10 NOISE AND VIBRATION

10.1 INTRODUCTION

This chapter of the Environmental Impact Assessment Report (EIAR) describes the potential noise and vibration impact from the proposed Carrownagowan wind farm project. The overall project is described in Chapters 1 and 2 and a detailed description of the project, including the proposed development is provided in **Chapter 2** of this EIAR.

Once operational there will be noise from the wind turbines and associated substation. There will be noise from plant and machinery during the construction phase of the project. No significant noise effects are expected from the replacement forestry lands and it is anticipated that planting will be carried out manually. The noise associated with felling is typical of forestry operations and carried out in accordance with Forest Service Guidance the felling licence approval. The replacement forestry lands are therefore scoped out from further assessment in this chapter.

Noise and vibration assessments were undertaken for the construction, operational and decommissioning phases of the proposed development and the grid route. It is worth noting that construction noise from the wind farm itself is the worst case scenario for the construction of the project as the works along the grid route and turbine delivery route are of a much less scale and duration. Accordingly, the noise sensitive receptors relate to the construction and operation of the wind turbines.

10.1.1 Noise Emissions from a Wind Farm Development

The main sources of noise from a wind turbine include aerodynamic noise (rotating blades in the air) and mechanical noise (gearbox (if not a direct drive system) and generator).

Noise only occurs above the 'cut-in' wind speed and below the 'cut-out' wind speed. The typical 'cut in' wind speed of a modern turbine is 3 meters per second (m/s) and the 'cut-out' wind speed is approximately 25 to 30 m/s.

There are currently several candidate turbines being considered for the site. To allow maximum flexibility in turbine selection, the loudest turbine currently under consideration, the Nordex N133 4.8 MW, has been modelled in the proceeding analyses to enable a worst case assessment. This turbine is a pitch regulated upwind turbine. Ultimately, the most appropriate turbine model and operating modes will be selected in order to achieve the noise limits set down in the current DoEHLG *Wind Energy Development Guidelines*, 2006 or imposed by way of planning condition. The chosen turbine will comply with the parameters assessed.

Construction noise will occur during excavation and earth moving, laying of roads and hard standings, transportation of materials and erection of the wind turbines. The construction phase will be phased and temporary. The decommissioning phase works will be similar in magnitude to the construction phase.

10.1.1.1 Note on the 2019 Draft Wind Energy Development Guidelines

It is acknowledged that the 2006 Wind Energy Development Guidelines are currently being revised. A draft version of the replacement Wind Energy Development Guidelines (WEDG) was published in December 2019. At the time of writing this chapter, submissions were being received on the draft document. There is no timeline on the publication of the finalised document and at the time of writing, the 2006 Guidelines were in force until the new WEDGs are published in final form. As the 2019 Draft WEDGs have undergone further consultation and have yet to be finalised, they are subject to further change.

In anticipation of the final version of the WEDGs being published during the planning stage of this Wind Farm development, a 1 kilometre separation distance between turbines and dwellings was integral to the design of the wind farm. Such a separation distance in combination with the most appropriate turbine operating in the most appropriate noise mode, will allow the wind farm if granted permission to meet whatever WEDGs are in force at the time of grant.

The noise limits set out in the 2006 guidelines are currently the guidelines which An Bord Pleanala must have regard to and which are adopted by the expert community when assessing the potential impact from wind farm noise. However, the methodology set out in the Good Practice Guide (GPG) to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (Institute of Acoustics, 2013) is recognised as the best way (it is tried and tested since 2013) to apply the noise limit criteria set out in the DOEHLG wind energy planning guidelines 2006.

10.1.2 Fundamentals of Noise

Fundamentally, noise is vibrations of the air which are detectable by the ear. Sound waves radiate out spherically from a sound source in three dimensions.

The human ear can detect a very wide range of pressure variations. In order to cope with this wide range, a logarithmic scale (decibel (dB) scale) is used to translate pressure values into manageable numbers from 0dB to 140 dB. 0 dB is the threshold of hearing and 120 dB is the threshold of pain.

Measuring in decibels means that a 3 dB increase is equivalent to a doubling of the sound energy and a 10 dB increase in a tenfold increase in energy. For broadband sounds which are very similar in all but magnitude, a change or difference in noise level of 1 dB is just perceptible under laboratory conditions, 3 dB is perceptible under most normal conditions and a 10 dB increase generally appears twice as loud.

A healthy human ear is also sensitive to a large range of frequencies (approximately 20 Hz to 20,000 Hz) and varies in sensitivity depending on the frequency.

The human ear is not equally sensitive to sound at all frequencies and is less sensitive to sound at low frequencies and high frequencies. A -weighting (dB A) is the main way of adjusting measured sound pressure levels (noise) to take account of the uneven human response to frequencies.

Figure 10.1 illustrates some everyday sounds on the dB(A) scale. A quiet bedroom is around 35 dB(A), a busy office around 60dB(A) and a rock concert around 100 dB(A). The illustration is extracted from draft Wind Energy Development Guidelines 2019.

Figure 10-1 The Level of Typical Common Sounds on the dB(A) Scale

10.1.3 Scope of assessment

The scope of the assessment has been defined by industry standard best practice and guidance **(section 10.1.4.1**) used in Ireland. In general, this includes:

- Establishing the existing or baseline noise conditions at representative noise sensitive receptors in this case, residential dwellings.
- Establishing noise limits based on the measured baseline noise levels in accordance with best practice and guidance.
- Using computer software, predict the noise emissions from the proposed wind farm and associated infrastructure at the noise sensitive receptors.
- Comparing the wind farm noise emissions against the noise limit criteria. The predicted wind farm noise emissions must not exceed the noise limit criteria.

10.1.4 Methodology

In general, the methodology used to assess the noise impact from Wind Farms includes extended measurements of the existing background noise levels (across a range of wind speeds) at nearby representative dwellings and comparisons against the predicted noise output from the wind farm, which also varies with wind speed. The methodology and planning guidance framework are described in the following sections.

10.1.4.1 Operational Wind Farm Noise Policy and Guidance

As with any development a balance must be struck between the noise restrictions placed on a wind farm, the protection of amenity and the national and global benefits of renewable energy development. The guidance documents used in the preparation of this chapter represent best practice in assessing wind farm noise and are outlined as follows:

Department of the Environment, Heritage, and Local Government (DoEHLG) – Wind Energy Development Guidelines (2006)

This document provides the framework for wind farm noise assessment in Ireland. The noise limit thresholds in this publication are those currently endorsed by the Irish Government and deemed to strike the balance between the protection of residential amenity and renewable energy developments. These guidelines remain in force until the final version of the replacement WEDGs is published.

Information Note Review of the Wind Energy Development Guidelines 2006 "Preferred Draft Approach" 2017

Following detailed engagement between the Department of Housing, Planning, Community and Local Government (DHPCLG) and the Department of Communications, Climate Action and Environment (DCCAE), an emerging "preferred draft approach" to the Review of the 2006 Wind Energy Development Guidelines was jointly announced on 13 June 2017.

The 2017 Information Note, "preferred draft approach" proposes noise restriction limits in broad terms consistent with World Health Organisation standards, proposing a relative rated noise limit of 5dB(A) above existing background noise within the range of 35 to 43dB(A), with 43dB(A) being the maximum noise limit permitted, day or night. The detail surrounding the derivation of the proposed noise limit criteria was not published in this document.

Draft Wind Energy Guidelines 2019

In December 2019, the Draft Wind Energy Guidelines were published in detail. This 2019 Draft document contained significantly more technical detail than was outlined in the 2017 Information Note and included a change in how the noise limit criteria were to be derived. As discussed in the introduction, the core of this assessment is based on the only Irish guidelines currently in force. At this point it is not known what the specific parameters for assessment will be provided in the final version of the revised Wind Energy Guidelines. A large volume of submissions has been received regarding the draft document and due consideration must be given to these submissions.

ETSU-R-97 – The Assessment and Rating of Wind Farm Noise (1997)

The assessment was undertaken with cognisance to ETSU-R-97 – *The Assessment and Rating of Wind Farm Noise* (1997). This document is currently used extensively in the UK and Ireland and the noise levels contained within the DoEHLG *Wind Energy Development Guidelines* 2006 are adapted from this document.

A Good Practice Guide (GPG) to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (Institute of Acoustics, 2013)

This publication which was issued by the Institute of Acoustics in May 2013, is endorsed by the UK, Department of Energy and Climate Change (DECC), the Northern Ireland Executive, the Scottish Executive and the Welsh Assembly and provides guidance on all aspects of the use of ETSU-R-97. The assessment presented herein adopts the recommendations of the GPG.

EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports Draft August 2017

A description and significance of the effects of the proposed development are described in accordance with this document.

EPA Advice Notes for Preparing Environmental Impact Statements, (Draft September 2015)

This chapter has been prepared with cognisance to this document.

10.1.4.2 Construction and Decommissioning Phases Impact Assessment- Best Practice and Guidance

There are no mandatory noise limits for construction noise in Ireland. The most recent revision of *British Standard 5228-1:2009+A1:2014, Code of practice for noise and vibration control on construction and open site* outlines noise thresholds for significant impacts.

The Irish National Roads Authority (NRA) - *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes*, March 2014 was also consulted for noise and vibration related impact nuisance thresholds.

The construction and decommissioning works will be broadly similar. Similar plant and machinery will be involved, the assessment criteria will be the same and both will be temporary impacts of short duration. Therefore, for the purpose of this assessment the conclusions of the construction phase impacts can be assumed for the decommissioning phase.

10.1.4.3 Criteria for Evaluating the Operational Phase Impact from Wind Turbines

Current wind farm noise limit thresholds are described in the Department of Environment Heritage and Local Government (DoEHLG), *Wind Energy Development Guidelines*, 2006.

It recommends that noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed. Wind turbine noise is directly related to wind speed. Therefore, the guidelines are based on the principle that turbine noise should be controlled with reference to fixed limits when background noise is low, or relative to background noise itself as it increases with wind speed, whichever is the greater. The interpretation of these limits is that turbine-attributable noise should be limited to:

- 43 dB $L_{A90\ 10min}$ for night-time hours
- 45 dB $L_{A90\ 10\ min}$ or 5 dB above background noise, whichever is the greater, at the noise sensitive receptor for daytime hours
- 35 to 40 dB $L_{A90\ 10\ min}$ or 5 dB above background noise, whichever is the greater, at the noise sensitive receptor where background noise is less than 30 dB L_{A90}.

For the purpose of this assessment the fixed lower limit has been set at L_{90} 40dB(A). This lower limit value for areas of low background noise is lower than typical noise limits (L_{A90} 43dB or 5 dB above background) set down in recent planning conditions for similar developments. It is also lower than the lower limit value (45dB(A) for daytime in the EPA document 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities' (NG4).

Information Note - Preferred Draft Approach 2017 and Draft 2019 WEDGs

Until the 2019 Document is published in final form, the Board is required to have regard to the 2006 guidelines. Therefore, the assessment criteria in this chapter remains those outlined in the 2006 Guidelines. As the 2019 Draft WEDGs have undergone further consultation and received a large volume of submissions, they are subject to further change

10.1.4.4 Criteria for Evaluating Construction and Decommissioning Noise Effects

There is no statutory guidance in Ireland relating to the maximum noise levels permitted during construction works, and in the absence of statutory guidance or other specific limits prescribed by local authorities, the thresholds outlined in the *British Standard 5228-12009+A1:2009, Code of Practice for Noise and Vibration Control on Construction and Open Sites - Noise* has been adopted in this assessment, as they are recognised by the expert community as the most appropriate in the assessment of construction noise. The noise levels, which are reproduced in **Table 10-1**, are typically deemed acceptable.

Table 10-1: Construction Stage Noise Level Thresholds

Assessment category and threshold value period (T)	Threshold values, L_{AeqT} dB		
	Category A Note A	Category B Note B	Category C Note C
Night-time (23:00 to 07:00hrs)	45	50	55
Evening and Weekends Note D	55	60	65
Daytime (07:00 – 19:00hrs) and Saturdays (07:00 -13:00hrs)	65	70	75

Note A: Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.

