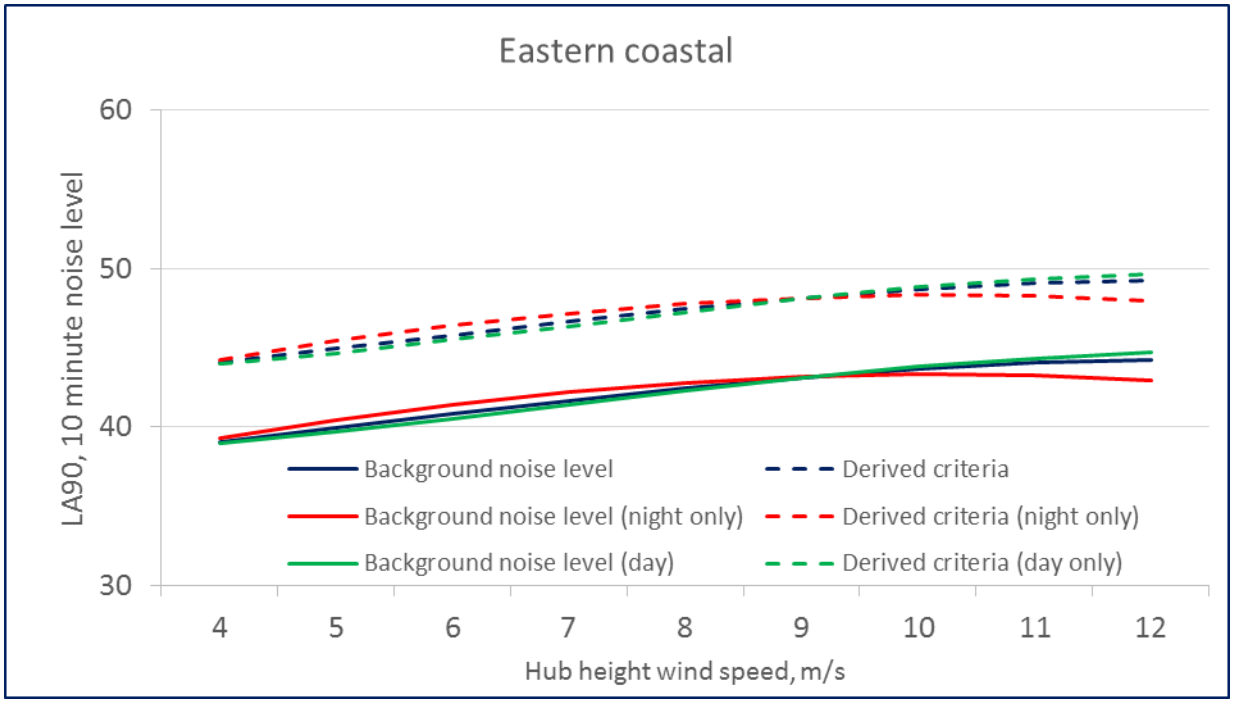


Figure 6-2 Derived noise criteria for central / town-centre receivers

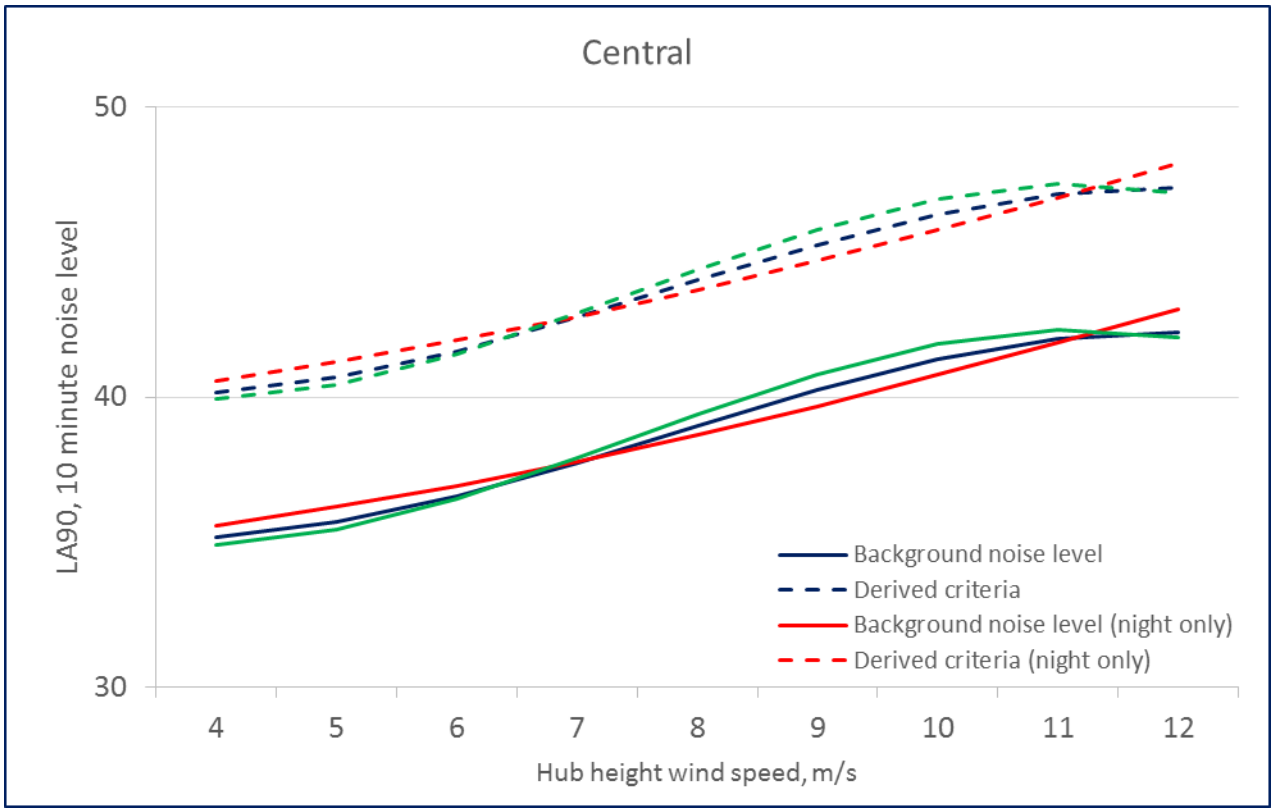


