APPENDIX D.1

BASELINE NOISE MONITORING

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GROUSEMOUNT WIND FARM

BASELINE NOISE MONITORING

Technical Report Prepared For

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Our Reference

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Title	Acoustic Consultant	Senior Acoustic Consultant
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EXECUTIVE SUMMARY

AWN Consulting Ltd has been appointed by ESB Wind Development Ltd to undertake baseline noise monitoring and assessments at a number of residential locations in the vicinity of the Grousemount wind farm development site near Kilgarvan, Co. Kerry. A two week baseline noise survey has been carried out at six locations and based on the collated data various regression analysis curves have been developed for review.

This report presents the results of the noise monitoring programme and derives appropriate noise criteria curves for each of the six noise sensitive locations based on best practice guidance.

All noise and wind speed data obtained during the surveys has been reviewed. For the statistical analysis on which the baseline noise curves are based, reference has been made to noise data collated during ‘quiet periods’ of the day and night as defined in best practice approaches. The definition applied in this instance is as follows:

- All evenings from 18:00 to 23:00hrs;
- Saturday afternoons from 13:00 to 18:00hrs;
- All day Sunday from 07:00 to 18:00hrs;
- Night is defined as 23:00 to 07:00hrs.

As part of the assessment a number of noise sensitive locations were identified as having been potentially impacted by noise from existing wind turbines during the baseline noise survey. Corrective measures have been taken to address this issue in line with best practice.

Following review of relevant local and international guidance, appropriate noise criteria for the development has been identified. Criteria curves have been established for each of the noise sensitive locations based on the following adopted turbine noise criteria.

- 40dB $L_{A90,10min}$ for quiet daytime environments of less than 30dB $L_{A90,10min}$
- 45dB $L_{A90,10min}$ for daytime environments of greater than 30dB $L_{A90,10min}$ or a maximum increase of 5dB(A) above background noise (whichever is higher), and;
- 43dB $L_{A90,10min}$ for night time periods.

Table A presents the noise criteria curves for each of the six locations.

Location	Period	LA90, 10 min Turbine Noise Criteria Values (dB) at 10m Height Wind Speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
NSL 1	Day	45.0	45.0	45.0	45.0	45.2	45.8	46.6	47.5	48.6	49.5
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 2	Day	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 3	Day	45.0	45.0	45.0	45.0	45.0	45.0	45.3	46.0	46.7	47.4
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 4	Day	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 5	Day	45.0	45.0	45.0	45.0	45.0	45.0	45.4	47.2	48.6	49.8
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 6	Day	45.0	45.0	45.0	45.0	45.0	45.7	47.9	49.9	52.0	54.2
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Table A Derived Noise Criteria Curves

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1.0 INTRODUCTION

This document describes the baseline noise monitoring and assessment procedures undertaken by AWN Consulting Ltd as part of the baseline noise monitoring programme for the proposed Grousemount wind farm, near Kilgarvan in Co. Kerry

Figure 1 illustrates the site's proposed turbine locations and identifies the six noise monitoring locations (NSL 1 to 6).

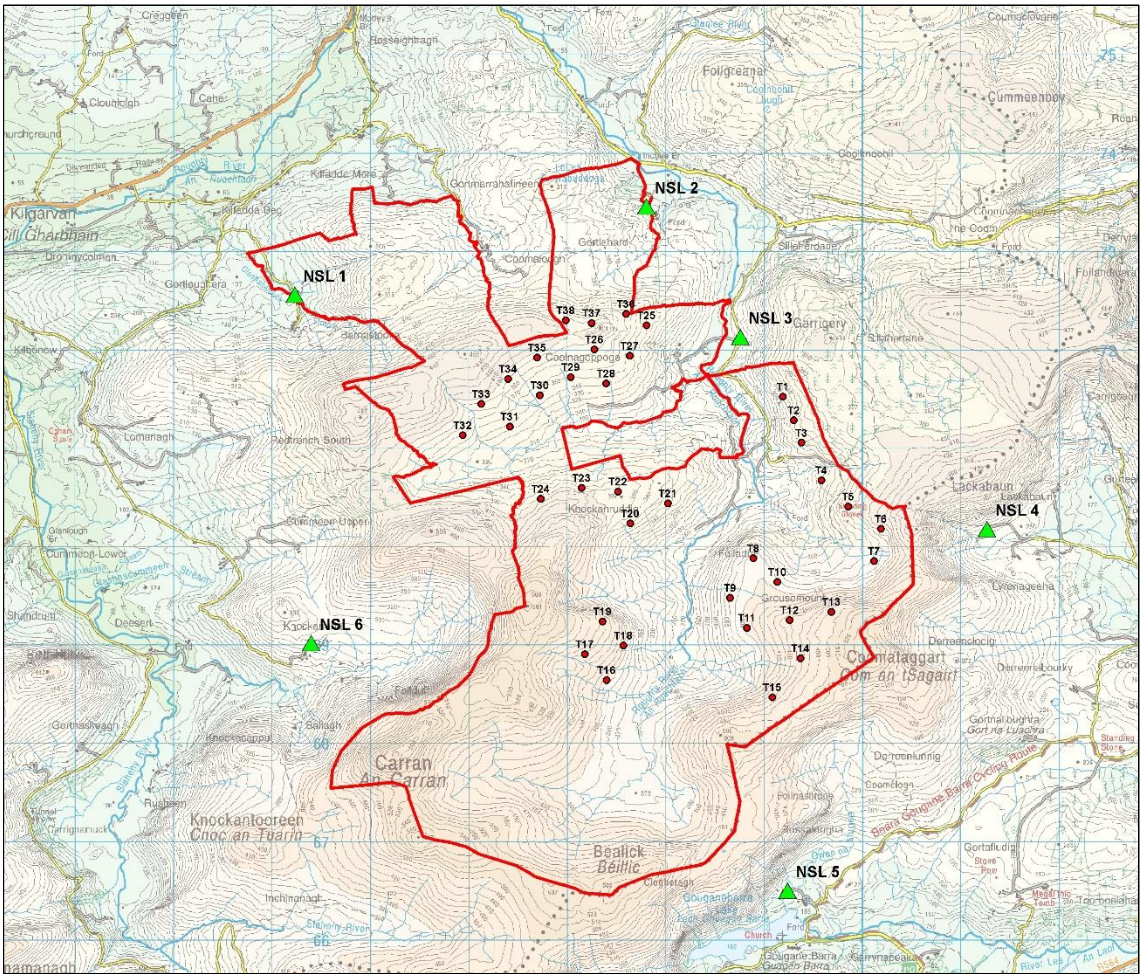

Figure 1 Site Locations & Context (Source: OSI/site operator)

The purpose of the assessment is to determine the pre-existing noise levels in the vicinity of the Grousemount wind farm development site and derive appropriate turbine noise criteria curves for the site. The results of this exercise are presented and discussed within the body of this report.

Appendix A presents a glossary of the acoustic terminology used throughout this report.

2.0 FUNDAMENTALS OF ACOUSTICS

In order to provide a broader understanding of some of the technical discussion in this report, this section provides a brief overview of the fundamentals of acoustics and the basis for the preparation of this noise assessment.

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. In order to take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of Sound Pressure Levels is 0dB (for the threshold of hearing) to 120dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10dB increase in SPL. It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 3dB.

The frequency of sound is the rate at which a sound wave oscillates, and is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250Hz. In order to rank the SPL of various noise sources, the measured level has to be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. Several weighting mechanisms have been proposed but the 'A-weighting' system has been found to provide one of the best correlations with perceived loudness. SPL's measured using 'A-weighting' are expressed in terms of dB(A). An indication of the level of some common sounds on the dB(A) scale is presented in Figure 2.

The 'A' subscript denotes that the sound levels have been A-weighted. The established prediction and measurement techniques for this parameter are well developed and widely applied. For a more detailed introduction to the basic principles of acoustics, reference should be made to an appropriate standard text[1].

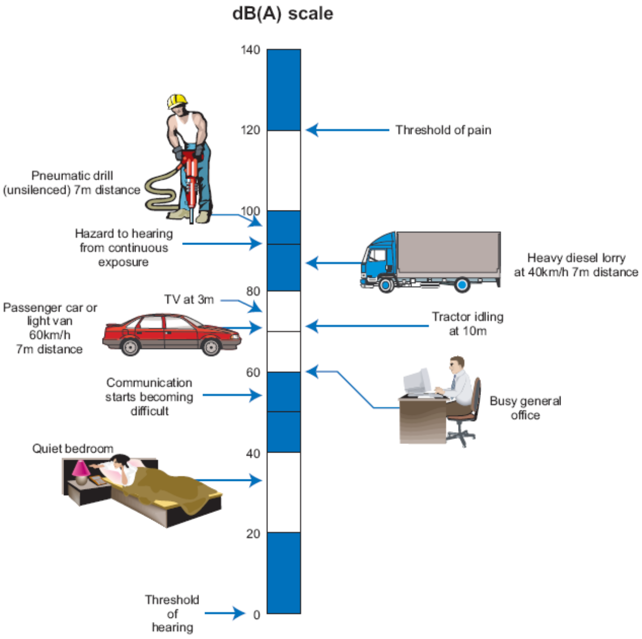

Figure 2
Level of Typical Common Sounds on the dB(A) Scale – (*NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004*)

1 For example, *Woods Practical Guide to Noise Control* by Ian Sharland.

3.0 RECEIVING ENVIRONMENT

The measurement locations were spread across a relatively large area. Almost all of the locations are situated in rural farm lands. The terrain around the site is mountainous and due to this fact, a large number of rivers and streams can be found in the locality. The following section describes the selected noise monitoring locations in detail.

The selected locations for the noise monitoring are identified in Figure 3.

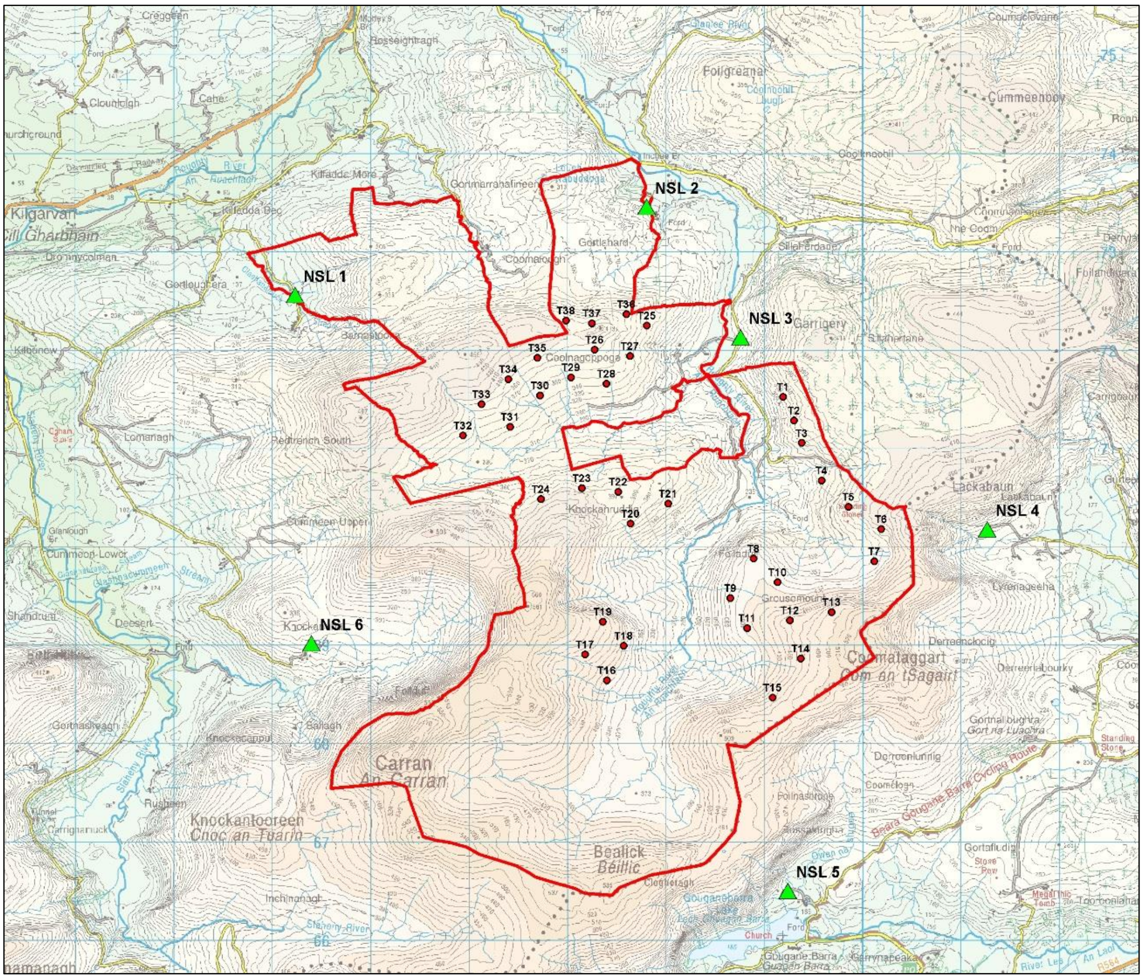

Figure 3 Noise Monitoring Locations

Figures 4 through 10 illustrate the installed noise monitoring kits at the various locations identified in Figure 3 and Table 1.