Note B: Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.

Note C: Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.

Note D: 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

Given the rural nature of the site, all properties will be afforded a Category A designation. Therefore, if the predicted construction noise exceeds 65dB $L_{Aeq(T)}$ then this is assessed as a significant impact.

10.1.4.5 Criteria for Evaluating Construction and Operational Vibration Effects

Vibration emissions are limited to the construction phase of the grid route and the proposed development. Once operational, there will be no significant vibrations from any element of the development.

According to *NRA's 2014 Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes,* there are two separate considerations for vibration during the construction phase namely 1) that which affects human comfort and 2) that which affects cosmetic or structural damage to buildings.

The guidelines suggest that human tolerance for daytime blasting and piling, two of the primary sources of construction vibration, limits vibration levels to a peak particle velocity (ppv) of 12mm/s and 2.5mm/s respectively. Blasting may be required during this project. In the event that poor ground conditions are encountered during excavation and a significant depth to sub-formation is required, a piled foundation may be considered. A piled foundation requires the use of a piling machine equipped with an auger drill to rotary bore a number of holes around the area of the turbine base to the sub-formation depth determined at construction stage.

To avoid the risk of even cosmetic damage to buildings, the guidelines suggest that vibration levels should be limited to 8mm/s at frequencies of less than 10Hz, to 12.5mm/s for frequencies of 10 to 50Hz, and to 20mm/s at frequencies of 50Hz and above.

10.1.5 Statement on Limitations and Difficulties Encountered

There has been some difficulty surrounding the uncertainty of the assessment criteria. The current 2006 Guidelines remain in force until the revised Guidelines are published in final form.

However, in recognition of the potentially more onerous noise limit criteria, a 1 km setback to dwellings, twice that suggested by the 2006 Guidelines was achieved in the design of the Wind Farm layout. Preliminary modelling undertaken based on an interpretation of the 2017 Information Note (the Information Note lacked any detail) indicates, that should a revised assessment be required, the proposed Wind Farm can operate within the expected noise limit criteria with certain turbines operating in noise reduced modes at certain wind speeds.

The 2019 draft WEDGs suggest potentially higher day time and evening limit criteria, when compared to the 2017 Information Note. However, uncertainty remains surrounding the publication date of the finalised version of the revised Guidelines, its eventual content, and its potential impact on this development.

10.2 EXISTING RECEIVING ENVIRONMENT

This section describes the existing environment in terms of the noise monitoring locations, existing noise sources at these locations and the prevailing background noise levels.

The wind farm is to be developed in a rural area of county Clare, designated for wind farm development. A detailed description of the locality is provided in Chapter 2 of this EIAR. The land use in the immediate area is mainly agricultural and forestry related. This also applies to the works areas of the turbine delivery route.

The main sources of noise in the area include traffic on the local and regional road network, and machinery involved in working agricultural land and forestry. Natural noise sources include wind borne noise in vegetation and water in streams and rivers.

The noise sensitive receptors (NSR's) are dwellings in typical ribbon style development along the local road network. A 1 kilometre (km) set back distance between wind turbines and houses was integral to the design of the wind farm, in recognition of the potential impact of the new noise limit criteria outlined in the 2017 Information Note on the revised 2019 WEDGs.

The following sections describe how the existing pre-development noise environment was measured and characterised.

10.2.1 Noise Sensitive Receptors

At the start of the noise assessment, a preliminary desktop modelling exercise was undertaken using computer software in order to locate noise sensitive receptors (NSR's) which may be affected and to identify suitable locations at which to monitor background noise. The first iteration of the wind turbine layout was input into the software using noise data for the candidate turbine representative of the type that could be installed on the site.

The noise contour plot predicted wind turbine noise levels at the NSR's surrounding the proposed development with predicted turbine noise (measured in dB(A), L_{90}) decreasing with distance from the proposed development. All properties or clusters of properties within or close to the 35dB(A) contour were then identified and assessed to determine which NSR's would provide representative background noise data for others in the area. Irrespective of the 35dB(A) contour noise level predictions for all receptors numbered in **Figure 10-2** were calculated.

In accordance with the Institute of Acoustics Good Practice Guide (IOA GPG), the noise contour plot is based on a noise level at a wind speed of 8 m/s (as standardised to 10m height) as the manufacturer determined that this is the wind speed with the highest predicted noise level for the candidate turbine, namely the Nordex N133 4.8 MW turbine.

The EPA's Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (2016), defines a noise sensitive location as "*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*".

In total, six (6) noise monitoring locations (NML) were selected to characterise the existing noise environment and derive the noise limit criteria for potentially impacted locations. These locations were carefully selected in accordance with guidelines, to characterise the existing local noise environment. A description of the noise monitoring locations is presented in **Table 10-2**.

Table 10-2 Noise Monitoring Locations

NML Number	Receptor	Approximate GPS
NML 1	**H27** and Representative of **H26 and H27**	52.845092 / -8.617051
NML 2	**H28** and Representative of **H28, H30, H31, H32, H37** and **H38**	52.820179 / -8.609577
NML 3	**H34** and Representative of Receptors **H33, H34** and **H35**	52.848880 / -8.597255
NML 4	**H36**	52.851675, -8.593423
NML 5	**H53** and Representative of **H42** to **H55**	52.866065 / -8.561486
NML 6	**H58** and Representative of **H58, H59, H79** and **H80.**	52.863922 / -8.537478

10.2.2 Background Noise Monitoring

Background noise monitoring was undertaken over the period 12th September to 11th October 2018. Details of the exact monitoring periods, the rationale behind the exact kit location and the dominant noise sources observed at each of the Noise Monitoring Locations (NML) were detailed in Field Data Sheets (FDS) attached as **Appendix 10-A**. The FDS describe the position of the noise meter at each location. The relative NML's, dwellings and turbine are illustrated on **Figures 10-2.**

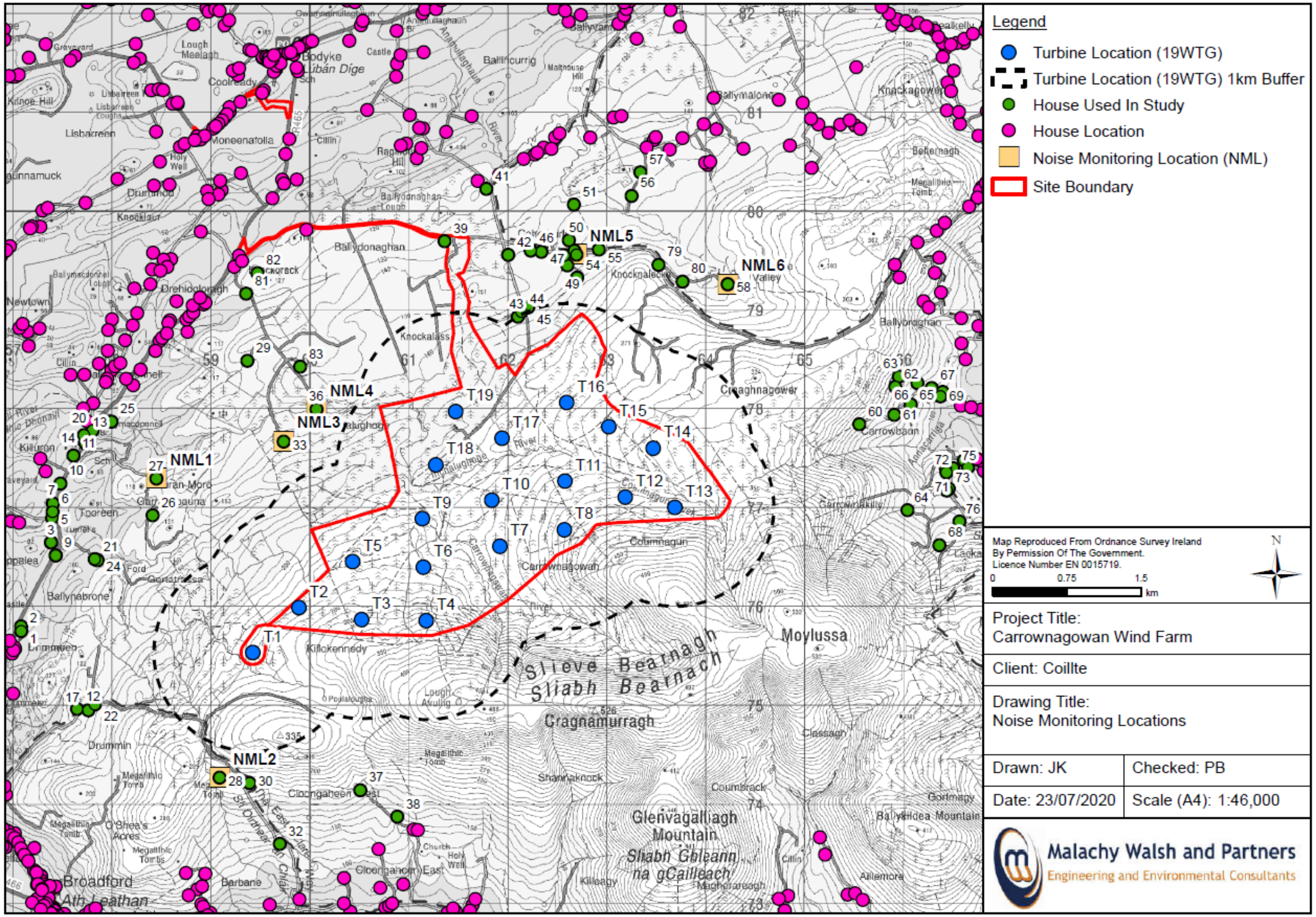


Figure 10-2 Noise Monitoring Locations

10.2.2.1 Noise Monitoring Equipment

Section 2.4 of the IOA GPG, includes information on the type and specification of noise monitoring equipment which should be used for background noise surveys and states:

Noise measurement equipment and calibrators used on site should comply with Class 1/ Type 1 of the relevant standard(s). Enhanced microphone windscreens should be used. Standard windshields of a diameter of less than 100 mm cannot be relied upon to provide sufficient reduction of wind noise in most circumstances.

The noise monitoring equipment used for the background noise survey meets with the requirements of the IOA GPG. Details of the noise monitoring equipment, the calibration drift recorded and photographs at each NML are detailed in the FDS. There was no significant calibration drift.

The microphones were all mounted between 1.2 m and 1.5 m above ground level, situated between 3.5 and 20m from the dwelling. The noise meters were located away from obvious sources of noise such as boiler flues, fans and ephemeral running water. The meters were situated away from hard reflective surfaces such as fences and walls.

Copies of the calibration certificates with serial numbers for the sound level meters and sound level calibrator are attached as **Appendix 10-B**.

10.2.2.2 Meteorological Data

In accordance with the IOA GOG:

Background noise measurements should be correlated with wind speed measurements performed at the proposed site, such that actual operating noise levels from the turbines may be compared with the noise levels that would otherwise be experienced at a dwelling.

The IOA GPG states that three methods of wind speed measurement may be adopted.

A) Direct measurement at hub height using a large mast or Lidar/ Sodar unit;
B) A met mast lower than hub height but carrying anemometers at two different heights; these are then used to calculate hub height wind speed; and
C) A met mast carrying an anemometer at 10 metres height.

The IOA GPG states that Methods A and B are preferred, and that Method C *should only be adopted for smaller-scale developments for which the installation of a tall met mast or deployment of a SODAR or LIDAR system at the planning stage might not be justified economically.*

For this assessment, wind speeds were recorded using Method B.

A tipping bucket rain gauge was installed at NML 5 for the duration of the noise survey to record periods of rainfall.

10.2.2.3 Wind Shear

Wind shear can be defined as the changes in the relationship between wind speed at different heights. Due to wind shear, wind speeds recorded on one meteorological mast, at different heights, are usually different. Generally, the higher the anemometer the higher the wind speed recorded. For example, if a wind speed of 4 m/s is recorded at 80 m height, 3.5 m/s may be recorded at 40 m and 2.5 m/s may be recorded at 10 m.