Figure 6-3 Derived noise criteria for western coastal receivers

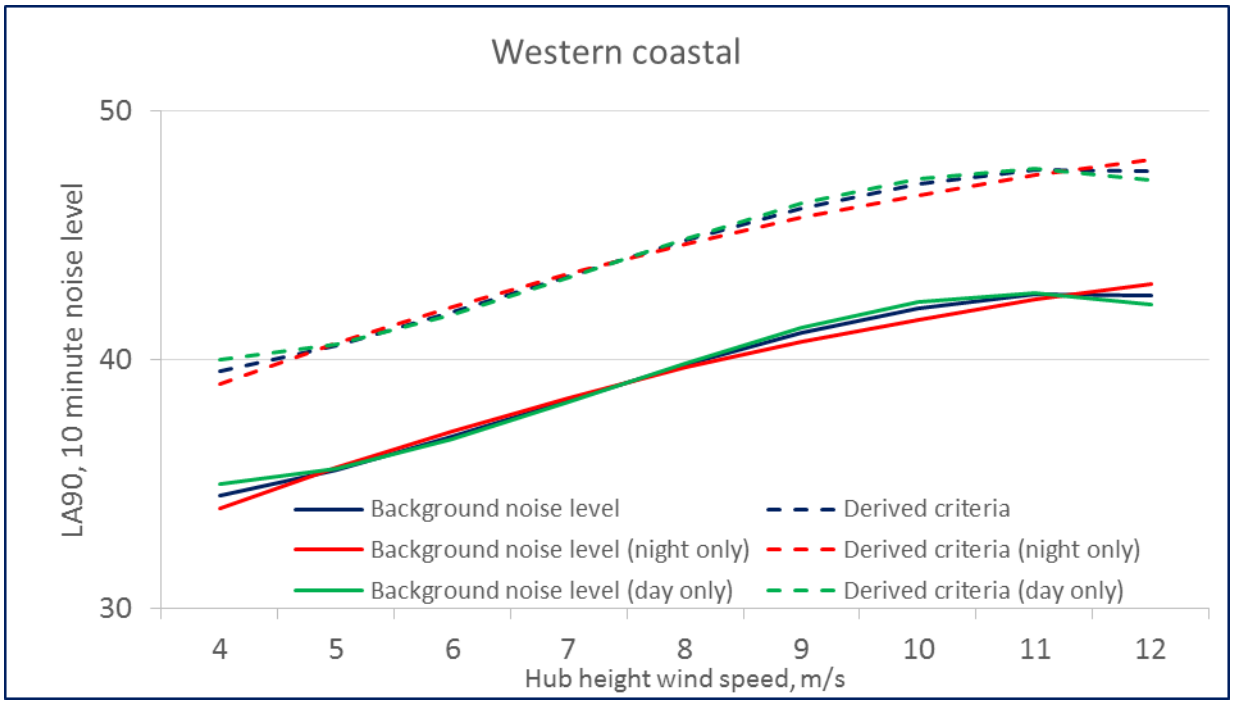


Figure 6-4 Derived noise criteria for southern receivers