Location	Co – Ordinates (ING)	
	Easting	Northing
NSL 1	104,270	72,542
NSL 2	107,778	73,478
NSL 3	108,785	72,155
NSL 4	111,357	70,223
NSL 5	109,237	66,489
NSL 6	104,461	68,992

Table 1 Co-Ordinates of Monitoring Equipment

Figure 4 Noise Monitoring Location NSL 1

Figure 5 Noise Monitoring Location NSL 2

Figure 6 Noise Monitoring Location NSL 3

Figure 7 Noise Monitoring Location NSL 4

Figure 8 Noise Monitoring Location NSL 5

Figure 9 Noise Monitoring Location NSL 6

4.0 METHODOLOGY

The noise surveys have been carried out in accordance with guidance contained in *ISO 1996: 2007: Acoustics – Description, measurement and assessment of Environmental Noise* and *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Noise from Wind Turbines. The Institute of Acoustics, November 2013*.

In summary, the following methodology for the bassline noise monitoring was adopted:

- Measure the existing background noise levels through the installation of unattended noise monitoring terminals at the nearest noise sensitive locations for a period of at least two weeks.
- Perform regression analysis on the measured noise and wind speed data in order to determine the typical background noise levels at various wind speeds.
- Present the results for each of the noise sensitive locations with reference to noise data collated during 'quiet periods' of the day and night as defined in the best practice guidance.

4.1 Measurement Periods

Noise measurements were conducted at all locations over the periods shown in Table 2:

Location	Start Time and Date	End Time and Date
NSL 1	16:10hrs 12/02/2015	12:10hrs 27/02/2015
NSL 2	15:20hrs 12/02/2015	11:20hrs 27/02/2015
NSL 3	14:50hrs 12/02/2015	11:00hrs 27/02/2015
NSL 4	13:50hrs 12/02/2015	10:20hrs 27/02/2015
NSL 5	12:40hrs 12/02/2015	09:50hrs 27/02/2015
NSL 6	16:50hrs 12/02/2015	11:50hrs 27/02/2015

Table 2 Noise Monitoring Periods

The wind speed conditions encountered during the survey period is illustrated in Figure 10.

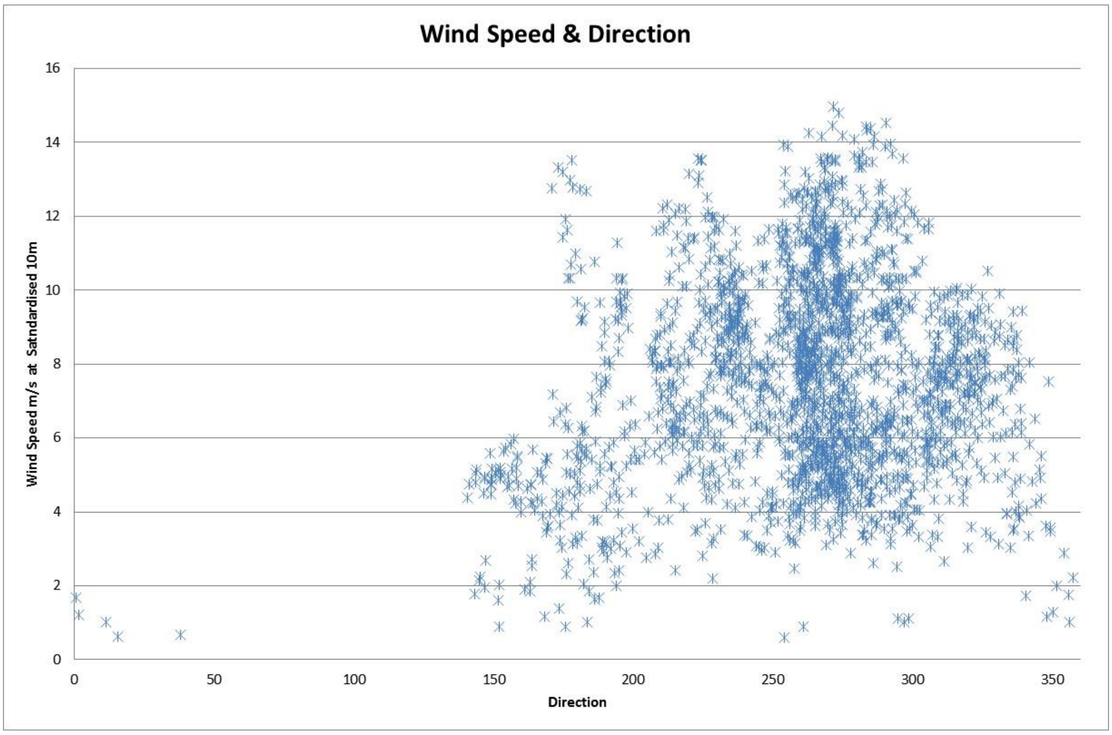

Figure 10 Distributions of Wind Speeds & Direction during the Survey.

The IOA's *A Good Practice Guide to the Application of ETSU-R-97*[2] recommends that the minimum wind speed range (at standardised 10m) for background noise surveys is:

- For pitch-regulated turbines: between cut-in wind speed and the wind speed corresponding to its maximum sound power level.
- For stall-regulated turbines: between cut-in wind speed and 12 m/s.

4.2 Personnel & Instrumentation

Dermot Blunnie (AWN) installed and removed the noise monitors at all locations. The following instrumentation was used at the various locations:

Location	Equipment	Serial Number
NSL 1	Brüel & Kjær 2238	2638294
NSL 2	Brüel & Kjær 2238	2654428
NSL 3	Brüel & Kjær 2238	2684495
NSL 4	Brüel & Kjær 2238	2638292
NSL 5	Brüel & Kjær 2238	2562663
NSL 6	Brüel & Kjær 2238	2555333

Table 3 Instrumentation Details

All noise meters and calibrators meet Type 1 precision standards and have been independently calibrated within the past 24 months. Copies of the relevant calibration certificates are presented in Appendix B. All equipment was assembled on site with the required environmental protection as specified by the manufacturers. To fulfill the recommendations of the IOA's Good Practice Guide, a secondary windscreen was used at the microphone.

2 *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Noise from Wind Turbines. The Institute of Acoustics, May 2013*

Before and after the survey all of the noise monitoring equipment was field calibrated and checked using a Brüel & Kjær Type 4231 sound level calibrator.

Rain fall data was recorded for the monitoring period, using an installed rain-gauge over the monitoring periods. This information was obtained using a Texas Instruments TR525T rain collector tipping bucket (0.2mm) with data logger. The rain gauge data allows for periods of rainfall to be identified and removed from the noise monitoring data sets in line with best practice and this has been done in this instance.

Wind speed and direction data was supplied by ESB Wind Development. The data was obtained from an on-site Met Mast and that was representative of the wind conditions occurring across the development site.

Wind speed measurements were made at 80m height and referenced to a standardised 10m wind speed using Equation 1 as defined in the ESTU[3] document.

$$v_{10} = v_{hh} \times \left(\frac{\ln\left[{10}/{z_0} \right]}{\ln\left[{hh}/{z_0} \right]} \right)$$ Equation 1.

Where v_{10} is the wind speed at 10m height, v_{hh} is the hub height or anemometer height wind speed and z_0 the standard ground roughness length of 0.05m.

4.3 Procedure

Measurements were conducted at the six locations over a period of 15 days. Sample times for the noise measurements were of 10-minute duration. The results were saved to the instrument memory for later analysis. Survey personnel noted potential primary noise sources contributing to noise build-up during the installation and removal of the sound level meters from site (e.g. identified significant noise sources in the area such as local traffic or farm yard activities along with a level of noise from any existing wind energy developments). $L_{Aeq,}$ $L_{A90,}$ $L_{Amax,}$ and L_{Amin} parameters were measured in this instance.

4.4 Results

The results of the background noise monitoring programme are extensive. The raw data sets are not included in this document but are available on request along with the measured Met data for the survey period.

All noise data obtained during the survey has been reviewed with the exception of the sample periods affected by rainfall or following periods of heavy rainfall and a relatively small number of samples identified as atypical for the location. An example of an atypical sample is any measurement significantly affected by short isolated periods of raised noise levels attributable to local sources such as agricultural activity, boiler flues, periods after heavy rainfall etc.

Note that for the data presented in the following sections all noise data obtained during the survey has been reviewed however, for the statistical analysis on which the baseline noise curves are based, reference has been made to noise data collated

3 Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication "The Assessment and Rating of Noise from Wind Farms" (1996)

during 'quiet periods' of the day and night as defined in best practice guidance. This definition is as follows:

- All evenings from 18:00 to 23:00hrs;
- Saturday afternoons from 13:00 to 18:00hrs;
- All day Sunday from 07:00 to 18:00hrs;
- Night is defined as 23:00 to 07:00hrs.

Following review of the collated data and with due consideration of the noise climate within the receiving environment, it would be reasonable to assume that the full data sets are more representative of the baseline noise environment at the various measurement locations than during the 'quiet periods'. The full data sets, denoted as 'all periods' have therefore been assessed and are presented for review in the following sections.