The issue of wind shear has been considered in accordance with the IOA GPG, Supplementary Guidance Note (SGN) 4: Wind Shear, July 2014. Wind speed measurements at two different heights from the on-site met mast were standardised to 10 m using the following equations.

Equation A

Shear Exponent Profile - this uses the following equation:

$$\mathbf{U = U_{ref} \times (H \div H_{ref})^{m}}$$

Where:

U	=	calculated wind speed
Uref	=	measured wind speed
H	=	height at which the wind speed will be calculated
Href	=	height at which the wind speed is measured
m	=	shear exponent

Equation B

Roughness Length Shear Profile – this uses the following equation:

$$\mathbf{U1 = U2 \times [(\ln (H_1 \div z))/ (\ln (H_2 \div z))]}$$

Where:

H_1	=	The height of the wind speed to be calculated (10m)
H_2	=	The height of the measured wind speed
U_1	=	The wind speed to be calculated
U_2	=	The measured wind speed
z	=	The roughness length

Note: A roughness length of 0.05m is used to standardise hub height wind speeds to 10m height in the IEC 61400-11:2003 standard, regardless of what the actual roughness length seen on a site may have been. This ‘normalisation’ procedure was adopted for comparability between test results for different turbines.

A data set from the met mast was available for the duration of the baseline noise survey undertaken here. This data set was used to perform a calculation of the shear exponent found between the highest two wind speed measurements for every ten-minute period using the equation;

$$M = \ln(v_2 \div v_1) / \ln(h_2 \div h_1)$$

Where:

V_1 = wind speed at lower anemometer h_1
V_2 = wind speed at higher anemometer h_2

The shear exponents calculated for every ten-minute period were then used to calculate the hub height wind speed from that measured at the relevant hub height proposed here, using equation B. Equation A was then used to calculate a ten-metre height wind speed from the hub height wind speed every ten minutes, assuming the reference roughness length of 0.05 m.

10.2.2.4 Filtering and Analysis of Data

Analysis of the measured data has been undertaken in accordance with the recommendations in ETSU-R-97 and the IOA GPG.

The purpose of data analysis is to provide a representative background noise level across a range of wind speeds for Amenity and Night-time Hours and thereby help define appropriate noise limits for a proposed wind energy development.

To obtain a typical representation of the existing noise environment, analysis of the collected data should minimise the influence of atypical sources for a representative location (or other locations for which a proxy is being applied) during the period of noise measurement.

ETSU – R- 97 requires the filtering of noise, wind and rain data for Amenity and Night-time hours which are defined as follows:

Amenity hours
18:00 to 23:00 hrs. Monday to Sunday
13:00 to 18:00 Saturday and 07:00 to 18:00 Sunday.

Night-time
23:00 to 07:00 (weekday and weekend)

Raw meteorological data was screened upon receipt and where rainfall occurred, the noise and wind speed data has been excluded from the assessment.

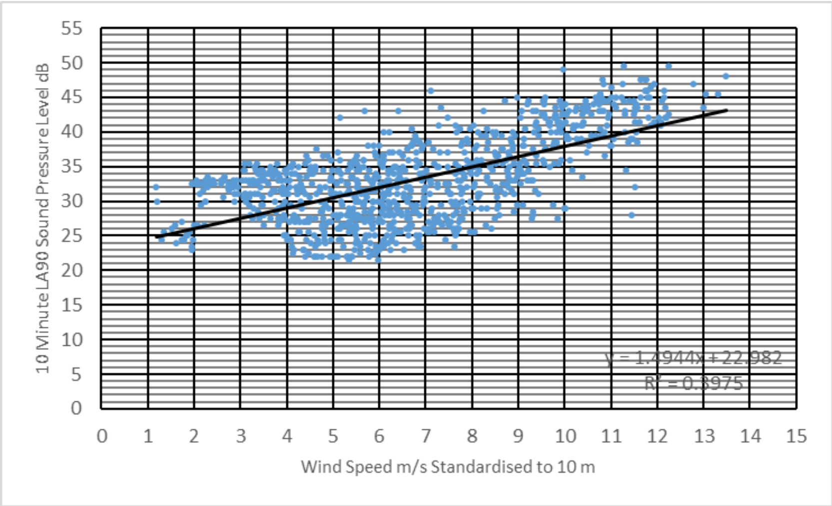
The potential impact of a dawn chorus was also removed by filtering night-time hours to 23:00 to 04:00.

A graph of the wind speed and distribution is illustrated is attached as **Appendix 10-C.**

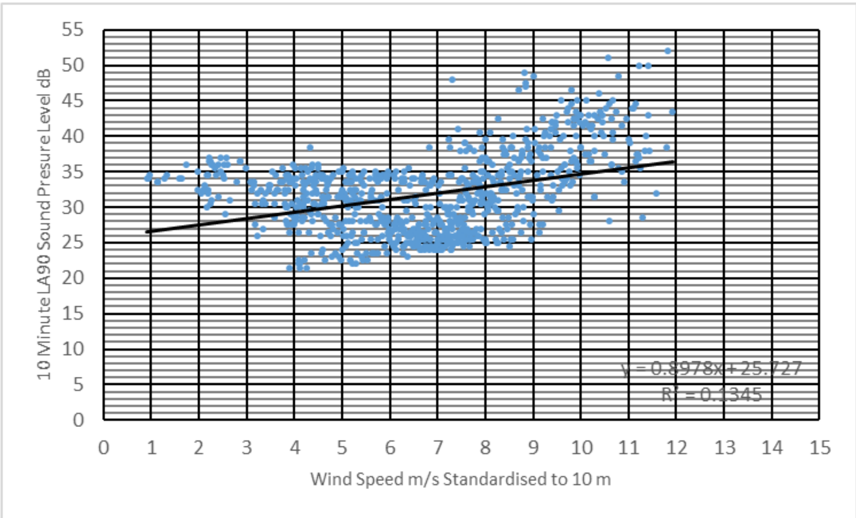
10.2.2.1 Prevailing Background Noise Level

The prevailing measured background noise levels have been calculated using a best fit polynomial regression line of no more than a fourth order through the measured $L_{A90\ 10\ min}$ noise data, as required by ETSU-R-97 and the IOA GPG. The regression analysis curve is shown as a continuous black line on the following series of graphs. The graphs show the 10-minute average wind speeds plotted against the 10-minute average recorded noise levels at the noise monitoring locations along with a calculated best fit for the quiet daytime and night-time periods.

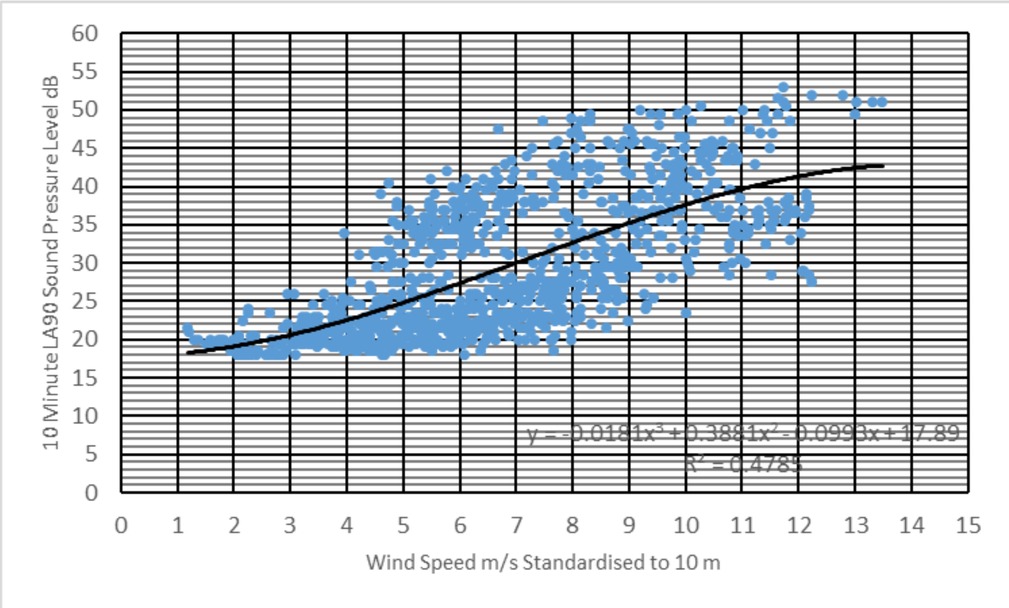
NML 1 (H27) Amenity Hours Prevailing Background Noise Level



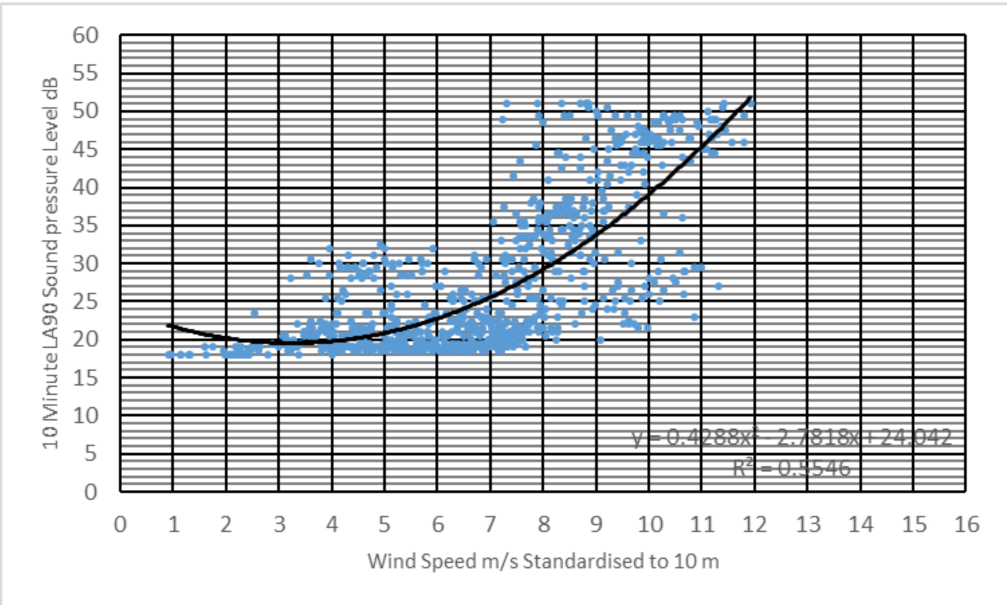
NML 1 (H27) Night-time Prevailing Background Noise Level



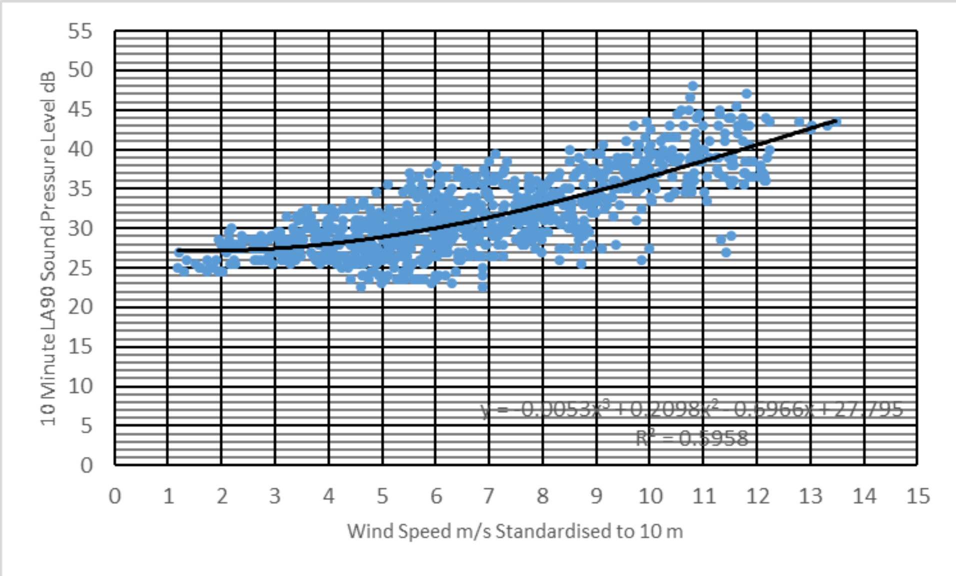
NML 2 (H28) Amenity Hours Prevailing Background Noise Level



