12.0 NOISE AND VIBRATION

12.1 INTRODUCTION

This chapter of the Environmental Impact Assessment Report (EIAR) describes the assessment undertaken of the potential noise and vibration impact from the proposed Cloghercor Wind Farm on local residential amenity. The proposed project consists of 19 no. wind turbines with an overall top of foundation level to blade tip height of 185 to 200 m, a hub height range of 112 to 125m and a rotor diameter range of 149 to 164m. A full description of the proposed project is provided in Chapter 2 (Description of the Proposed Project).

Noise and vibration impact assessments have been prepared for the operational phase, the construction and decommissioning phases of the proposed project to the nearest noise sensitive locations (NSLs). To inform this assessment baseline noise levels have been measured at eight representative NSLs surrounding the proposed project site. Noise predictions to the nearest NSLs have been prepared for both the construction and operational phases.

For a glossary of terms used in this chapter please refer to Appendix 12.1.

12.1.1 Statement of Authority

This chapter of the EIAR has been prepared by the following staff of AWN Consulting Ltd:

Mike Simms (Senior Acoustic Consultant) holds a BE and MEngSc in Mechanical Engineering and is a member of the Institute of Acoustics (MIOA) and of the Institution of Engineering and Technology (MIET). Mike has worked in the field of acoustics for over 20 years. He has extensive experience in all aspects of environmental surveying, noise modelling and impact assessment for various sectors including, wind energy, industrial, commercial, and residential.

Dermot Blunnie (Senior Acoustic Consultant) holds a BEng (Hons) in Sound Engineering, MSc in Applied Acoustics and has completed the Institute of Acoustics (IOA) Diploma in Acoustics and Noise Control. He has been working in the field of acoustics since 2008 and is a member of the Institute of Engineers Ireland (MIEI) and the Institute of Acoustics (MIOA). He has extensive knowledge and experience in relation to commissioning noise monitoring and impact assessment of wind farms as well as a detailed knowledge of acoustic standards and proprietary noise modelling software packages. He has commissioned noise surveys and completed noise impact assessments for numerous wind farm projects within Ireland.

12.1.2 Fundamentals of Acoustics

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. To take account of the enormous range of pressure levels that can be detected by the ear, it is widely accepted that sound levels are measured and expressed using a decibel scale i.e., 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 0 dB (for the threshold of hearing) to 120 dB (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 10 dB 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 3 dB.

The frequency of sound is the rate at which a sound wave oscillates 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 250 Hz. To rank the SPL of various noise sources, the measured level must be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. The 'A-weighting' system defined in the international standard, BS ISO 226:2003 *Acoustics. Normal Equal-loudness Level Contours* has been found to provide the best correlations with human response to perceived loudness. SPLs 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 Figure12-1.