4.4.1 Location NSL1

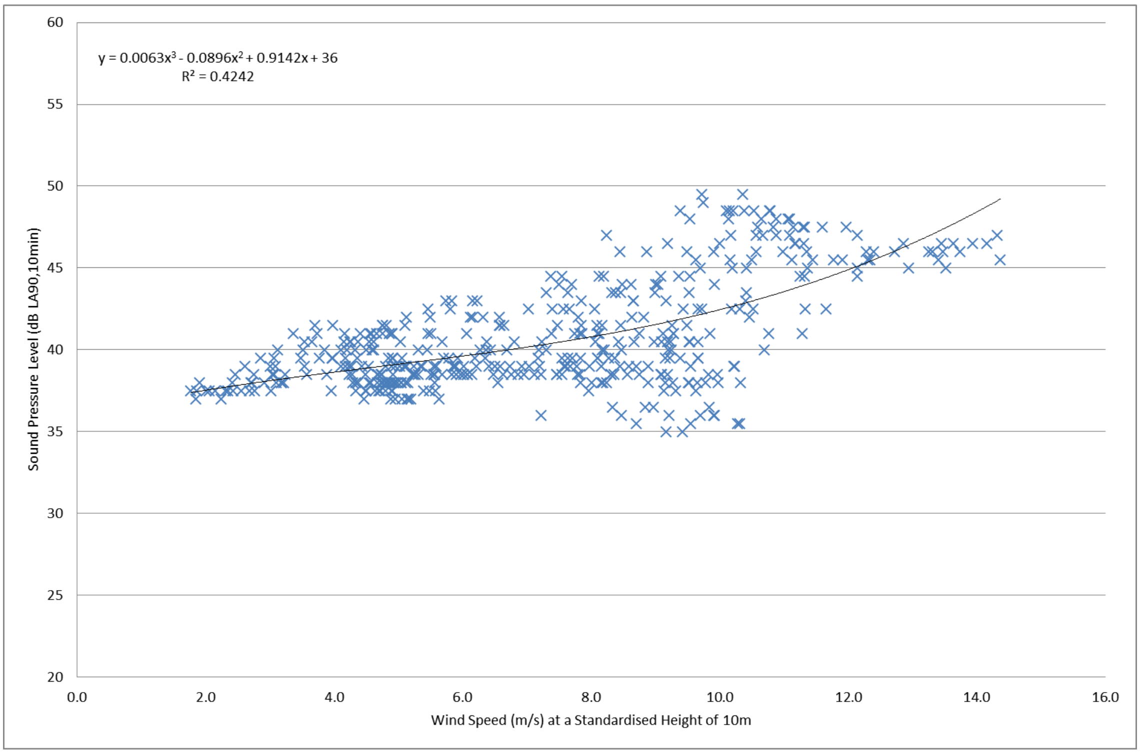

Figure 11 Daytime Baseline Noise Levels – NSL1

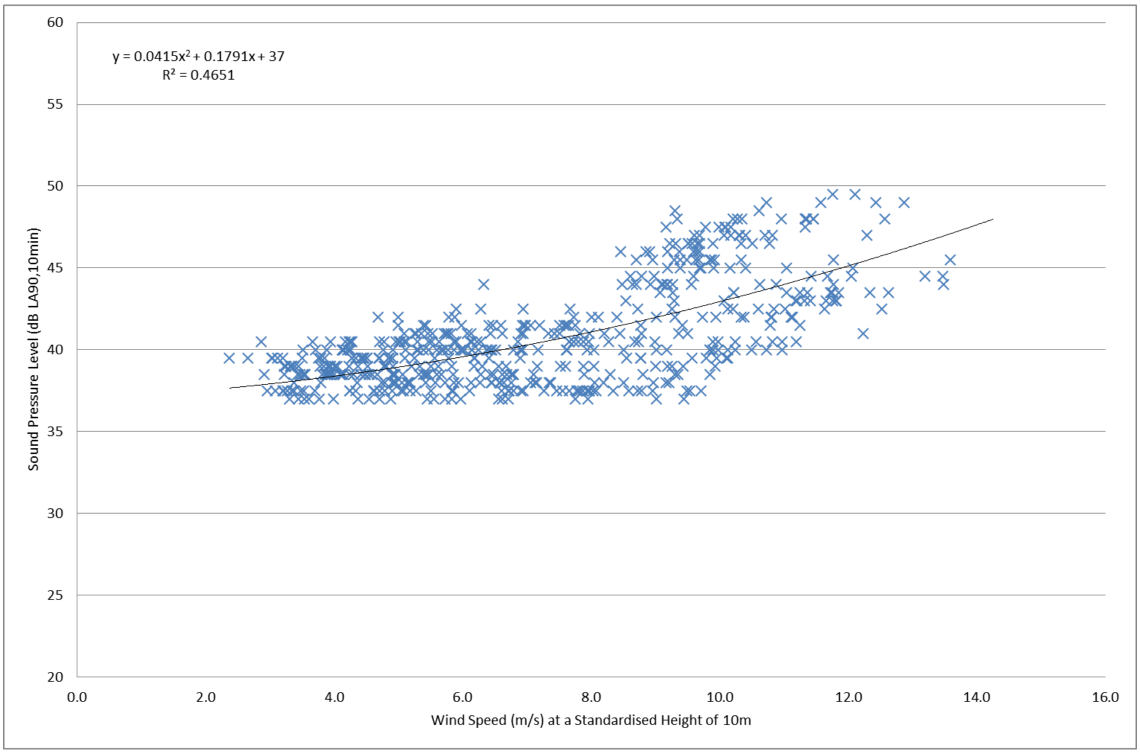

Figure 12 Night Time Baseline Noise Levels – NSL1

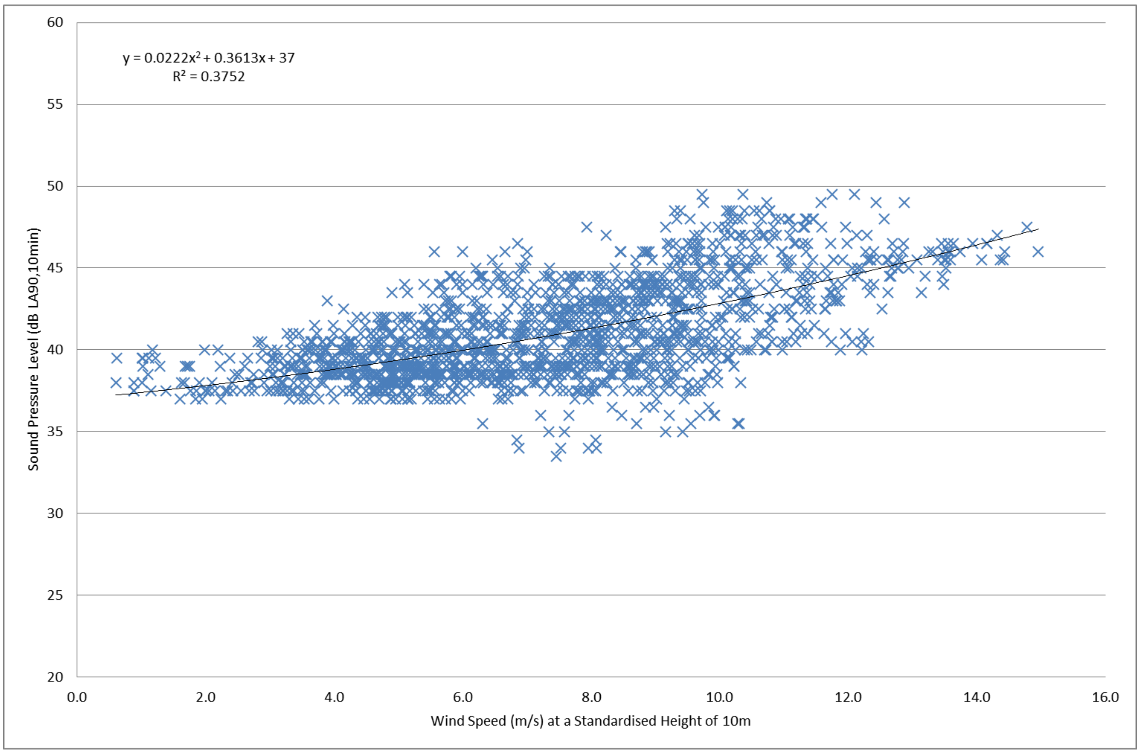

Figure 13 Baseline Noise Levels All periods – NSL1

4.4.2 Location NSL2

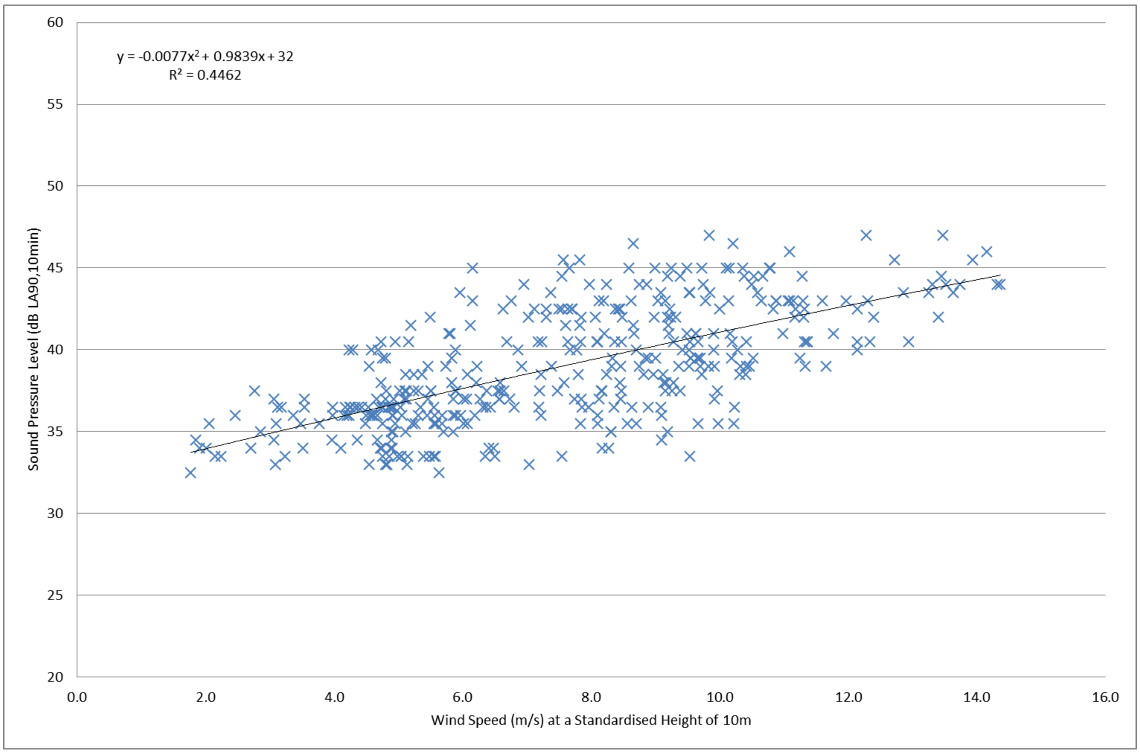

Figure 14 Daytime Baseline Noise Levels – NSL2

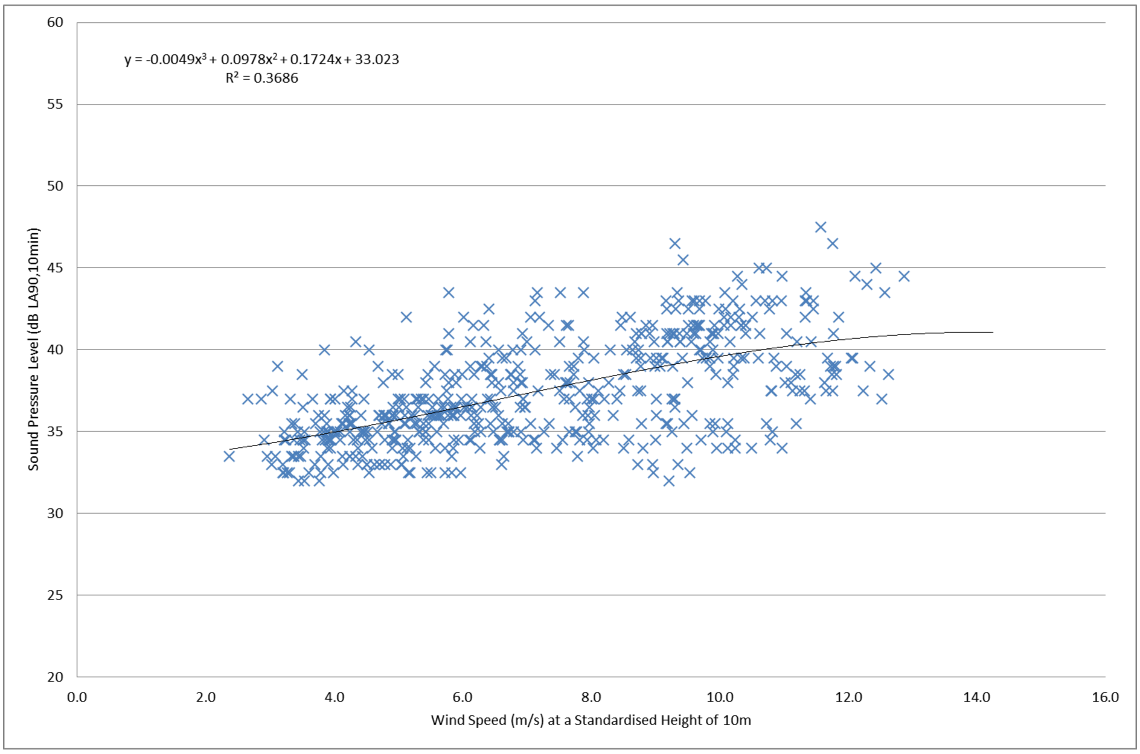

Figure 15 Night Time Baseline Noise Levels – NSL2

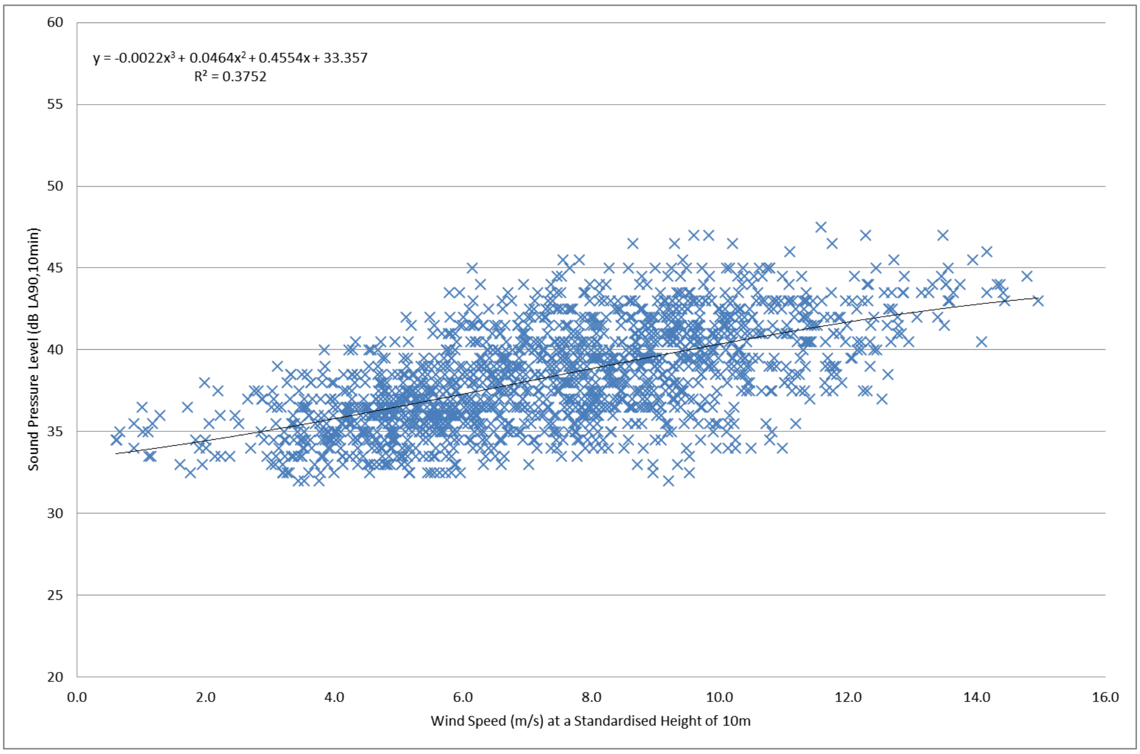

Figure 16 Baseline Noise Levels All periods – NSL2

4.4.3 Location NSL3

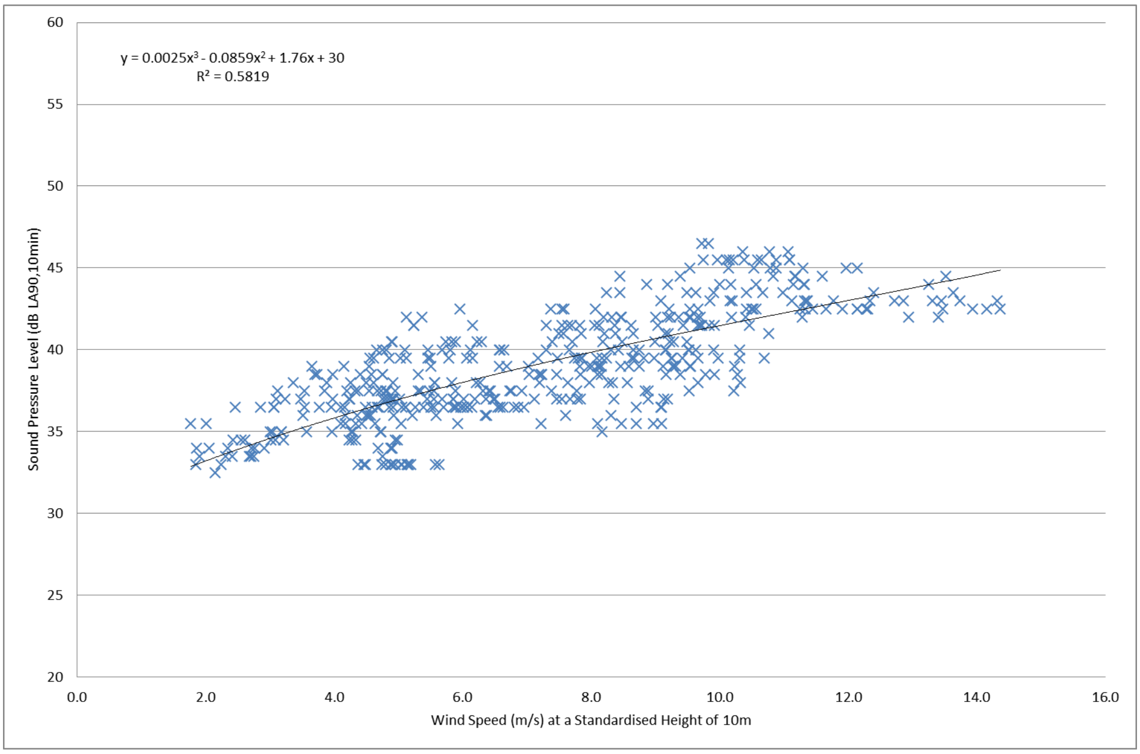

Figure 17 Daytime Baseline Noise Levels – NSL3

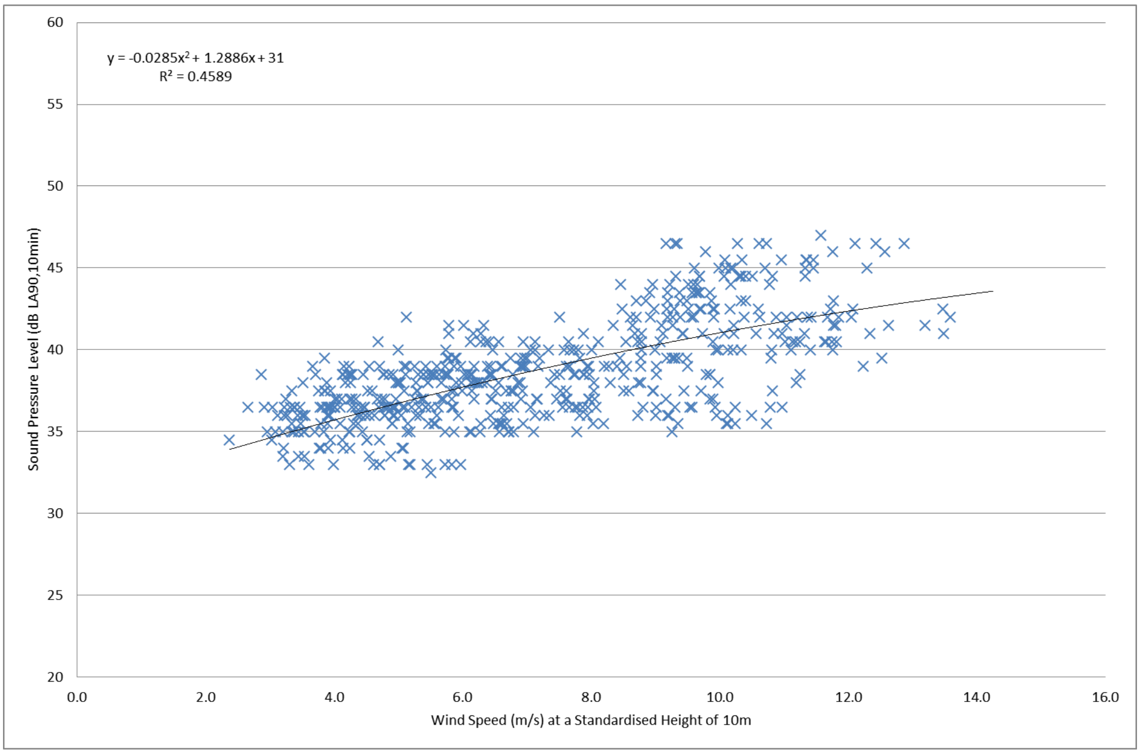

Figure 18 Night Time Baseline Noise Levels – NSL3

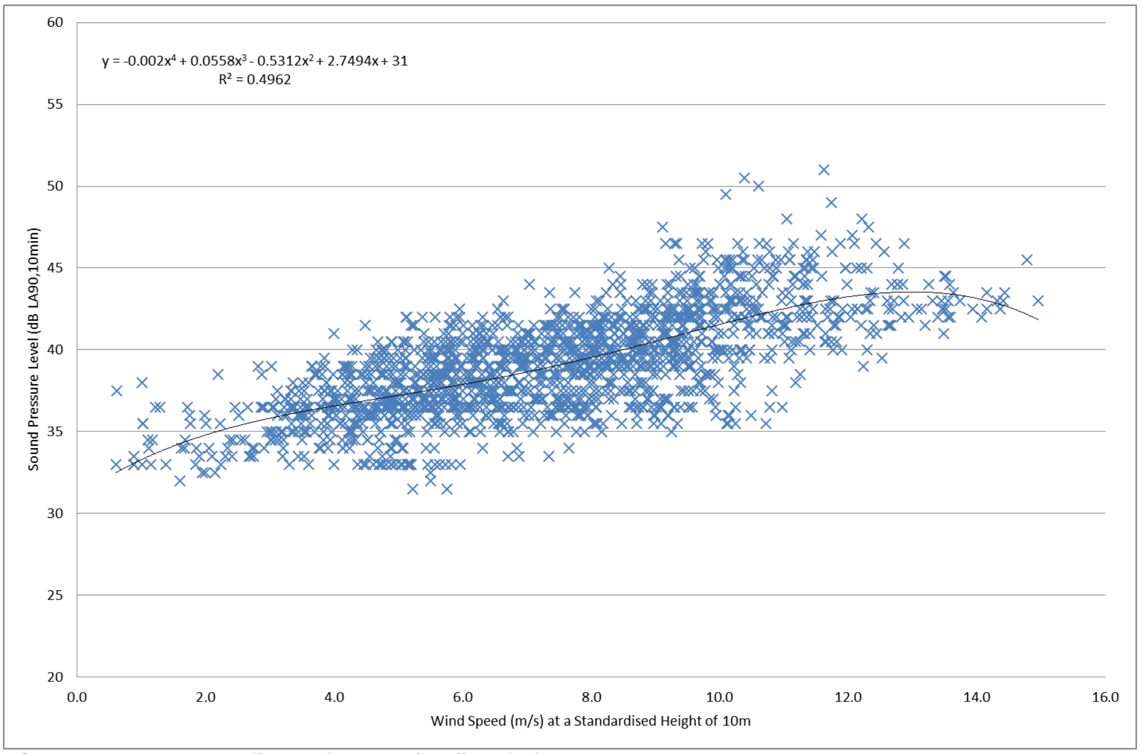

Figure 19 Baseline Noise Levels All periods – NSL3

4.4.4 Location NSL4

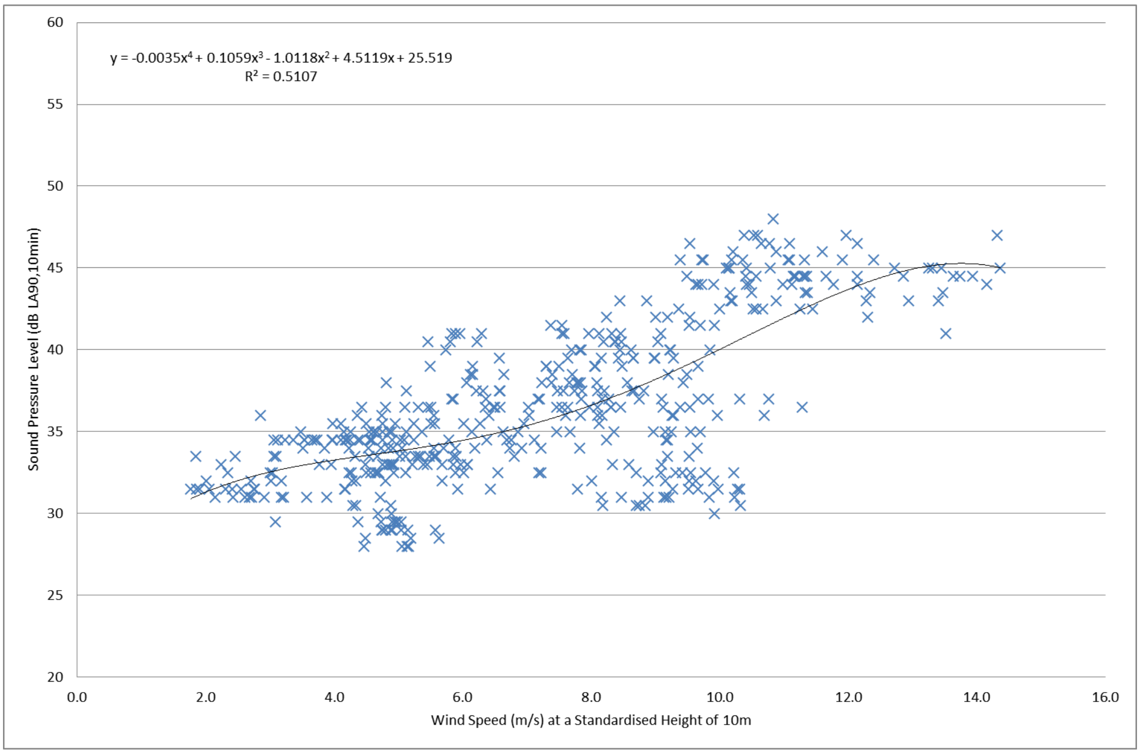

Figure 20 Daytime Baseline Noise Levels – NSL4

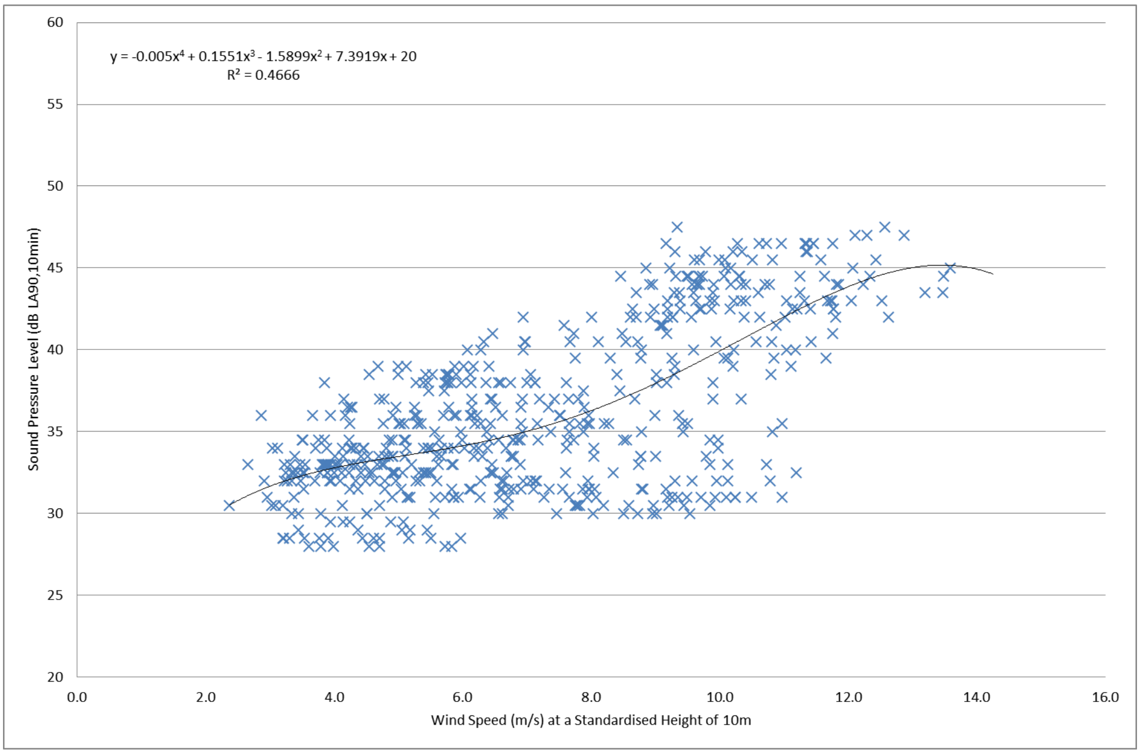

Figure 21 Night Time Baseline Noise Levels – NSL4