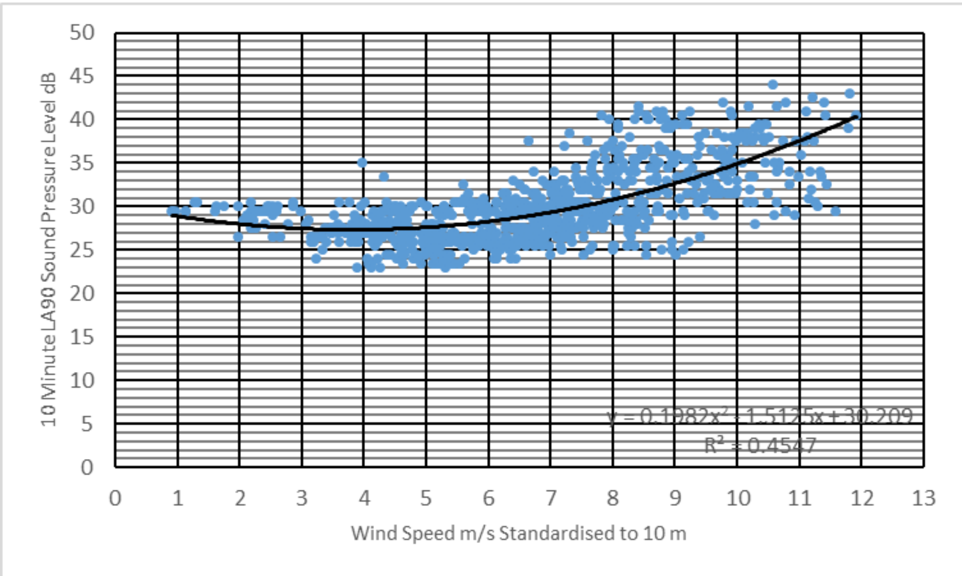
NML 2 (H28) Night-time Prevailing Background Noise Level



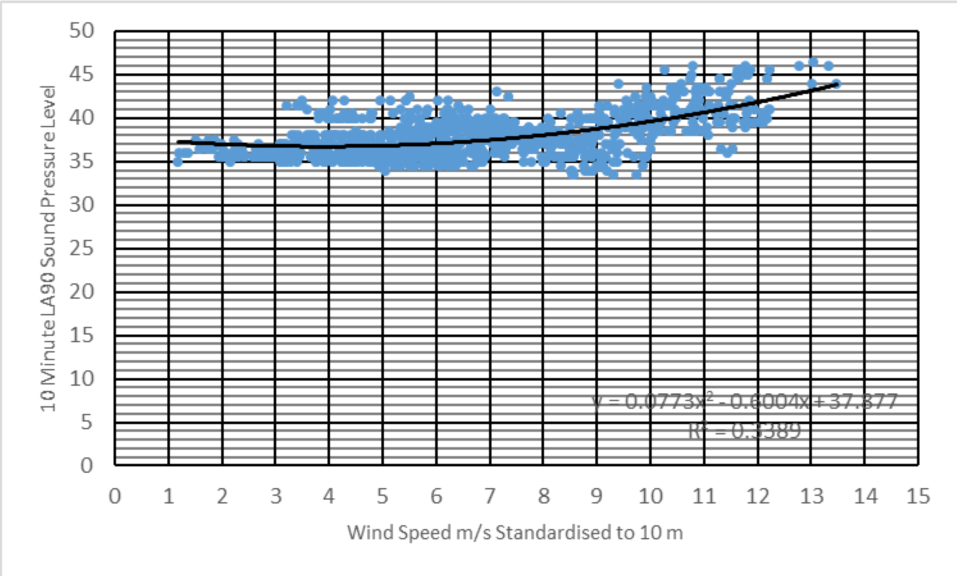
***NML 3** (H34) Amenity Hours Prevailing Background Noise Level*



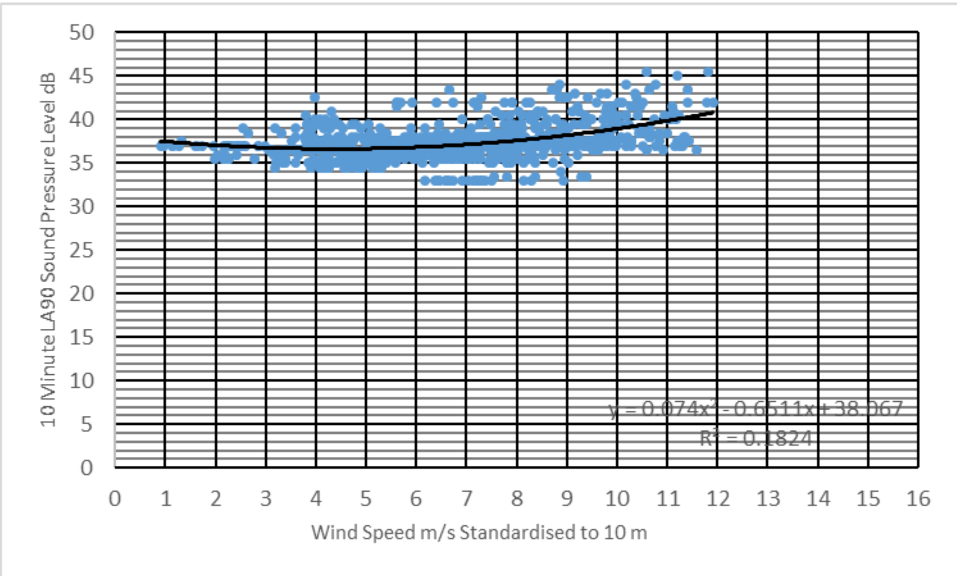
***NML 3** (H34) Night-Time Prevailing Background Noise Level*



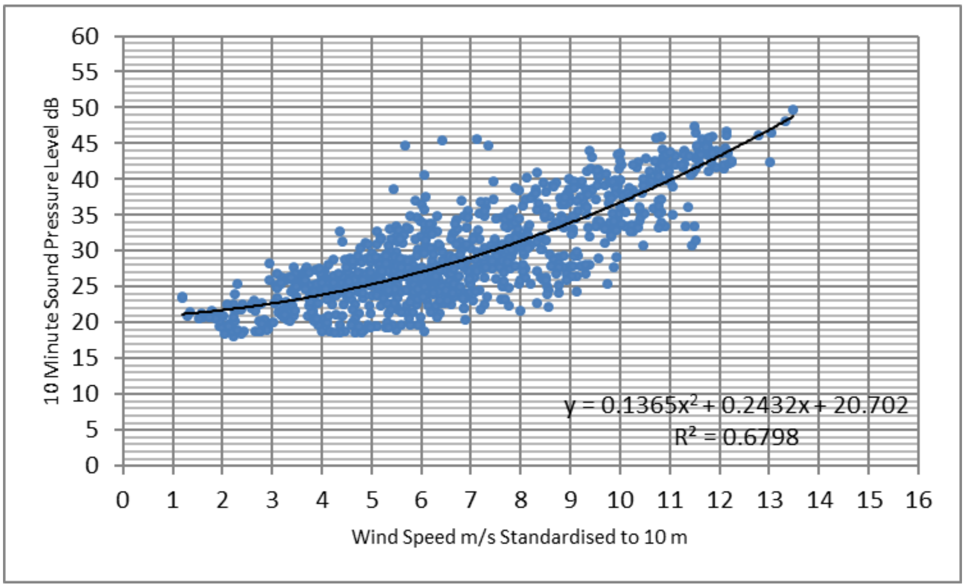
***NML 4** (H36) Amenity Hours Prevailing Background Noise Level*



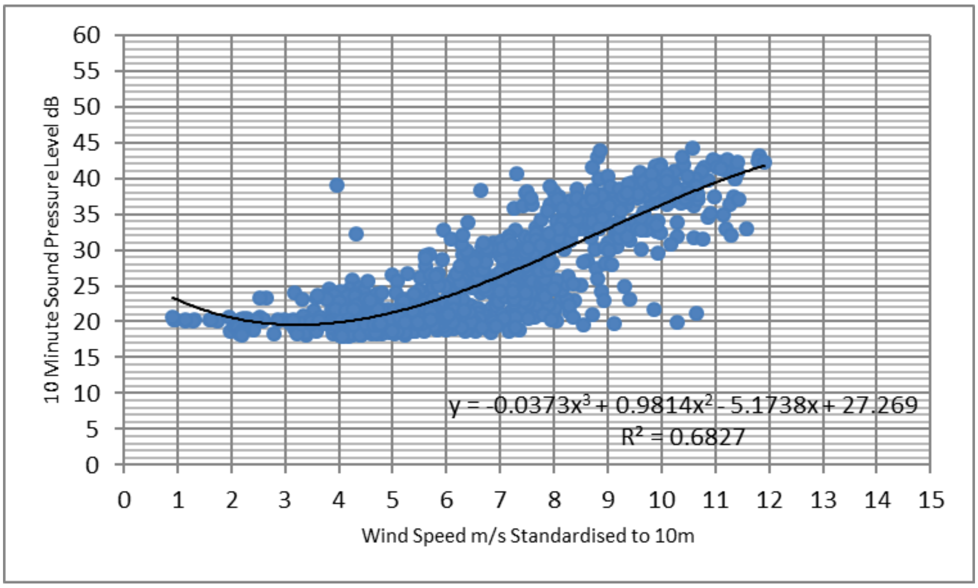
***NML 4** (H36) Night-time Prevailing Background Noise Level*



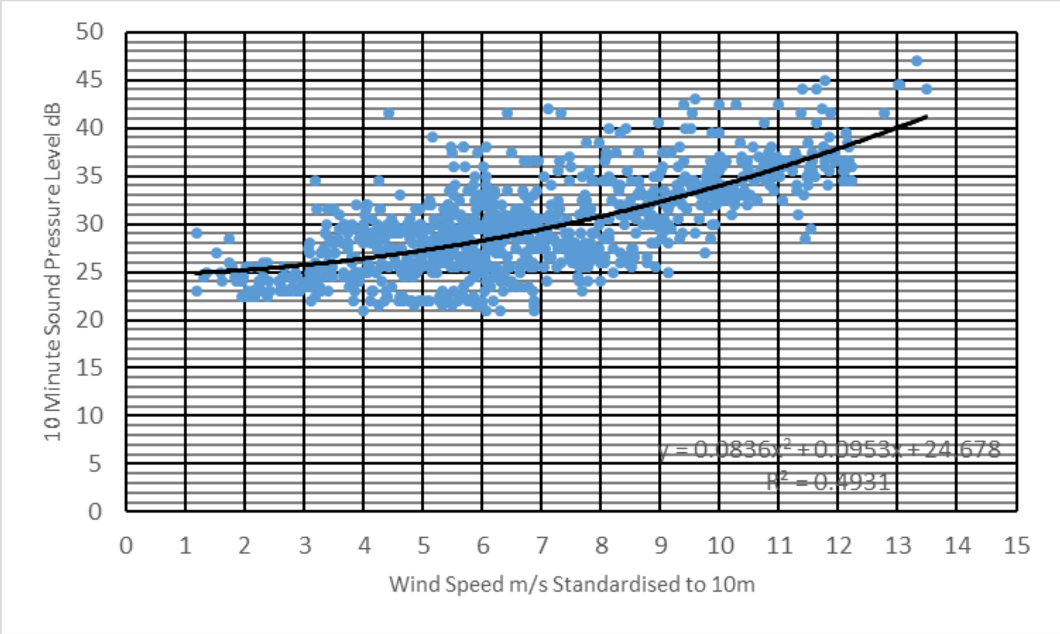
NML 5 *(H53) Amenity Hours Prevailing Background Noise Levels*