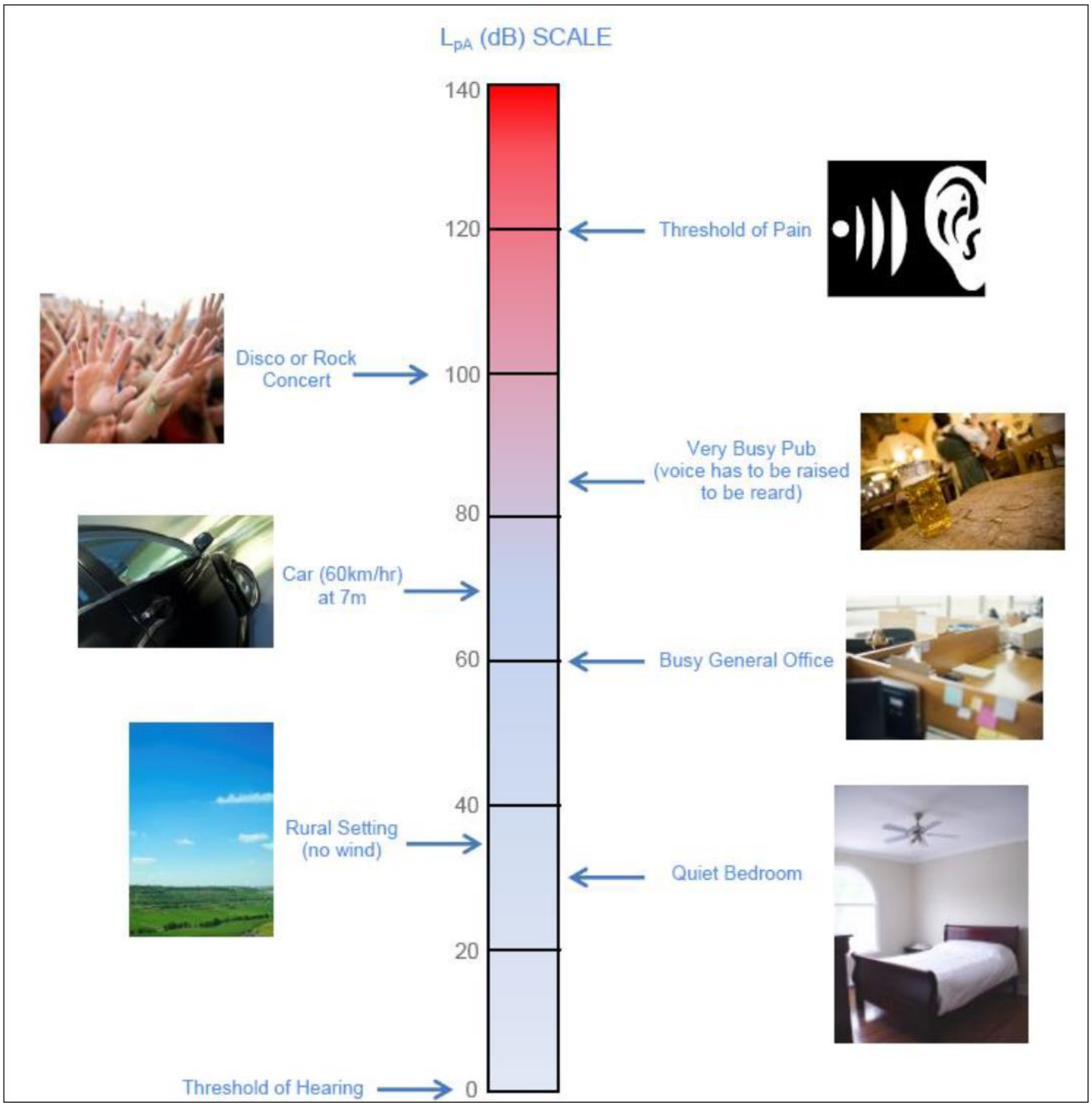

Figure12-1: dB(A) Scale & Indicative Noise Levels – (EPA: Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4 – 2016))

12.2 METHODOLOGY

The assessment of impacts for the proposed project have been undertaken with reference to the most appropriate guidance documents relating to environmental noise and vibration, in addition to specific guidance documents that have been consulted when preparing this chapter of the EIAR:

- EPA Guidelines on the Information to be contained in Environmental Impact Statements, (EPA, 2022).
- Wind Energy Development Guidelines for Planning Authorities, Department of the Environment, Heritage, and Local Government (2006).
- The Assessment and Rating of Noise from Wind Farms, Department of Trade, and Industry (UK) Energy Technology Support Unit (ETSU) (1996).
- A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (IOA GPG) (2013).
- Guidelines for the Treatment of Noise and Vibration in National Road Schemes, Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA) (2004).
- British Standard BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.
- British Standard BS 5228-2:2009+A1:2014 Code of practice for vibration control on construction and open sites – Vibration.
- BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration (BSI, 1993).
- United Kingdom Highways Agency (UKHA) Design Manual for Roads and Bridges (DMRB) Sustainability & Environment Appraisal LA 111 Noise and Vibration Revision 2 (UKHA 2020)
- ISO 1996: 2017: Acoustics – Description, measurement, and assessment of environmental noise.
- ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation (1996).

The assessment methodology undertaken is summarised as follows:

- Review of appropriate guidance to identify appropriate noise and vibration criteria for both the construction, operational and decommissioning phases.
- Characterise the receiving environment through baseline noise surveys at various NSLs surrounding the proposed project.
- Undertake predictive calculations to assess the potential impacts associated with the construction phase of the proposed project at NSLs.
- Undertake predictive calculations to assess the potential impacts associated with the operational of the proposed project at NSLs.
- Specify mitigation measures to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the proposed project.
- Describe the significance of the residual noise and vibration effects associated with the proposed project.

This assessment considers all scenarios within the proposed turbine range as described in section in 12.2.3.3. See that section for details of the approach.

This chapter comprehensively assesses all scenarios within the turbine range which is described in Section 12.2.3.3. The potential impacts that could arise from the proposed project during the construction, and decommissioning phases relate to increases in noise due to construction and decommissioning activities. There will be no change to the potential impacts or predicted effects irrespective of which turbine is selected within the turbine range. The potential impacts that could arise from the proposed project during the operational phase relate to increases in noise caused by the operational wind turbines.

It is important to emphasise in this context that it is both the height of the hub of the turbine and the sound power level of the turbine which dictate a difference in the resulting noise levels at noise sensitive locations across the Turbine Range.

A range of candidate turbines is listed in Section 12.2.3.3, incorporating various hub heights, tip heights, rotor diameters and sound power levels. Based on this set of turbines, a set of sound power levels have been developed based on manufacturer's data for each candidate turbine. On review of the results this exercise, sound power levels representing the upper end and the lower end of the Turbine Range were selected for use in the assessment.

A proposed mitigation scheme to control the operational modes of the turbines when criteria exceeded is described in Section 12.4.4.1 and these mitigation measures and will be implemented in full where required for the turbine selected within the Turbine Range. This will ensure the operational wind farm noise levels will meet the daytime and night time criteria set out in Section 12.3.1.10 irrespective of the turbine selected within the Turbine Range.