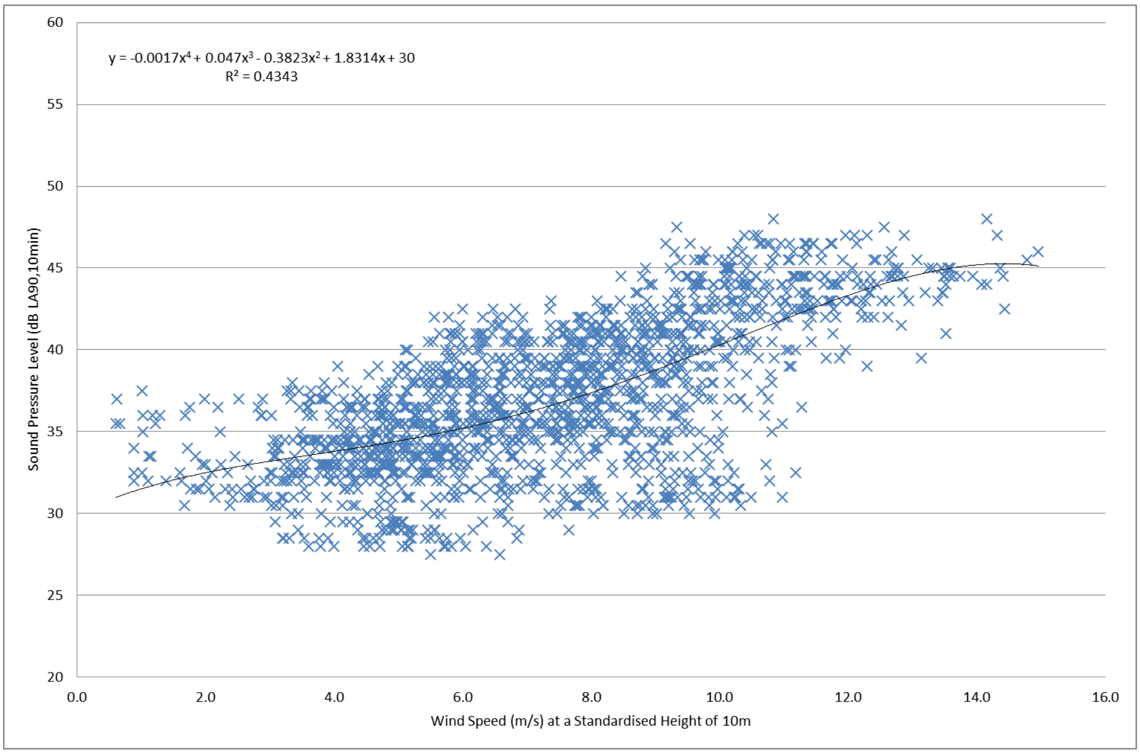

Figure 22 Baseline Noise Levels All periods – NSL4

4.5.5 Location NSL5

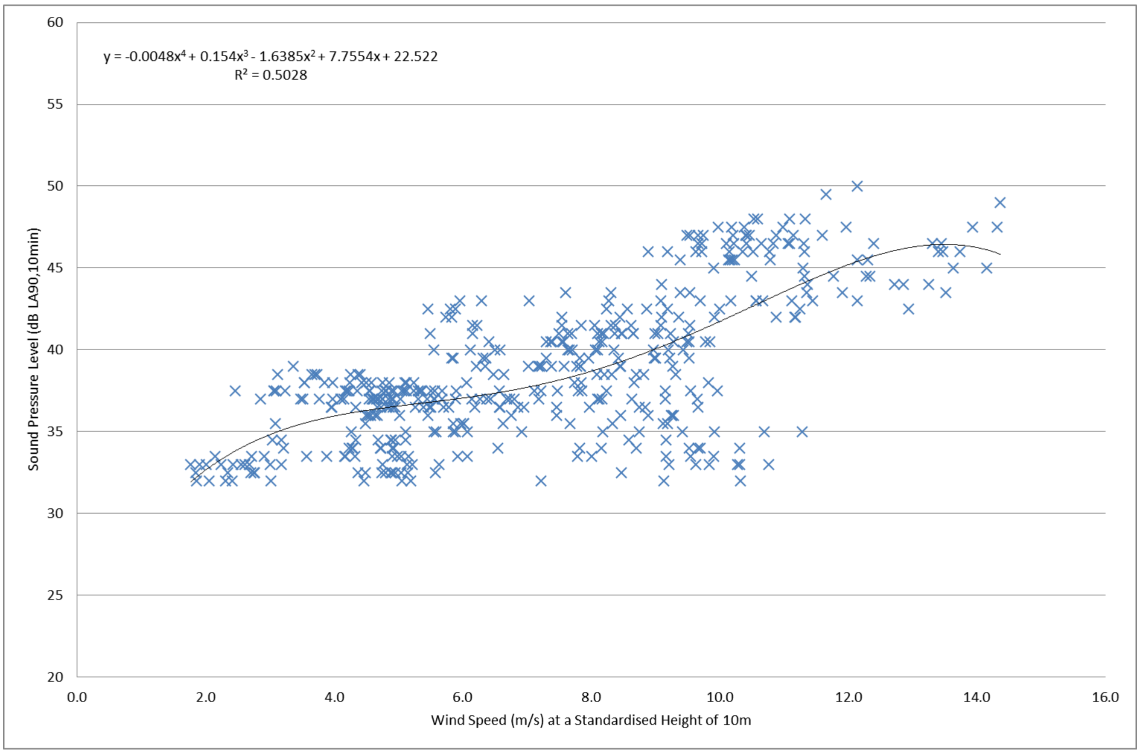

Figure 23 Daytime Baseline Noise Levels – NSL5

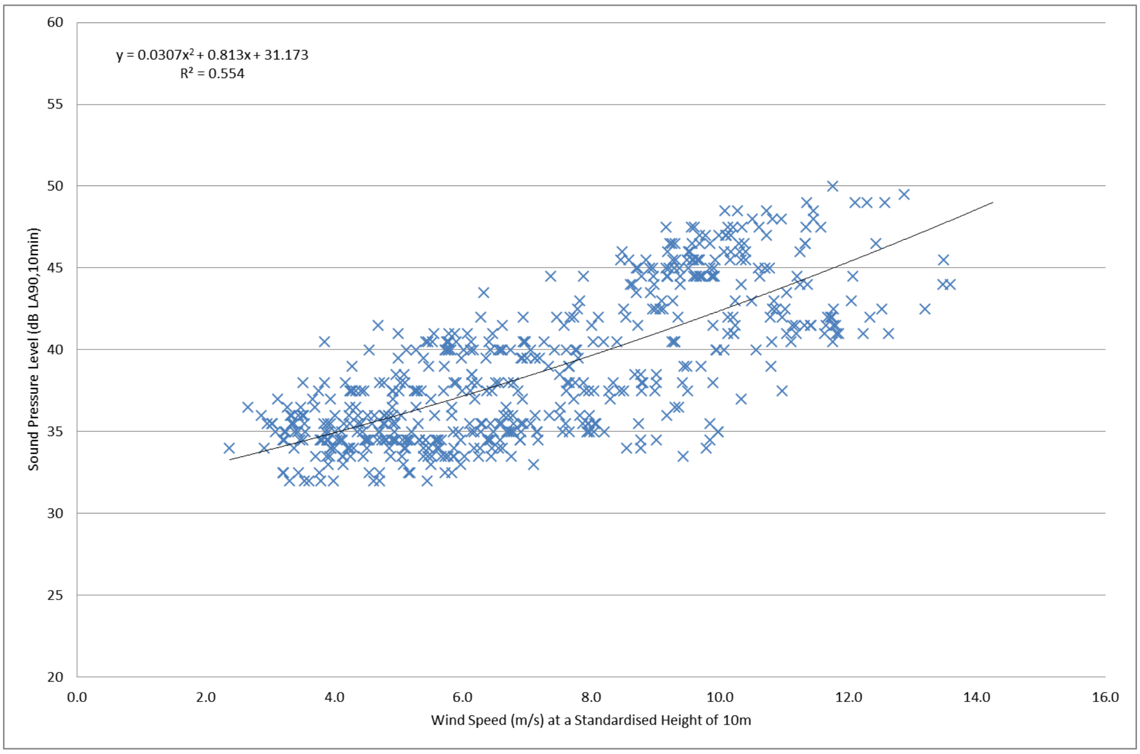

Figure 24 Night Time Baseline Noise Levels – NSL5

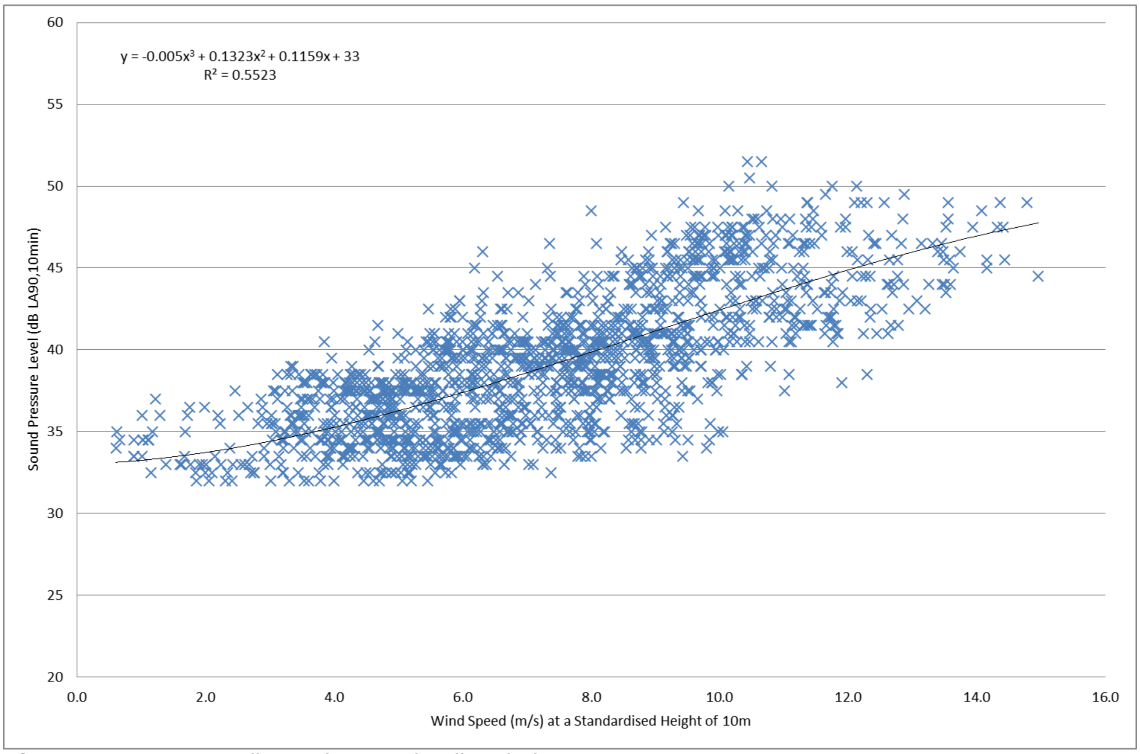

Figure 25 Baseline Noise Levels All periods – NSL5

4.5.6 Location NSL6

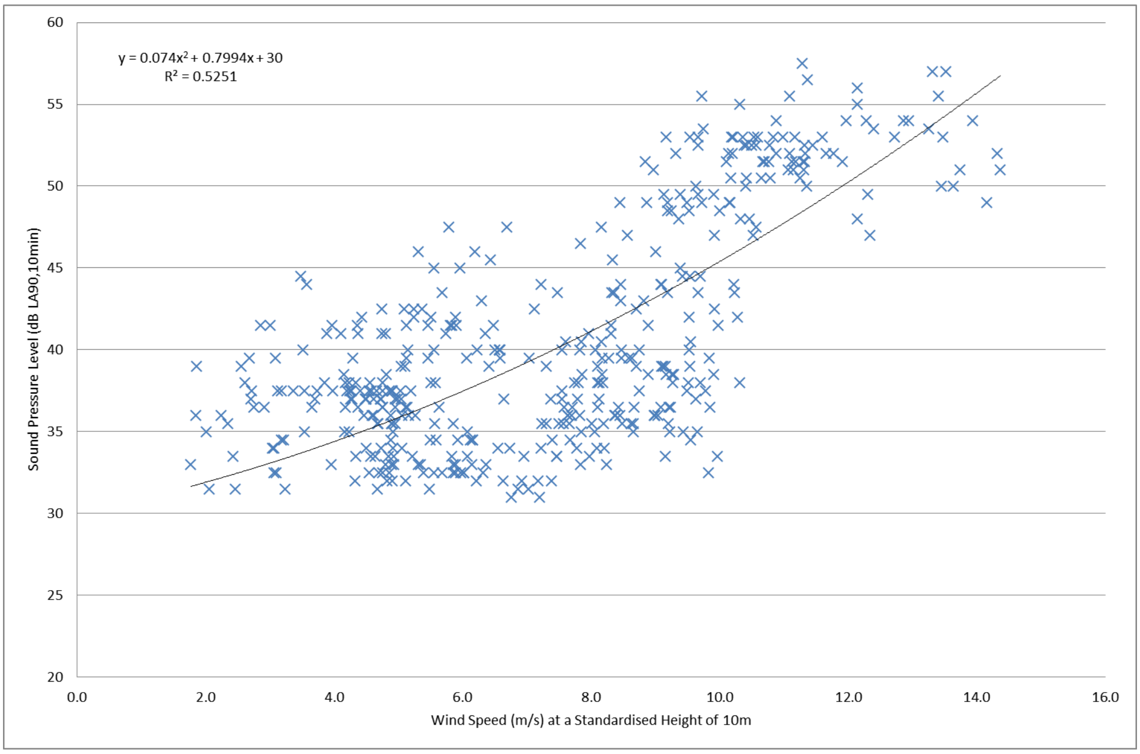

Figure 26 Daytime Baseline Noise Levels – NSL6

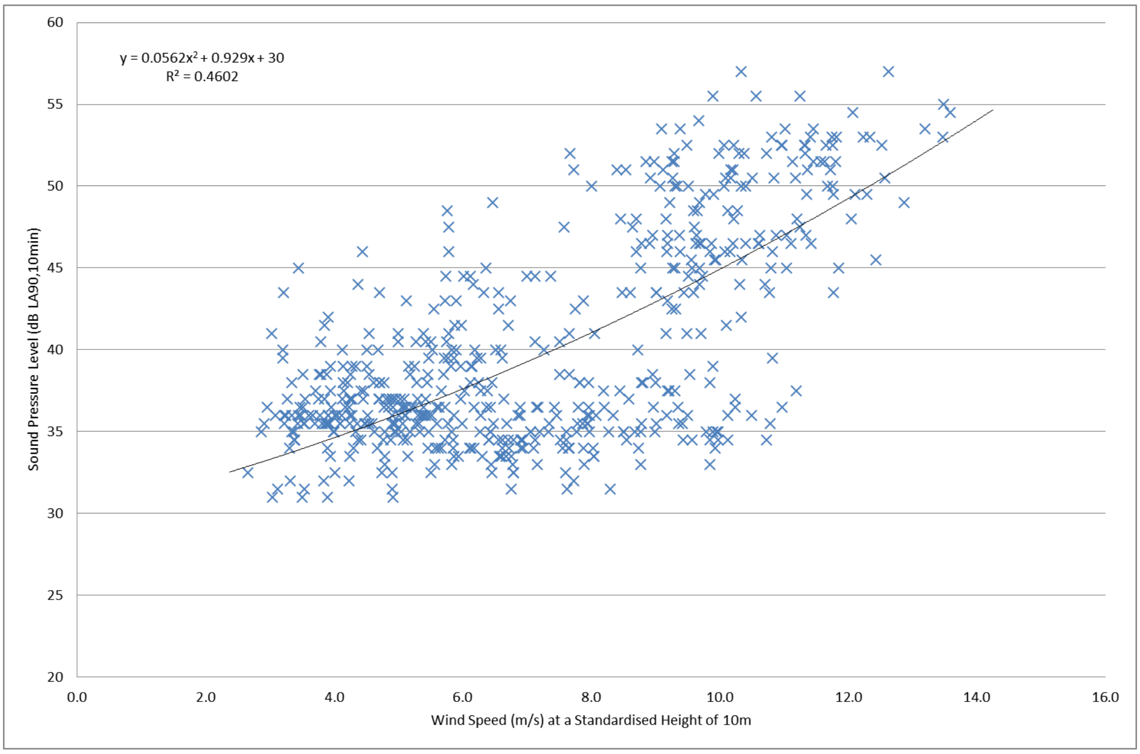

Figure 27 Night Time Baseline Noise Levels – NSL6

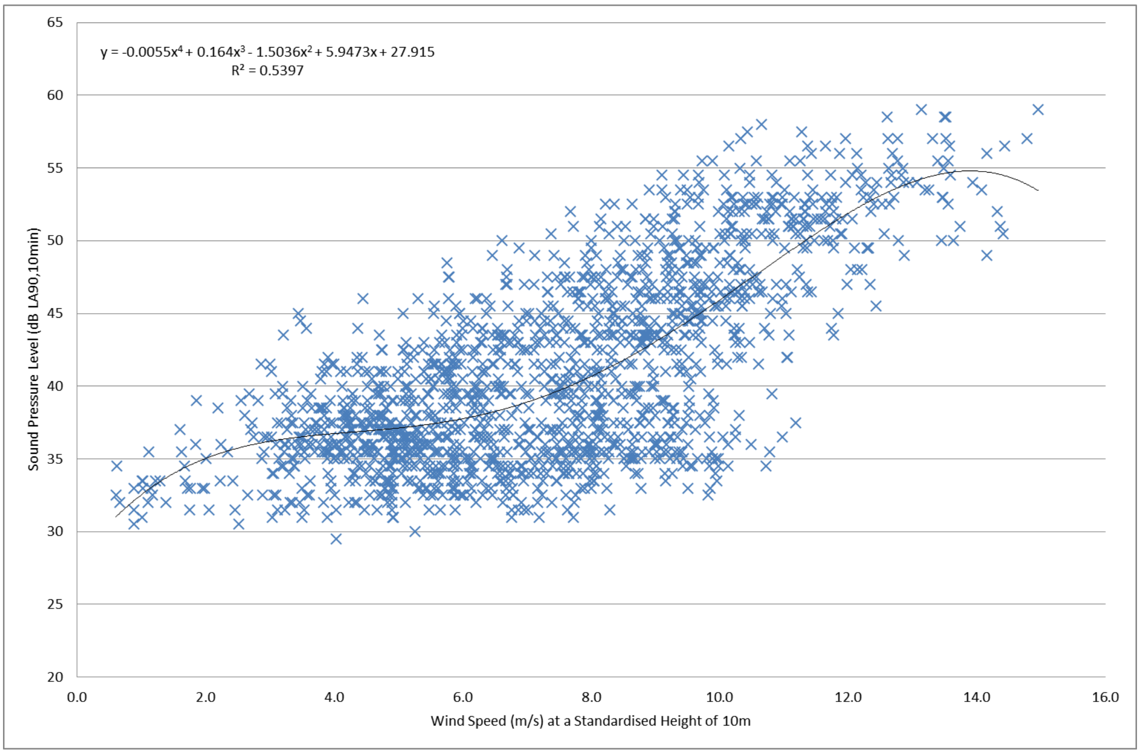

Figure 28 Baseline Noise Levels All periods – NSL6

4.5 Noise from Existing Wind Turbines

It was noted during installation and retrieval of equipment that a number of existing wind turbines are situated within the study area. Whilst noise from existing windfarms was only noted at one location (NSL2) review of maps provided by ESB has identified three locations where noise from existing turbines could have potentially influenced the baseline noise measurements. The locations of concern are NSL2, NSL3 and NSL4,