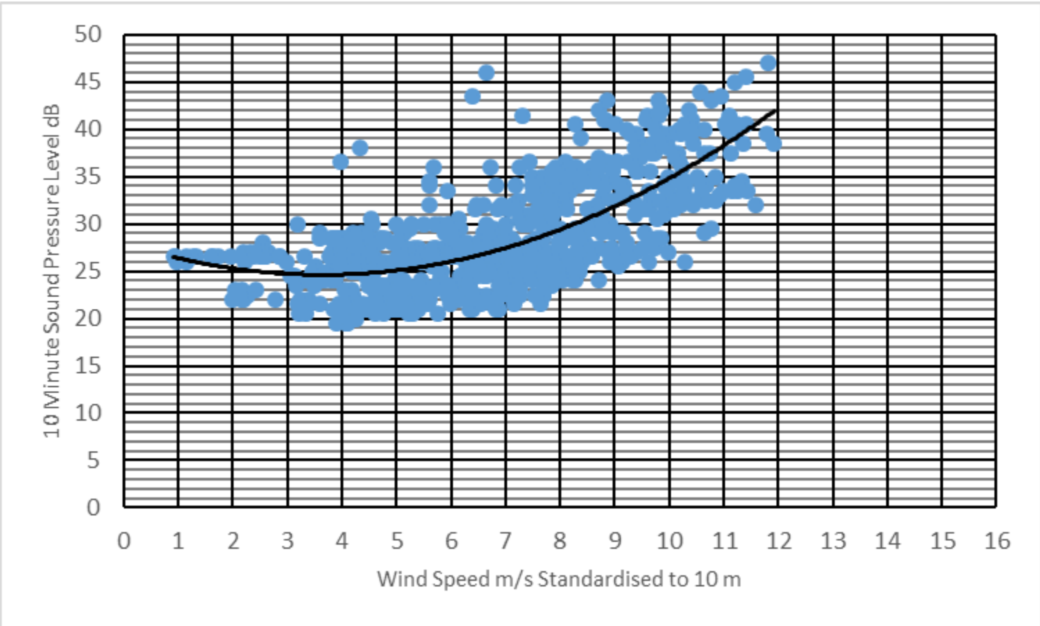
NML 5 *(H53) Night-time Prevailing Background Noise Levels*



NML 6 *(H58) Amenity Hours Prevailing Background Noise Levels*



NML 6 *(H58) Night-time Prevailing Background Noise Levels*



Tables 10-3 & 10-4 presents the derived $L_{A90\ 10\ min}$ noise levels for the monitoring locations for both the amenity hours and night-time periods. These levels have been derived using regression analysis carried out on the data sets and presented on the graphs above.

Table 10-3 Prevailing Background Noise Levels - Amenity Hours

Location Reference		Wind Speed Standardised to 10m							
Monitoring Location	Representative Of	3	4	5	6	7	8	9	10
		Prevailing Background L90 dB(A)							
H27	H26 & H27	27	29	30	32	33	35	36	38
H28	H30, H31, H32, H37 & H38	22	23	25	27	30	33	35	37
H34	H33 to H35	27	28	29	30	32	33	35	36
H36	H36	37	37	37	37	37	38	39	40
H53	H42 to H55	23	24	25	27	29	31	34	36
H58	H79, 80, 58 & 59	26	26	27	28	29	31	32	34
Lowest Measured Background Noise Level		22	23	25	28	29	31	32	34

Table 10-4 Prevailing Background Noise Levels - Night Hours

Monitoring Location	Representative Of	Wind Speed Standardised to 10m							
		3	4	5	6	7	8	9	10
		Prevailing Background L90 dB(A)							
H27	H26 & H27	28	29	30	31	32	33	34	35
H28	H30, H31, H32, H37 & H38	21	21	22	23	26	29	34	39
H34	H33 to H35	27	27	27	28	29	31	33	35
H36	H36	37	37	37	37	37	38	38	39
H42 to H55	H42 to H55	20	20	21	24	26	30	33	36
H58	H79, 80, 58 & 59	25	25	25	26	27	30	32	35
Lowest Measured Background Noise Level		20	20	21	23	26	30	32	35

10.2.3 Do-Nothing Scenario

Should the proposed development not proceed it is likely that noise levels will remain unchanged. Vehicle traffic and accordingly noise may increase but at the same time, more electric vehicles will make up the national car fleet which are much quieter than combustion engine vehicles.

10.3 LIKELY SIGNIFICANT EFFECTS

The following sections describe the potential noise and vibration impact from the proposed Carrownagowan Wind Farm and associated infrastructure. The construction, operational and decommissioning phases are assessed.

10.3.1 Construction Phase

The construction phase entails the building of the wind farm infrastructure including, roads, hard standings, turbine bases, drainage system, substation, control buildings, and borrow pits, and also the turbine delivery route works areas. The main noise sources include heavy machinery and support equipment used to construct the various elements. This typically means heavy earth moving machinery, generators and material transport trucks. For the purpose of assessing the likely construction phase impacts, the construction phase has been separated into separate categories as described in the following sections.

The noise levels described in the following sections for the various construction phases are indicative only and are based on theoretical worst case assumptions in order to demonstrate that it will be possible to undertake the works without significant noise impacts. By their nature the works are temporary and will only potentially impact on a small number of receptors at any one time. In reality construction noise levels will be lower than those presented.

10.3.1.1 Roads, Cabling and Turbine Erection

In this category, the construction of the wind farm roads will include the noisiest plant and machinery. The works areas along the turbine delivery route will be contained to each of the three minor site areas and will be short duration and temporary (refer to **Chapter 2** section 2.3.1.3.1 for more information on the locations, namely Coolready, Drummod and Ballydonaghan).

The exact equipment to be used is not known at this stage, but the plant and machinery outlined in **Table 10-5** are typical of plant commonly used and can provide an accurate assessment of construction noise emissions.

The associated noise levels have been sourced from *BS 5228 Noise and Vibration from open and construction sites*, totalled, and extrapolated to the nearest noise sensitive location. The resultant noise level is then compared against the relevant noise threshold. The result is a theoretical worst case, as it assumes all machinery will be operating simultaneously which will not be the case and accounts for attenuation due to distance only. In reality there will be further noise attenuation due to atmospheric absorption, ground absorption, and landform screening. Therefore, the noise levels presented herein are an overestimate.

Using the following equation, noise emissions from the construction site are extrapolated to the nearest noise sensitive receptor.

$$SPL_2 = SPL_1 - 20\log(r2/r1)$$

Where:

- Sound Pressure Level 1 (SPL1) = Known noise level at 10m from construction site
- Sound Pressure Level 2 (SPL2) = Unknown noise level at nearest receptor
- r2 = Distance between noise sensitive receptor and construction site

- r1 = 10 m

Table 10-5 Plant and Machinery and associated noise levels to be used in Wind Farm Roads Construction

Activity	BS 5228, 2014 Sound Pressure Level (@10m (r_1) L_{eq} dB(A)	Predicted Sound Pressure Level @ 571 m (r_2), L_{eq} dB(A).
Dozer (35 tonne) – ground excavation earthworks	86	**56 (SPL_2)**
Wheeled loader – loading lorries	80	
Dump truck (40 tonne) empty	81	
Backhoe mounted hydraulic breaker - Breaking road surface	73	
Dozer (14 tonne) – spreading chipping/ fill	82	
Road planer (17 tonne) road planing	82	
Road roller (22 tonne) – rolling and compaction	80	
Asphalt paver (and tipper lorry) – Paving	84	
Total	**91 (SPL_1)**	

The above results are calculated for the nearest new road construction within the Wind Farm. This has been identified as the new road to borrow pit/ peat deposition area No. 3. The area distance to the nearest noise sensitive location is approximately 571 m.

The theoretical worst case predicted noise level at the nearest noise sensitive location during the roads construction stage is 56 dB(A), which does not exceed the construction noise threshold. The calculations were undertaken at the closest point of the new Wind Farm road to the nearest receptor. Roads construction is linear, will progress quickly, therefore the calculated noise impact will decrease rapidly as the works progress into the Wind Farm.

10.3.1.1 Borrow Pits

Three borrow pits which will also act as peat deposition areas have been identified to facilitate the extraction of hard core material for the construction phase of the project. Rock from the borrow pits may be broken out using a rock breaker or blasting. For the purpose of this assessment both scenarios have been assessed, Scenario 1 assumes rock breaking operations and Scenario 2 assumes blasting operations. The location of the three borrow pits in relation to the nearest noise sensitive receptors in illustrated in **Figure 10-3.**

A noise prediction model using the software iNoise was used to predict the noise levels from Scenario 1 and Scenario 2 at the nearest noise sensitive locations to the borrow pits.

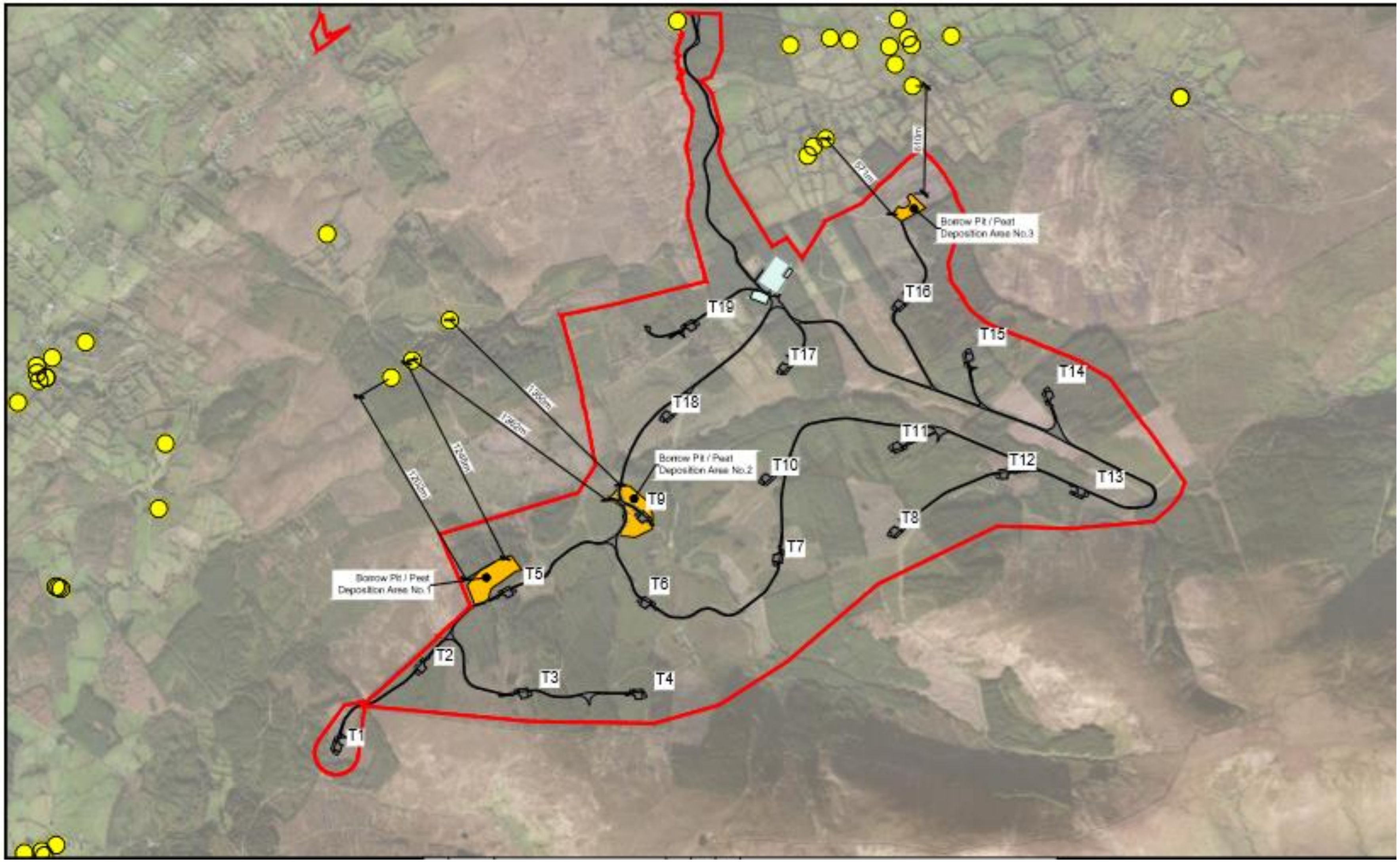


Figure 10-3 Borrow Pit Location

Scenario 1 Rock Breaking Operations

The main and noisiest items of plant to be used during rock breaking operations will include a rock breaker and a crusher to process the material. It is likely that more than one borrow pit will be in operation at any one time. For this assessment a rock breaker and crusher has been assumed to be in operation in each borrow pit simultaneously. The plant has been assumed to be in operation for 70% of a typical working day of 7 am to 7 pm. The noise emission from the rock breaker and crusher have been sourced from BS 5228-1:2009+A1:2014 Code of practice for noise and vibration on construction and open sites – Noise.