Figure 29 shows the existing turbines in respect of the noise monitoring locations and proposed development boundary. Existing wind turbines are identified by the red dots outside of the site boundary red line.

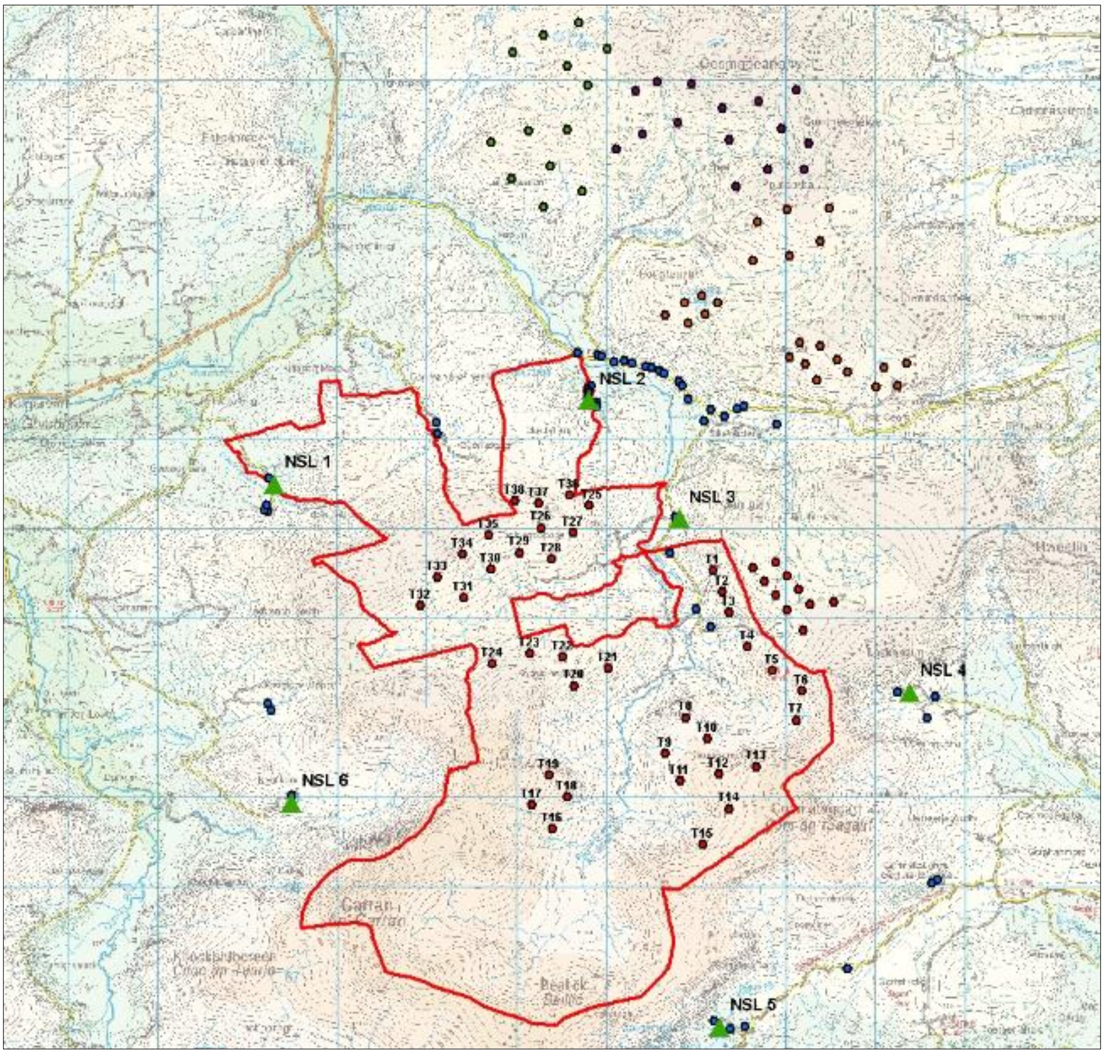

Figure 29 Existing Wind Turbines and Site Context

Any influence of noise from existing turbines in the baseline noise measurements needs to be addressed and corrected for where necessary.

4.5.1 <u>Best Practice Guidance</u>

For guidance, reference has been made to the IOA Good Practice document (IOA's GPG)[4]. This document provides various methods for the derivation of suitable background noise levels where the proposed wind farm is within an area acoustically affected by an already operational wind farm.

The approach adopted here is to apply wind directional filtering to the measured data in order to assess background noise data when it is not influenced by the existing turbines e.g. upwind of the receptor.

4 A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Nosie

4.5.2 Existing Turbines

The upwind direction of the existing wind turbines has been identified from OS maps issued by ESB and sent to AWN on 29 June 2015. Table 4 presents the details of the upwind directional filters applied to each of the following noise monitoring locations.

Location	Upwind Direction to Operational turbines (Degrees)
NSL 2	200 - 250
NSL 3	290 - 340
NSL 4	140 – 225Note 1

Table 4 Upwind Direction to Existing Wind Turbines

Note 1: The aperture of the filter has been expanded In order to obtain the required data set.

4.5.3 Results of Upwind Assessment

Regression analysis curves have been developed for the three locations discussed above and are presented in Figures 30 to 32. For the analysis on which the results are based the following is noted:

- Data samples affected by rain or following periods of heavy rainfall have been removed;
- data samples identified as atypical have been removed, and;
- the wind directional filters identified in Table 4 have been applied to the data sets.

With the exception of the above, all data samples measured during all other periods have been included in these results.

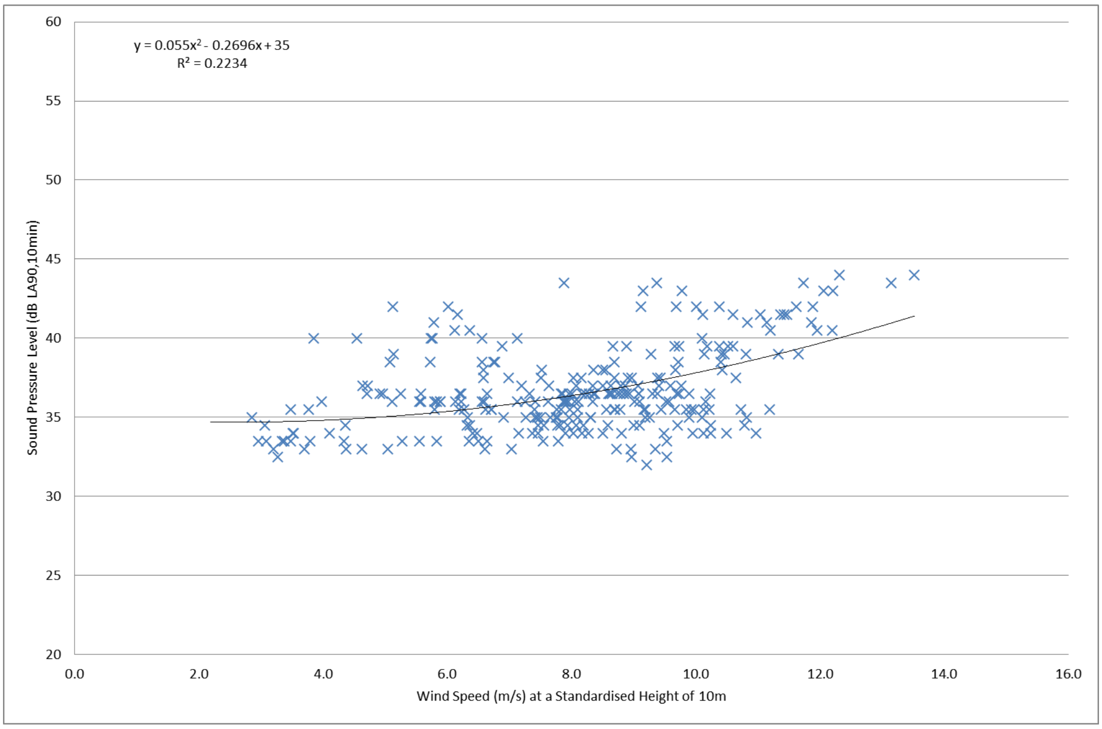

Figure 30 Filtered Baseline Noise Levels – NSL2

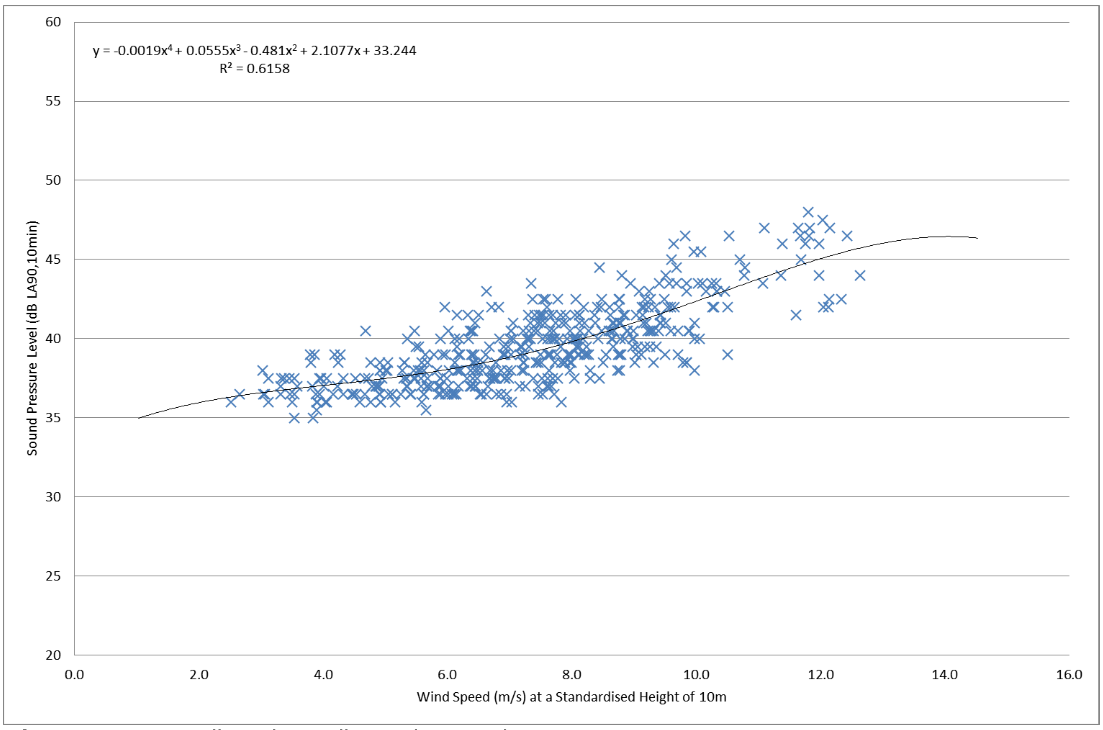

Figure 31 Filtered Baseline Noise Levels – NSL3

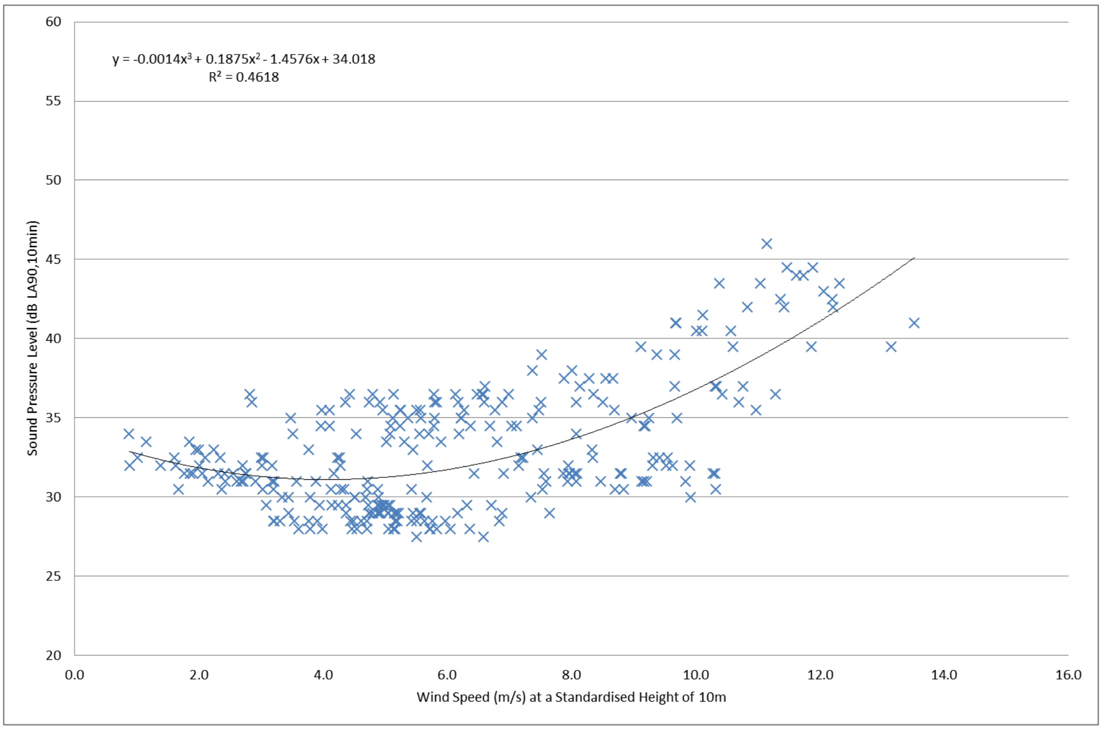

Figure 32 Filtered Baseline Noise Levels – NSL4

4.5.4 Summary of Upwind Assessment

Table 5 presents the average $L_{AF90,10min}$ noise levels measured at each location for ‘quiet periods’, night time periods, all periods and all periods upwind of existing turbines. The levels have been determined through regression analysis carried out on the data sets in line with best practice guidance.

Location	Period	Derived $L_{A90,10min}$ Levels (dB) at various derived 10m height Wind Speeds (m/s)									
		3	4	5	6	7	8	9	10	11	12
NSL 2	Day	34.9	35.8	36.7	37.6	38.5	39.4	40.2	41.1	41.9	42.7
	Night	34.3	35.0	35.7	36.5	37.3	38.2	38.9	39.6	40.2	40.7
	All	35.1	35.8	36.5	37.3	38.1	38.8	39.6	40.4	41.1	41.7
	All Upwind	34.7	34.8	35.0	35.4	35.8	36.4	37.0	37.8	38.7	39.7
NSL 3	Day	34.6	35.8	37.0	38.0	39.0	39.9	40.7	41.5	42.3	43.1
	Night	34.6	35.7	36.7	37.7	38.6	39.5	40.3	41.0	41.7	42.4
	All	35.8	36.6	37.2	37.8	38.6	39.4	40.3	41.2	42.0	42.5
	All Upwind	36.6	37.0	37.5	38.1	38.9	40.0	41.2	42.7	44.3	45.8
NSL 4	Day	32.5	33.3	33.8	34.5	35.4	36.7	38.4	40.4	42.4	44.4
	Night	31.6	32.8	33.5	34.1	35.0	36.3	38.0	40.0	42.2	44.1
	All	33.2	33.8	34.4	35.2	36.1	37.3	38.6	40.1	41.6	42.9
	All Upwind	31.1	31.1	31.2	31.7	32.5	33.6	35.1	36.8	38.8	41.1

Table 5 Average $L_{A90,10mins}$ Noise Levels at Various Wins Speeds

Following review of the noise levels presented in Table 5, it is noted that the directional filtered noise levels at locations NSL 2 and NSL 4 are generally lower than the unfiltered data sets however for NSL 3 the directional filtered samples were higher. There are a number of possible reasons for this, mainly, other noise sources in the area, the degree of contributing noise from existing wind turbines and furthermore the operational status of these turbines during the survey period is not known. It is recommended that the results of the upwind assessment for NSL 3 are disregarded as there is no evidence that noise from existing wind turbines has impacted on the measured baseline noise levels.

4.6 Summary

Table 6 presents the average $L_{AF90,10min}$ noise levels measured at each location for 'quiet periods' of the daytime (as described in Section 4.4), night time and all data measured during the survey (with the exception of samples affected by rainfall or samples identified as atypical for the location). The levels have been determined through regression analysis carried out on the data sets in line with best practice guidance.

Location	Period	Derived $L_{A90,10min}$ Levels (dB) at various derived 10m height Wind Speeds (m/s)									
		3	4	5	6	7	8	9	10	11	12
NSL 1	Day	38.1	38.6	39.1	39.6	40.2	40.8	41.6	42.5	43.6	45.0
	Night	37.9	38.4	38.9	39.6	40.3	41.1	42.0	42.9	44.0	45.1
	All	38.3	38.8	39.4	40.0	40.6	41.3	42.0	42.8	43.7	44.5
NSL 2	Day	34.9	35.8	36.7	37.6	38.5	39.4	40.2	41.1	41.9	42.7
	Night	34.3	35.0	35.7	36.5	37.3	38.2	38.9	39.6	40.2	40.7
	All	35.1	35.8	36.5	37.3	38.1	38.8	39.6	40.4	41.1	41.7
	Upwind	34.7	34.8	35.0	35.4	35.8	36.4	37.0	37.8	38.7	39.7
NSL 3	Day	34.6	35.8	37.0	38.0	39.0	39.9	40.7	41.5	42.3	43.1
	Night	34.6	35.7	36.7	37.7	38.6	39.5	40.3	41.0	41.7	42.4
	All	35.8	36.6	37.2	37.8	38.6	39.4	40.3	41.2	42.0	42.5
NSL 4	Day	32.5	33.3	33.8	34.5	35.4	36.7	38.4	40.4	42.4	44.4
	Night	31.6	32.8	33.5	34.1	35.0	36.3	38.0	40.0	42.2	44.1
	All	33.2	33.8	34.4	35.2	36.1	37.3	38.6	40.1	41.6	42.9
	Upwind	31.1	31.1	31.2	31.7	32.5	33.6	35.1	36.8	38.8	41.1
NSL 5	Day	34.8	36.0	36.6	37.1	37.8	38.9	40.4	42.2	44.3	46.2
	Night	33.9	34.9	36.0	37.2	38.4	39.6	41.0	42.4	43.8	45.3
	All	34.4	35.3	36.3	37.4	38.6	39.8	41.1	42.4	43.6	44.8
NSL 6	Day	33.1	34.4	35.8	37.5	39.2	41.1	43.2	45.4	47.7	50.2
	Night	33.3	34.6	36.1	37.6	39.3	41.0	42.9	44.9	47.0	49.2
	All	36.2	36.7	37.1	37.8	38.9	40.7	43.1	46.0	49.2	52.1

Table 6 Derived Levels of $L_{AF90, 10 min}$ for Various Wind Speeds

5.0 DERIVATION OF NOISE CRITERIA CURVES

5.1 Best Practice Guidance

The following sections review the best practice guidance that is commonly adopted in relation to developments such as the one under consideration here.