The noise levels predicted at the nearest noise sensitive locations to each borrow pit has been calculated. These include H34, H36, H43 and H54. A noise level of 45dB(A) is predicted at H34, 44dB(A) at H36, 51dB(A) at H44 and 51 dB(A) at H54. These are all well within the noise limit criteria.

Table 10-6 Typical Borrow Plant Noise Emissions

Item	BS 5228 Ref:	dB Lw Octave band (Hz)								Lw Total dB(A)
Rock Breaker	C9.11	119	117	113	117	115	115	112	108	121
Crusher	C1.14	121	114	107	108	103	99	94	87	110

Scenario 2 Blasting Operations

Blasting largely reduces the use of a rock breaker. The potential noise of blasting will be less than the prolonged daily use of a backhoe mounted rock breaker. Blasting will be a once off event which will occur approximately once or twice per month. Blast events will be controlled via a blast management plan which will be developed and agreed with Clare County Council. Refer to the project CEMP in **Volume III Appendix 3-1**.

The noise levels predicted at the nearest noise sensitive locations to each borrow pit has been calculated. These include H34, H36, H43 and H54. A noise level of 37 dB(A) is predicted at H34, 36 dB(A) at H36, 41 dB(A) at H44 and 40 dB(A) at H54. These are all well within the noise limit criteria.

The noise emissions of the blast itself have not been calculated as there are too many variables to accurately calculate. It will most likely be audible but will be a single instantaneous event on the day. Residents will be notified in advance of any blasting. Given the advance warning and infrequency of occurrence, i.e. once or twice a month, the impact is not considered significant.

The blast management plan will set out noise and vibration limit values set out in the Environmental Protection Agency's, *Environmental Management in the Extractive Industry* in addition to the mitigation measures which are described towards the end of this chapter (refer to **Section 10.4**).

10.3.1.2 Substation Construction

Table 10-7 below is a typical list of plant and machinery involved in substation construction activities. Noise levels from the equipment identified above have been sourced from *BS5228 Noise Database for Noise and Vibration Control on Construction and Open Site 1& 2: 2014+A1*.

Table 10-7 Typical Construction Plant and Machinery which will be used during the Substation Construction

Plant and Machinery	**Sound Pressure Level @10m dB(A)**	Predicted Sound Pressure Level @ 700 m L_{eq} dB(A)
Telescopic Handler	71	**47**
Mobile Crane	70	
30-50T Excavator	79	
15-30T Excavator	78	
12T Roller	80	
Dump truck	78	
Tractor & Trailer	79	
15-20T Rubber Tired	68	
3-10T mini digger	69	
Diesel Generator	61	
Total	**86**	

The construction works will be sequenced and all the noise sources in **Table 10-7** above will not be in operation continuously or simultaneously for the duration of the construction. The substation location is approximately 700 m from the nearest noise sensitive receptor. The resultant theoretical worst-case noise emission level at the nearest receptor is 47 dB(A). This is below the construction noise threshold.

Due to the separation distance between the proposed works area and sensitive locations, significant vibrations impacts are not expected. At 700 m distance, vibrations from the construction plant and activities involved will not be perceptible or cause structural or cosmetic damage.

10.3.1.3 Cable Trench/ Jointing Bays

The majority of the proposed underground cable route option for grid connection will be located within the curtilage of existing roads within an excavated trench. The stretch from T1 to the East Clare Way and on to the Broadford to Kilbane road is remote from dwellings and the potential for significant impact is very low.

In general, the construction takes place in distinct stages including 1) the excavation of the trench using an excavator machine, typically a back hoe loader, tracked machine, or directional drilling machine for water crossings 2) a dump truck to take away any spoil which is not used for back fill, 3) the trench surface receives a temporary surface dressing of either spray and chip or macadam and 4) once the overall scheme is completed, the cable route and associated road areas on the local road will receive a new permanent macadam finish as agreed with Clare County Council.

All the machinery above will not be in operation simultaneously. The resurfacing works will take place some-time after the cabling works are completed. The works move along quickly, therefore the exposure of any noise sensitive receptor is typically not more than 1 to 2 days.

Dwellings along the route will experience elevated noise levels from the excavation and road re surfacing machinery during the period it takes to pass the receptor enroute to the constructed substation. Given the very short time frame, the temporary and minor nature of the works and machinery (back-hoe loader, dump truck and road re-surfacing plant) in combination with the low number of receptors impacted at any one time, the potential impact is not considered significant. Noise emissions are already elevated on the road due to passing traffic.

Significant vibrations are not expected from the types of equipment to be used, i.e. backhoe loader, track machine and dumper.

10.3.1.4 Construction Traffic

On a wind farm the most intense period of construction traffic activity takes place during the pouring of the concrete for the turbine bases. This is because all the concrete required for a turbine base must be poured on a single day. Chapter 15, the Material Assets Chapter, considers the traffic and transport aspects of the project and states that the highest peak hour vehicle traffic volumes would be up to 24 heavy vehicles, both to and from the site (12 deliveries and 12 departures).

For mobile items of plant that pass at intervals it is possible to predict an equivalent continuous sound level using the following expression for predicting LAeq alongside a haul road used by single engine items of mobile plant:

$$L_{Aeq} = L_{wa} - 33 + 10\log_{10}Q - 10\log_{10}V - 10\log_{10}d,$$

Where

- Lwa is the sound power of the plant in decibels (dB);
- Q is the number of vehicles per hour;
- V is the average vehicle speed, in kilometres per hour (km/h)
- d is the distance of receiving position from the centre of the haul road, in metres (m)

Therefore

LAeq = 118Note 1 – 33 + 10Log 24 – 10log50 – 10log20 = 69 dB(A).

Note 1: Source, Maximum drive by sound power level (Table C.2 BS 5228 Part 1).

The averaged LAeq over the course of an hour from passing HGV's (as calculated above) is predicted to be 69 dBA. The base pours will only occur 19 times (19 turbines) and typically these days will not occur concurrently. In that regard, the noise impact from the HGV concrete deliveries is not considered significant. The noise levels are typical of any HGV traffic which already uses the road network.

10.3.2 Operational Phase

Once operational, the wind turbines and the substation facility will generate noise which will propagate into the receiving environment.

10.3.2.1 Wind Turbines

Noise prediction computer software was used to quantify the impact of the proposed Carrownagowan development.

The noise predictions were undertaken using noise prediction software, specifically Bruel & Kjaer's Predictor software (iNoise 2019.1 V1). The software calculations are based on ISO 9613, Attenuation of sound during propagation outdoors, Part 2, General Method of Calculation. This is the standard recommended by the IOA GPG.

The ISO 9613-2 model can take account of the following factors that influence sound propagation outdoors:

- Geometric divergence;
- Air Absorption;
- Reflecting obstacles;
- Screening;
- Vegetation; and
- Ground reflections

The model uses as its acoustic input data the octave band sound power of the turbine and calculates, on an octave band basis, attenuation due to factors above, as appropriate. The data input into the model was also defined by the IOA GPG and is presented in **Table 10-8**.

Table 10-8 Model Input Data

Item	Description
Turbine Locations	Irish grid 1965 9 (Appendix 10-D)
House Locations	Irish grid 1965 (Appendix 10-D)
Acoustic Emission	Turbine Sound Power Levels
Hub Height	101 m
Landform	Flat No Landform Screening

Ground Factor	0.5 Note 1
Receptor Height	4m
Wind Direction	Downwind
Relative Humidity	70%
Temperature	10ºC

Note 1: Ground Factor is a value between 0 and 1, where 0 represents hard/ reflective surfaces and 1, represents soft absorbent surfaces.

The following sections detail the noise spectra for the wind turbines under consideration for the proposed wind farm.

There are currently several candidate turbines being considered for the site. To allow maximum flexibility in turbine selection, the loudest turbine currently under consideration, the Nordex N133 4.8 MW (with serrated trailing edge), has been modelled in the proceeding analyses. This turbine is a pitch regulated upwind turbine.

If the site is granted planning permission and subsequently constructed it is possible that the final turbine used on the site will be quieter than the turbine considered here.

The actual turbine to be installed on the site will be the subject of a competitive tender process and may include turbine models not currently available. Noise emissions from the final turbine selection will be no greater than used for this assessment.

The maximum operating sound power level of the candidate turbine, namely the Nordex 133 is 106dB(A). The sound power levels (SWL) are presented with reference to the code IEC 61400-11 ed. 2.1, *Wind turbine generator systems, Acoustic noise measurement techniques*, (2006) based on a hub height of 100 m and a roughness length of 0.05 m as described in the IEC code. The SWL presented are valid for the corresponding wind speeds referenced to the height of 10 m above ground level in normal operating mode.

The IOA GPG states that it should be ensured that a margin of uncertainty is included within source wind turbine noise data used in noise predictions. There is uncertainty associated with the measurement of wind turbine noise. This is sometimes included in the warranted noise levels, sometimes it is not. In accordance with the IOA GPG guidelines:

If no data on uncertainty or test reports are available for the turbine then a factor of +2dB should be added.

For the purposes of all predictions presented in this report to account for various uncertainties in the measurement of turbine source levels, a factor of 2dB has been added to the manufacturer's values.

Table 10-9 Nordex 133 – Total Sound Power Levels

Wind Speed (m/s)	dB LwA	dB LwA (+2dBA)
3	93.5	95.5
4	95	97
5	100.5	102.5
6	104.7	106.7
7	106	108
8	106	108

Table 10-10 Nordex 133 – Total Sound Power Levels

Wind Speed referenced to 10m height w/s	Octave Band (Hz)								
	63	125	250	500	1000	2000	4000	8000	SWL dB(A)
8 m/s	88.9	94.6	96.9	97.7	99.5	100	97.7	87.1	106
7 m/s	87.8	94.8	98.6	99.5	99.9	98.7	94.4	85.2	106
6 m/s	86.4	93.4	97.2	98.1	98.6	97.3	93.3	83.8	104.7
5 m/s	82.2	89.2	93.0	93.9	94.4	93.1	88.8	79.6	100.5
4 m/s	78.0	84.8	88.5	88.3	87.8	86.6	84.5	76.2	95.0
3 m/s	76.5	88.3	87.0	86.8	86.3	85.1	83.0	74.7	93.5

10.3.2.2 Noise Assessment Results DoEHLG 2006

Table 10-11 outlines the derived noise limit criteria based on the lowest measured prevailing background noise levels in **Tables 10-3** and **10-4**. This is a robust approach. Once operational each location will have its own limit dependant on measured noise baseline noise levels. The approach herein is overly conservative for the purpose of this assessment. Each of the noise monitoring locations and the dwellings it represents will have its own set of noise limit criteria based on the noise limit curves illustrated in **Appendix 10-5** to this report.

Table 10-11 Noise Limits - Amenity and Night-time Hours

$L_{A90,\ 10\ min}$ (dB) Limits at Standardised 10m Height Wind Speed (m/s)								
Ref:	3	4	5	6	7	8	9	10
Background Noise Level	22	23	25	28	29	31	32	34
Day $L_{A90\ 10min}$ dB Limit	40	40	40	40	40	45	45	45
21	20	20	21	23	26	30	32	35
Night $L_{A90\ 10min}$ dB Limit	43	43	43	43	43	43	43	43

The results of the assessment shown in tabular form in **Table 10-12** show that the proposed Carrownagowan Wind Farm can meet the noise limit criteria as set out in the 2006 DoEHLG Wind Energy Guidelines. The margin above (+) or below (-) the noise limit criteria for the day and night-time periods are presented. At all locations and at all wind speeds the predicted noise emissions do not exceed the derived limit criteria for both the quiet daytime and night-time periods. The noise limit curves at the selected representative noise monitoring locations are illustrated in **Appendix 10-5**.