The noise assessment summarised in the following sections has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document "*Planning Guidelines on Wind Energy*" published by the Department of the Environment, Heritage and Local Government. These guidelines are in turn based on detailed recommendations set out in the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication "*The Assessment and Rating of Noise from Wind Farms*" (1996). The ETSU document has been used to supplement the guidance contained within the "*Planning Guidelines on Wind Energy*" publication where necessary.

5.2 Planning Guidelines on Wind Energy

Section 5.6 of the "*Planning Guidelines on Wind Energy"* published by the Department of the Environment, Heritage and Local Government outlines the appropriate noise criteria in relation wind farm developments.

The following extracts from this document should be considered:

> *"An appropriate balance must be achieved between power generation and noise impact."*

While this comment is noted it should be stated that the *Planning Guidelines on Wind Energy* gives no specific advice in relation to what constitutes an '*appropriate balance*'.

In the absence of this guidance will be taken from alternative and appropriate publications.

> *"In the case of wind energy development, a noise sensitive location includes any occupied house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational importance. Noise limits should apply only to those areas frequently used for relaxation of activities for which a quiet environment is highly desirable. Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."*

As can be seen from the calculations presented later in this document the various issues identified in this extract have been incorporated into our assessment.

> *"Any existing turbines should not be considered as part of the prevailing background noise."*

> *"In general, a lower fixed limit of 45dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours."*

This represents the commonly adopted daytime noise criterion curve in relation to wind farm developments. However, an important caveat should be noted as detailed in the following extract.

> *"However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global developments. Instead, in low noise environments where background noise is less than 30dB(A), it is recommended that the daytime level of the $L_{A90, 10min}$ of the wind energy development be limited to an absolute level within the range of 35 – 40dB(A)"*

In relation to night-time periods the following guidance is given:

> *"A fixed limit of 43dB(A) will protect sleep inside properties during the night."*

Note again this limit is defined in terms of the $L_{A90,10min}$ parameter. This represents the commonly adopted night time noise criterion curve in relation to wind farm developments. The above guidelines are summarised as follows:

- 35 to 40dB $L_{A90,10min}$ for quiet daytime environments of less than 30dB $L_{A90,10min}$;
- 45dB $L_{A90,10min}$ for daytime environments greater than 30 dB $L_{A90,10min}$, or; a maximum increase of 5dB(A) above background noise;
- 43dB $L_{A90,10min}$ fixed limit for night time;
- These are outdoor noise limits, which should not be exceeded at noise sensitive properties.

5.3 Adopted Criteria

In order to provide a robust approach for the proposed development, and with consideration of relevant local and international guidance, the following turbine noise criteria are proposed:

- 40dB $L_{A90,10min}$ for quiet daytime environments of less than 30dB $L_{A90,10min}$
- 45dB $L_{A90,10min}$ for daytime environments of greater than 30dB $L_{A90,10min}$ or a maximum increase of 5dB(A) above background noise (whichever is higher), and;
- 43dB $L_{A90,10min}$ for night time periods.

5.4 Noise Criteria Curves

Based on the adopted criteria and statistical analysis of the baseline noise level information, day and night time noise criteria curves have been developed. Table 7 below outlines the derived noise criteria curves based on an envelopment assessment of the information contained within Table 6. The envelope assessment takes the lowest measured noise level in each wind speed from the day night and upwind filtered data for each of the measurement locations. This approach is considered robust and in line with best practice guidance.

Location	Period	$L_{A90, 10 min}$ Turbine Noise Criteria Values (dB) at 10m Height Wind Speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
NSL 1	All (Baseline Assessment Envelope)	37.9	38.4	38.9	39.6	40.2	40.8	41.6	42.5	43.6	44.5
	Day Criteria	45.0	45.0	45.0	45.0	45.2	45.8	46.6	47.5	48.6	49.5
	Night Criteria	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 2	All (Baseline Assessment Envelope)	34.3	34.8	35	35.4	35.8	36.4	37	37.8	38.7	39.7
	Day Criteria	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
	Night Criteria	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 3	All (Baseline Assessment Envelope)	34.6	35.7	36.7	37.7	38.6	39.4	40.3	41.0	41.7	42.4
	Day Criteria	45.0	45.0	45.0	45.0	45.0	45.0	45.3	46.0	46.7	47.4
	Night Criteria	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 4	All (Baseline Assessment Envelope)	31.1	31.1	31.2	31.7	32.5	33.6	35.1	36.8	38.8	41.1
	Day Criteria	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1
	Night Criteria	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 5	All (Baseline Assessment Envelope)	33.9	34.9	36	37.1	37.8	38.9	40.4	42.2	43.6	44.8
	Day Criteria	45.0	45.0	45.0	45.0	45.0	45.0	45.4	47.2	48.6	49.8
	Night Criteria	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NSL 6	All (Baseline Assessment Envelope)	33.1	34.6	35.8	37.5	38.9	40.7	42.9	44.9	47.0	49.2
	Day Criteria	45.0	45.0	45.0	45.0	45.0	45.7	47.9	49.9	52.0	54.2
	Night Criteria	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Table 7 Derived Noise Criteria Curves and Assessment Envelope

6.0 ADDITIONAL INFORMATION

The following section provides additional information and details of the various noise sources that where noted on site and identifies any issues that should be considered when reviewing the data presented in this report.

6.1 Description of Noise Climate

6.1.1 <u>NSL 1</u>

The noise monitor was location approximately 30 metres southeast of the house to minimise the influence of noise from the nearby stream and from a boiler flue at the house which were both audible. The noise from of the nearby stream was prominent in the area, it should be noted that the level of noise from the stream may vary depending on the time of year and levels of rainfall.

6.1.2 <u>NSL 2</u>

The noise monitor was located on a hill just to the back of the house. The house is located in an area where there is a concentration of farm yards and dwellings. Turbine noise from the wind farm located to the northeast was just audible at this location.

6.1.3 NSL 3

The noise meter was located at the side of the house. To the back of the house were two fields that contained hens and sheep and across the road was a carpentry workshop. Noise from a nearby watercourse was noted on collection of the equipment.

6.1.4 NSL 4

The noise meter was located approximately 120 metres from the house in order to secure it from the sheep in the area. The noise climate at this location was noted to be the same as that at the house. The area is surround by steep hills to the north south and west.

6.1.5 NSL 5

The noise meter was located in a field close to the house. The noise levels in the area were noted to be quiet, some light construction work was audible from the village approximately 550 metres to the south. The house is situated at the foot of a steep hill located to the north. On collection it was noted that noise from streams and watercourses were audible.

6.1.6 NSL 6

The noise meter was located in a field close to the house. The location is situation on the side of a valley. It was noted that the wind conditions here were stronger than at the other locations during installation. Wind generated noise from the tress in the area was noted to be significant.

6.2 Weather Conditions

Given the mountainous terrain of the site, the influence of noise from streams and rivers following period of heavy rainfall was noted to be significant. It was also noted that subjectively the wind speeds conditions varied across the site at the various receptor locations, this is most likely due to the mountainous topography of the area.

Following a review of the wind conditions encountered during the survey period (see Figure 10), there was virtually no data for the easterly wind direction during the survey period. Whilst this generally doesn't a present issues for the baseline noise monitoring, this issue should be given due consideration at the assessment of likely impacts from the wind farm and at the commissioning stage i.e. if the topography of the area around the receptors is found to offer significant shelter to winds from an easterly direction.

APPENDIX A
Glossary of Terminology

A variety of acoustic parameters and terminology are used throughout this report. Significant definitions are identified in this appendix in order to inform the reader.

A – Weighting	The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing.
Background Noise	The ambient noise level already present within the environment in the absence of the wind farm operation. The $L_{A90\ (10\ minutes)}$ is the parameter that is used to define the background noise level in this instance. L_{A90} is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise. See Section 5.0 for a detailed review of the background noise surveys carried out as part of this assessment.
Daytime	Defined as 07:00 to 23:00hrs.
dB (decibel)	The scale in which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the RMS pressure of the sound field and the reference pressure of 20 micro-pascals (20 μPa).
dB(A)	An 'A-weighted decibel' – a measure of the overall noise level of sound across the audible frequency range (20 Hz – 20 kHz) with A-frequency weighting (i.e. A – Weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
Hub Height Wind Speed	The wind speed at the centre of the turbine rotor.
Night-time	Defined as 23:00 to 07:00hrs.
Noise	Noise is the term often used to describe unwanted sound (i.e. sound that annoys, interferes with activities or damages hearing). It is also used to describe a combination of sounds which vary randomly with time and which cover a wide frequency range.
Noise Sensitive Location	Any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels.
Pascal (Pa)	Pascal is a unit of pressure and so sound pressures are measured in Pascals.

APPENDIX A
Glossary of Terminology (Continued)

Sound Power Level (L_W)

The sound power level of an item is defined as:

$$L_p = 10 \times \log_{10}(W/W_o) \text{ dB.}$$

Where:

W is the acoustic power of the source in Watts (W)
W_o is a reference sound power chosen in air to be 10^{-12}W.

Sound Pressure Level (L_p)

The sound pressure level at a point is defined as:

$$L_p = 20 \times \log_{10}(P/P_o) \text{ dB.}$$

Where:

P is the sound pressure;
P_o is a reference pressure for propagation of sound in air and has a value of 2×10^{-5}Pa.

10 Minute Wind Speed (m/s)

The wind speed measured by a calibrated cup anemometer at a specified height above ground level, averaged over a 10 minute period.

APPENDIX B
Calibration Certificates

B.1 Brüel & Kjær 2238 Serial Number 2638294

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Certificate Number: 01696/4 Date of Issue: 27 February 2014

VERIFICATION OF A TYPE 1 SOUND LEVEL METER to BS7580 Part 1

FOR:	AWN Consulting Limited The Tecpro Building Clonshaugh Business and Technology Park Dublin 17
FOR THE ATTENTION OF:	Ronan Murphy
CALIBRATION DATE:	27 February 2014
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter							
Manu:	Bruel & Kjaer	Model:	2238	Serial No:	2638294		
Microphone							
Manu:	Bruel & Kjaer	Model:	4188	Serial No:	2580720		
Preamp							
Manu:	Bruel & Kjaer	Model:	ZC 0030	Serial No:	4961		
Associated Calibrator							
Manu:	Bruel & Kjaer	Model:	4231	Serial No:	2205805	Adaptor:	UC0210

Test Engineer (initial): ____ Name: Gary Phillips

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FOR THE ATTENTION OF:	Ronan Murphy
CALIBRATION DATE:	23 January 2014
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter
Manu: Bruel & Kjaer Model: 2238 Serial No: 2654428

Microphone
Manu: Bruel & Kjaer Model: 4188 Serial No: 2008312

Preamp
Manu: Bruel & Kjaer Model: ZC 0030 Serial No: 4227

Associated Calibrator
Manu: Bruel & Kjaer Model: 4231 Serial No: 2205805 Adaptor: UC0210

Test Engineer (initial): GP Name: Gary Phillips

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Certificate Number: 01520/3 Date of Issue: 11 November 2013

VERIFICATION OF A TYPE 1 SOUND LEVEL METER to BS7580 Part 1

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FOR THE ATTENTION OF:	JAMES MANGAN
CALIBRATION DATE:	11 November 2013
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter								
Manu:	Bruel & Kjaer	Model:	2238	Serial No:	2684495			
Microphone								
Manu:	Bruel & Kjaer	Model:	4188	Serial No:	2599947			
Preamp								
Manu:	Bruel & Kjaer	Model:	ZC 0030	Serial No:	4191			
Associated Calibrator								
Manu:	Bruel & Kjaer	Model:	4231	Serial No:	2394086	Adaptor: UC0210		

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Certificate Number: 02026/3 Date of Issue: 23 October 2014

VERIFICATION OF A TYPE 1 SOUND LEVEL METER to BS7580 Part 1

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FOR THE ATTENTION OF:	Ronan Murphy
CALIBRATION DATE:	23/10/2014
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter						
Manu:	Bruel & Kjaer	Model:	2238	Serial No:	2638292	
Microphone						
Manu:	Bruel & Kjaer	Model:	4188	Serial No:	2580720	
Preamp						
Manu:	Bruel & Kjaer	Model:	ZC 0030	Serial No:	2378	
Associated Calibrator						
Manu:	Bruel & Kjaer	Model:	4231	Serial No:	2394086	Adaptor: UC0210

Test Engineer (initial): GP Name: Gary Phillips

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Certificate Number: 01629/2 Date of Issue: 8 January 2014

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FOR:	AWN Consulting Limited The Tecpro Building Clonshaugh Business and Technology Park Dublin 17
FOR THE ATTENTION OF:	Ronan Murphy
CALIBRATION DATE:	8 January 2014
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter								
Manu:	Bruel & Kjaer	Model:	2238	Serial No:	2562663			
Microphone								
Manu:	Bruel & Kjaer	Model:	4188	Serial No:	2555333			
Preamp								
Manu:	Bruel & Kjaer	Model:	ZC 0030	Serial No:	3489			
Associated Calibrator								
Manu:	Bruel & Kjaer	Model:	4231	Serial No:	2205805	Adaptor: UC0210		

Test Engineer (initial): ______ Name: Gary Phillips