The wind turbine noise emission levels included in **Tables 10-13** and **10-15** below are based on the $L_{A90,\ 10\ minute}$ noise indicator in accordance with the recommendations in ETSU-R-97, which were obtained by subtracting 2dB(A) from the calculated $L_{Aeq\ T}$ noise levels based on the turbine sound power level data used.

Figure 10-4 illustrates the theoretical maximum noise emissions from the wind farm. Noise levels at receptors may be lower due to attenuation because of local landform or screening and wind direction effects.

Table 10-12 Carrownagowan Wind Farm predicted noise levels and noise limit comparison

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
1	Predicted	17	19	23	28	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-21	-17	-12	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-24	-20	-15	-14	-15	-15
2	Predicted	17	19	23	28	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-21	-17	-12	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-24	-20	-15	-14	-15	-15
3	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
4	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
5	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
6	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
7	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
8	Predicted	18	20	25	29	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-20	-15	-11	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-23	-18	-14	-13	-14	-14
9	Predicted	18	20	25	29	30	29	29
	Day Limit	40	40	40	40	40	45	45

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Margin Day	-22	-20	-15	-11	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-23	-18	-14	-13	-14	-14
10	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
11	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
12	Predicted	19	20	25	29	31	30	30
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-21	-20	-15	-11	-9	-15	-15
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-24	-23	-18	-14	-12	-13	-13
13	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
14	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
15	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
16	Predicted	19	20	25	30	31	30	30
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-21	-20	-15	-10	-9	-15	-15
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-24	-23	-18	-13	-12	-13	-13
17	Predicted	19	20	25	30	31	30	30
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-21	-20	-15	-10	-9	-15	-15
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-24	-23	-18	-13	-12	-13	-13
18	Predicted	18	20	24	29	30	29	29

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-20	-16	-11	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-23	-19	-14	-13	-14	-14
19	Predicted	18	20	24	29	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-20	-16	-11	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-23	-19	-14	-13	-14	-14
20	Predicted	18	20	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-20	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-23	-19	-15	-13	-14	-14
21	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
22	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
23	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
24	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
25	Predicted	19	20	25	29	31	30	30
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-21	-20	-15	-11	-9	-15	-15
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-24	-23	-18	-14	-12	-13	-13
26	Predicted	22	23	28	32	34	33	33
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-18	-17	-12	-8	-6	-12	-12
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-21	-20	-15	-11	-9	-10	-10

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
27 NML 1	Predicted	21	22	27	32	33	32	32
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-19	-18	-13	-8	-7	-13	-13
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-22	-21	-16	-11	-10	-11	-11
28 NML 2	Predicted	22	23	28	32	34	33	33
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-18	-17	-12	-8	-6	-12	-12
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-21	-20	-15	-11	-9	-10	-10
29	Predicted	22	23	28	32	34	33	33
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-18	-17	-12	-8	-6	-12	-12
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-21	-20	-15	-11	-9	-10	-10
30	Predicted	22	24	29	33	34	33	33
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-18	-16	-11	-7	-6	-12	-12
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-21	-19	-14	-10	-9	-10	-10
31	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
32	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
33	Predicted	25	26	32	36	37	36	36
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-15	-14	-8	-4	-3	-9	-9
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-18	-17	-11	-7	-6	-7	-7
34 NML 3	Predicted	25	27	32	36	37	36	36
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-15	-13	-8	-4	-3	-9	-9
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-18	-16	-11	-7	-6	-7	-7
35	Predicted	25	27	32	36	38	37	37
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-15	-13	-8	-4	-2	-8	-8
	Night Limit	43	43	43	43	43	43	43

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Margin Night	-18	-16	-11	-7	-5	-6	-6
36 NML 4	Predicted	26	27	32	36	38	37	37
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-14	-13	-8	-4	-2	-8	-8
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-17	-16	-11	-7	-5	-6	-6
37	Predicted	23	24	29	33	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-16	-11	-7	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-19	-14	-10	-8	-9	-9
38	Predicted	21	23	28	32	33	32	32
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-19	-17	-12	-8	-7	-13	-13
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-22	-20	-15	-11	-10	-11	-11
39	Predicted	22	23	28	33	34	33	33
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-18	-17	-12	-7	-6	-12	-12
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-21	-20	-15	-10	-9	-10	-10
41	Predicted	20	22	26	31	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-18	-14	-9	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-21	-17	-12	-11	-12	-12
42	Predicted	23	25	30	34	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-15	-10	-6	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-18	-13	-9	-8	-9	-9
43 NML 5 proxy	Predicted	27	28	33	38	39	38	38
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-13	-12	-7	-2	-1	-7	-7
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-16	-15	-10	-5	-4	-5	-5
44 NML 5 proxy	Predicted	27	28	33	37	39	38	38
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-13	-12	-7	-3	-1	-7	-7
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-16	-15	-10	-6	-4	-5	-5
45 NML 5 proxy	Predicted	26	28	33	37	39	38	38
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-14	-12	-7	-3	-1	-7	-7

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-17	-15	-10	-6	-4	-5	-5
46	Predicted	23	24	29	34	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-16	-11	-6	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-19	-14	-9	-8	-9	-9
47	Predicted	23	25	30	34	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-15	-10	-6	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-18	-13	-9	-8	-9	-9
48	Predicted	23	25	30	34	36	35	35
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-15	-10	-6	-4	-10	-10
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-18	-13	-9	-7	-8	-8
49	Predicted	24	25	30	34	36	35	35
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-16	-15	-10	-6	-4	-10	-10
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-19	-18	-13	-9	-7	-8	-8
50	Predicted	23	24	29	33	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-16	-11	-7	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-19	-14	-10	-8	-9	-9
51	Predicted	21	22	27	31	33	32	32
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-19	-18	-13	-9	-7	-13	-13
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-22	-21	-16	-12	-10	-11	-11
52	Predicted	23	24	29	34	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-16	-11	-6	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-19	-14	-9	-8	-9	-9
53 NML 5	Predicted	23	25	30	34	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-15	-10	-6	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-18	-13	-9	-8	-9	-9
54	Predicted	25	26	31	35	37	36	36

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-15	-14	-9	-5	-3	-9	-9
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-18	-17	-12	-8	-6	-7	-7
55	Predicted	23	24	29	33	35	34	34
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-17	-16	-11	-7	-5	-11	-11
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-20	-19	-14	-10	-8	-9	-9
56	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
57	Predicted	19	20	25	29	31	30	30
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-21	-20	-15	-11	-9	-15	-15
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-24	-23	-18	-14	-12	-13	-13
58	Predicted	22	23	28	32	34	33	33
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-18	-17	-12	-8	-6	-12	-12
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-21	-20	-15	-11	-9	-10	-10
59	Predicted	22	23	28	32	34	33	33
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-18	-17	-12	-8	-6	-12	-12
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-21	-20	-15	-11	-9	-10	-10
60	Predicted	20	21	26	30	32	31	31
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-20	-19	-14	-10	-8	-14	-14
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-23	-22	-17	-13	-11	-12	-12
61	Predicted	19	20	25	29	31	30	30
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-21	-20	-15	-11	-9	-15	-15
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-24	-23	-18	-14	-12	-13	-13
62	Predicted	18	20	24	29	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-20	-16	-11	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Margin Night	-25	-23	-19	-14	-13	-14	-14
63	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
64	Predicted	18	20	25	29	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-20	-15	-11	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-23	-18	-14	-13	-14	-14
65	Predicted	18	19	24	28	30	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-10	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-13	-14	-14
66	Predicted	18	19	24	28	29	29	29
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-22	-21	-16	-12	-11	-16	-16
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-25	-24	-19	-15	-14	-14	-14
67	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
68	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
69	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
70	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
71	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17

House Number	Description	dB LA90 Standardised wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
72	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
73	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
74	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
75	Predicted	17	18	23	27	29	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-11	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-14	-15	-15
76	Predicted	17	18	23	27	28	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-12	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-15	-15	-15
77	Predicted	17	18	23	27	28	28	28
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-23	-22	-17	-13	-12	-17	-17
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-26	-25	-20	-16	-15	-15	-15
78	Predicted	16	18	22	27	28	27	27
	Day Limit	40	40	40	40	40	45	45
	Margin Day	-24	-22	-18	-13	-12	-18	-18
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-27	-25	-21	-16	-15	-16	-16

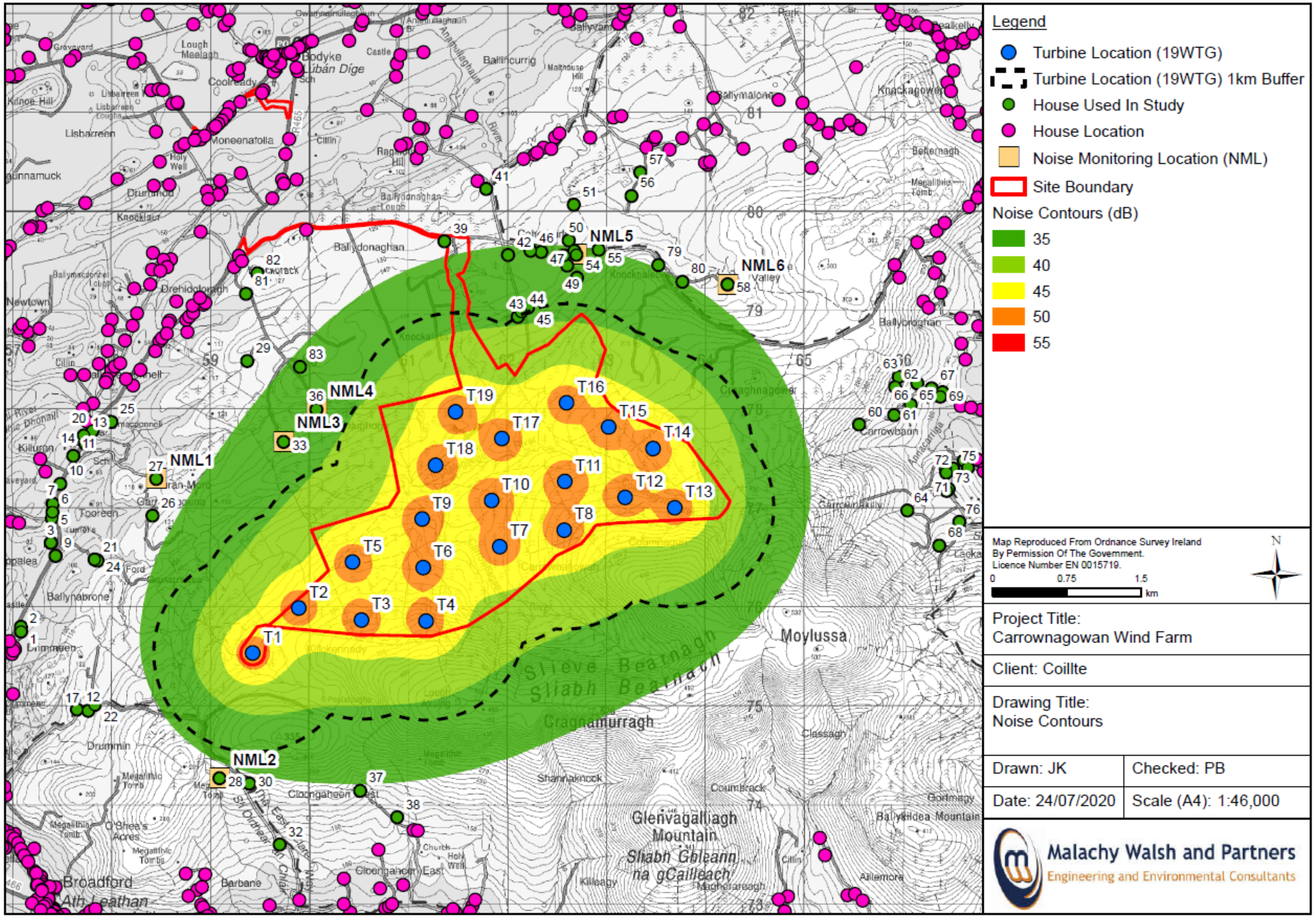


Figure 10-4 Noise Level Contours – Max Noise Emissions from Turbine

10.3.2.1 Special Audible Characteristics

There are three categories of special audible characteristics that may arise from wind turbines:

1. Tonal Noise

2. Amplitude Modulation

3. Low Frequency Noise

These are discussed in the following sections.

10.3.2.1.1 Tonal Noise

A tone can be described as an identifiable characteristic from a particular sound. It can be commonly described as a whine, hum or hiss. Tonal wind turbine noise can generally be attributed to gearbox related noise. Improvements in turbine design have greatly reduced potential tonal noise.

Such characteristics incur an additional acoustic penalty to the wind turbine noise emission. Typically wind turbines are broadband in nature and there are no clearly audible tones when operating normally, therefore no penalty has been included.

A warranty will be sought from the turbine manufacturer guaranteeing no tonal content at the nearest noise sensitive receptors.

10.3.2.1.2 Amplitude Modulation

The variation in noise level associated with turbine operation, at the rate at which turbine blades pass any fixed point of their rotation (the blade passing frequency), is often referred to as blade swish and amplitude or aerodynamic modulation (AM). It is often referred to as a ‘whooping’ or ‘thumping’ noise which may cause annoyance at a considerable distance from the wind energy development.

The Institute of Acoustics (IoA) Working Group defined wind turbine amplitude modulation as follows:

"Wind turbine amplitude modulation is defined as periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency of the turbine rotor(s)."

This effect is identified within the UK document ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (1996), upon which the Department of the Environment, Heritage, and Local Government, Wind Energy Planning Guidelines, 2006, noise limits are based. ETSU-R-97 states that ‘… modulation of blade noise may result in variation of the overall A-Weighted noise level by as much as 3 dB(A) (peak to trough) when measured close to a wind turbine... ’ and that at distances further from the turbine where there are‘… more than two hard, reflective surfaces, then the increase in modulation depth may be as much as 6 dB(A) (peak to trough)’. It concludes that 'the noise levels (i.e. limits) recommended in this report take into account the character of noise described ... as blade swish'.

Modern wind turbines can generate normal AM but this usually disappears at 3 to 4 rotor lengths (with the exception of cross wind conditions). Where the modulation characteristics change, AM can give rise to annoyance. Recent research into AM was conducted by Renewable UK, published as 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' (December 2013). This research focused on the less understood 'Other AM' where reported incidents are relatively limited and infrequent but is a recognised phenomenon. However, the occurrence and intensity of OAM is specific to a location and its likelihood of occurrence cannot be reliably predicted.

Section 6 of the 'Summary of Research into Amplitude Modulation of Aerodynamic Noise from Wind Turbines- Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' states that "At present there is no way of predicting OAM at any particular location before turbines begin operation due to the general features of a site or the known attributes of a particular turbine"

Should AM arise it will be investigated thoroughly and if a complaint is justified, the required mitigation measures will be undertaken.

10.3.2.1.3 Infrasound and Low Frequency Noise

Low frequency noise is noise that is dominated by frequencies less than 200 Hz. It is audible to the human ear, can travel large distances and is difficult to attenuate.

Infrasound is typically described as sound at frequencies below 20 Hz. This is below the threshold of human hearing.

Further information on Infrasound and its potential impact is provided in the EPA document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licenced Sites (NG3)*. The document states:

"There is similarly no significant infrasound from wind turbines. Infrasound is high level sound at frequencies below 20 Hz. This was a prominent feature of passive yaw "downwind" turbines where the blades were positioned downwind of the tower which resulted in a characteristic "thump" as each blade passed through the wake caused by the turbine tower. With modern active yaw turbines (i.e. the blades are upwind of the tower and the turbine is turned to face into the wind by a wind direction sensor on the nacelle activating a yaw motor) this is no longer a significant feature."

The final turbine selected for the site will be a modern active yaw turbine.

The Draft 2019 WEDGs state *"There is no evidence that wind turbines generate perceptible infrasound.* It also states the following with regard to low frequency sound":

"Natural levels of low frequency noise arise in the environment. Regular environmental low frequency noise sources include rivers, waterfalls, waves on the sea, and air turbulence from the wind. Occasional short duration sources include thunder, landslides, avalanches and earthquakes. Low frequency noise from man-made sources includes industrial facilities, transportation, mechanical ventilation systems and some household tools and appliances".

If a complaint arises regarding Low Frequency Sound, it will be investigated in accordance with the most appropriate guidance at the time and corrective action will be taken if the complaint is found to be justified.

10.3.2.2 Substation

The proposed substation is approximately 700m from the nearest noise sensitive receptor. The substation will typically be in operation 24 hours a day, 7 days a week. The noise emission from a substation required for a wind farm development of this size would be in the order of 93 dB(A) Lw.

Using the noise prediction software, the noise level associated with the operation of the substation at the nearest noise sensitive receptor is predicted to be 22 dB(A). This is a worst case result as it does not factor in any attenuation due to screening or local topography. There will be no significant cumulative impact including the Wind Farm on overall noise levels at any noise sensitive receptor within the study area.

10.3.2.3 Vibration

Once operational, there will be no significant sources of vibration from the wind farm development. There will no significant sources of vibration from the ongoing maintenance through the lifetime of the wind farm.

10.3.2.4 Cumulative Impact

There are no other operational, permitted, or proposed wind farm developments which may impact cumulatively with the proposed development.

Noise emissions from the proposed substation (22dBA) are 18dB below the lower limit threshold value that applies to the operation of the wind turbines i.e. 40 dB (A). Due to the logarithmic addition of decibels if one noise source is 10 dB below another cumulatively there is no increase in noise levels. Therefore the substation, in combination with the wind farm will not exceed noise limits at any dwelling.

10.4 MITIGATION

10.4.1 Construction Phase

Best practice in the form of BS5228 –1&2:2009 + A1 2014, *Code of Practice for the Control of Noise and Vibration on Construction and Open Sites* will be adopted during the construction phase in order to minimise the noise generated by construction activities and nuisance to neighbours.

Measures to be taken in the Construction and Environmental Management Plan (CEMP) (refer to **Appendix 3-1**, **Volume III** of this EIAR) to minimise noise and vibration during the construction phase. The measures will be adopted from best practice described in BS5228-1&2 +A1 2014. It will include a nominated community liaison officer tasked with responding in a prompt manner to any noise and vibration complaints which may arise.

Wherever possible the contractor will inform residents where appropriate of the proposed blasting times and any deviation from this programme in advance. Where blasting takes place, it will be restricted to regular times. Each blast will be carefully designed to maximise its efficiency and reduce transmission of noise. These details will be finalised by the appointed contractor in agreement with the local authority and design team prior to any blast taking place and documented in a Blast Management Plan. Should blasting be utilised, a Blast Management Plan will be completed prior which will include full details of the locations of the bores for the blasts, the types of materials to be used, details of the necessary controls and responsibilities, and compliance with the relevant safety legislation.

Vibration levels will not exceed those described in BS5228 –1&2:2009 + A1 2014, *Code of Practice for the Control of Noise and Vibration on Construction and Open Sites* and this chapter.

10.4.2 Operational Phase

As the proposed turbines are predicted not to exceed DoEHLG noise limit criteria in standard operating mode mitigation measures are not required.

In the unlikely event that a complaint of Amplitude Modulation arises during the operation of the wind farm, an investigation into the phenomenon will be carried out in accordance with best practice, specifically the Institute of Acoustics' (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG), *Method for Rating Amplitude Modulation in Wind Turbine Noise (August 2016)*. If required, mitigation measures will be put in place to eliminate any nuisance that is found to occur. These mitigation measures will be applied during the specific meteorological conditions which causes the AM to happen and typically involve one or more of the following:

- slowing down or stopping the relevant wind turbine.
- altering the pitch of the blades (i.e. changing the amount of rotation of the blade along its length).
- realigning the yaw of the rotor (i.e. changing the angle at which the turbine rotor faces into the wind).

In the unlikely event an issue regarding low frequency arises, the matter will be fully investigated with regard to best practice and guidance at the time. Currently guidance is outlined in Appendix VI of the EPA document entitled *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (NG4) (EPA, 2016).

10.4.3 Decommissioning Phase

Best practice in the form of BS5228 –1&2:2009 + A1 2014, *Code of Practice for the Control of Noise and Vibration on Construction and Open Sites* will be adopted during the decommissioning phase in order to minimise the noise generated by construction activities and nuisance to neighbours.

10.5 RESIDUAL IMPACTS

10.5.1 Construction and Decommissioning Phase

Potential Impact	Significance of Unmitigated Impact	Mitigation	Residual Impact
Noise Nuisance at nearest noise sensitive receptors	The significance of impact is assessed against the noise limits in the BS5228 Construction Noise Guidelines. As these thresholds are predicted not to be exceeded, then no significant impact is concluded.	Additional mitigation above adhering to best practice referred to herein (BS 5228) is not necessary.	Once the construction phase is over, there will be no residual impact.

10.5.2 Operational Phase

Potential Impact	Significance of Unmitigated Impact	Mitigation	Residual Impact
Noise Nuisance at nearest noise sensitive receptors	The significance of impact is assessed against the noise limits in the 2006 DoEHLG Wind Energy Guidelines. As these thresholds are predicted not to be exceeded then no significant impact is concluded.	No mitigation is required in order to comply with the noise limit criteria.	Once operational, the noise levels from the turbines will not exceed planning limit criteria for the protection of residential amenity.

10.6 CONCLUSION

- This chapter has assessed the potential impact of operational noise from the proposed Carrownagowan wind farm on the residents of nearby receptors. The guidance contained within the current 2006 DoEHLG *Wind Energy Development Guidelines*, ETSU-R-97 and current good practice (IoA GPG) has been used to assess the potential noise impact of the proposed development.
- A 1 km set back has been achieved in the design of the wind farm. This allows for scope to meet anticipated revised noise limit criteria through the use of appropriate turbine selection and operating modes.
- Six residential locations neighbouring the proposed development were selected as assessment locations, being representative of the closest properties. Background noise monitoring was undertaken at each of the six locations.
- Wind speed data was measured using an on-site met mast. The wind data was standardised to a height of 10m in accordance with the IoA GPG.
- Analysis of the measured data has been performed in accordance with ETSU-R-97 and the IoA GPG to determine the pre-existing background noise environment at these locations. The quiet day time and night-time noise limits were established in accordance with the 2006 DoEHLG Wind Energy Development Guidelines. A worst case background noise envelope was used for the purposes of the assessment.
- Predictions of wind turbine noise have been made, based upon sound power level data for a candidate wind turbine model for the proposed development and a noise propagation model that can be considered to be a worst case impact assessment.
- Predicted wind turbine noise emissions meet the noise limits established for the assessment for both day and night-time periods.
- There are a number of wind turbine makes and models that may be suitable for the proposed development. Should the application be granted, the final choice of turbine will be subject to a competitive tendering process. The final choice of turbine will be selected to comply with the noise parameters assessed and will have to meet the noise limits within any conditions imposed.
- The operation of the substation compound has also been assessed and can achieve the adopted noise limit criteria at the nearest noise sensitive receptors.
- The construction phases of each element of the proposed project has also been assessed and found to comply with construction noise thresholds.

10.7 REFERENCES

Attenuation of sound during propagation outdoors –Part 2: General method of calculation, ISO 9613-2-1996- Acoustics.

Code of Practice for Noise and Vibration Control on Construction and Open Sites + A1 2014 British Standard 5228 Parts 1 & 2.

Environmental Management in the Extractive Industry (Non-Scheduled Minerals), Environmental Protection Agency, 2006.

Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, Institute of Acoustics, 2013.

Guidelines for Environmental Noise Impact Assessment, Institute of Environmental Management and Assessment (IEMA), 2014.

Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4), Environmental Protection Agency, (EPA, 2016)