12.2.1 EPA Description of Effects

The significance of effects of the proposed project shall be described in accordance with the EPA guidance document Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), (2022). Details of the methodology for describing the significance of the effects are provided in Chapter 1 – Introduction.

The effects associated with the proposed project are described in the relevant sections of this chapter in accordance with the EPA guidance set out in Chapter 1 (Introduction).

12.2.2 Guidance Documents and Assessment Criteria

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

12.2.2.1 Construction Phase Noise

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities normally control construction activities by imposing limits on the hours of operation and may consider noise limits at their discretion.

In the absence of specific noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise* (BS5528-1).

The approach adopted here calls for the designation of an NSL into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. A threshold noise value is applied to each category. Exceedances (construction noise only) of the threshold value, at the facade of a noise-sensitive location (NSL) during construction, indicates a potential significant noise impact associated with the construction activities. The threshold values recommended by BS5228-1 are depicted in Table 12-1.

Table 12-1: Example Threshold Potential Significant Effect at Dwellings

Assessment category and threshold value period (T)	Threshold value, in $L_{Aeq,T}$ dB		
	Category A Note A	Category B Note B	Category C Note C
Night-time (23:00 to 07:00hrs)	45	50	55
Evenings 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.

It should be noted that this assessment method is only valid for residential properties. The following method should be followed:

For the appropriate period (e.g., daytime) the ambient noise level is determined and rounded to the nearest 5 dB. At some properties, particularly those located close to busy roads, the ambient noise levels are expected to be relatively high. However, given the rural nature of the site in general, daytime noise levels are below 65dB $L_{Aeq,T}$. Therefore, for the purposes of this assessment, as a worst case, all properties will be afforded a Category A designation. See Section 12.4.2.1 for the detailed assessment in relation to properties. If the specific construction noise level exceeds the appropriate category value (e.g., 65 dB $L_{Aeq,T}$ during daytime periods) then a significant effect is deemed to occur.

12.2.2.2 Construction Phase Vibration

Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. With respect to this development, the range of relevant criteria used for building protection is expressed in terms of Peak Particle Velocity (PPV) in mm/s.

Guidance relevant to acceptable vibration within buildings is contained in the following documents:

- BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration (BSI, 1993) (BS7385).
- BS 5228-2:2009+A1:2014 – Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration (BSI, 2014) (BS5228-2).

BS7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15 mm/s at low frequencies rising to 20 mm/s at 15 Hz and 50 mm/s at 40 Hz and above. These guidelines relate to relatively modern buildings and should be reduced to 50% or less for more critical buildings.

BS5228-2 recommends that, for a soundly constructed residential properties and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e., non-structural) damage should be taken as a peak particle velocity of 15 mm/s for transient vibration at frequencies below 15 Hz and 20 mm/s at frequencies above than 15 Hz. Below these vibration magnitudes minor damage is unlikely, although the standard notes that where there is existing damage these limits may be reduced by up to 50%. In addition, where continuous vibration is such that resonances are excited within structures the limits discussed above may need to be reduced by 50%.

The Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) publication *Guidelines for the Treatment of Noise and Vibration in National Road Schemes (NRA, 2004)* also contains information on the permissible construction vibration levels during the construction phase as shown in Table 12-2.

Table 12-2: Allowable Vibration at Sensitive Properties (NRA, 2004)

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of		
Less than 10Hz	**10 to 50Hz**	**50 to 100Hz (and above)**
8 mm/s	12.5 mm/s	20 mm/s

Following review of the guidance documents set out above, the values in Table 12-2 are considered appropriate for this assessment as they provide more stringent vibration criteria.

12.2.2.3 Additional Vehicular Activity on Public Roads Construction Phase

There are no specific guidelines or limits relating to traffic related sources along the local or surrounding roads. Given that traffic from the project will make use of existing roads already carrying traffic volumes, it is appropriate to assess the calculated increase in traffic noise levels that will arise because of vehicular movements associated with the proposed project.

For the assessment of potential noise impacts from construction related traffic along public roads and it is proposed to adopt guidance from Design Manual for Roads and Bridges (DMRB), Highways England, Transport Scotland, The Welsh Government and The Department of Infrastructure 2019., Table 12-3, taken from DMRB offers guidance as to the likely short term impact associated with any change in traffic noise level.

Table 12-3: Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2019).

Change in Sound Level (dB L_{A10})	Magnitude of Impact
0	No change
0.1 – 0.9	Negligible
1 – 2.9	Minor
3 – 4.9	Moderate
5+	Major

Section 3.19 of DMRB states that construction noise and construction traffic noise shall constitute a significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:

- 10 or more days or nights in any 15 consecutive days or nights; or
- A total number of days exceeding 40 in any 6 consecutive months.

The DMRB guidance will be used to assess the predicted increases in traffic levels on public roads associated with the proposed project and comment on the likely short-term impacts during the construction phase.

12.2.2.4 Operational Phase Noise

The noise assessment documented in this chapter is based on guidance in relation to acceptable levels of noise from wind farms as contained in the document *Wind Energy Development Guidelines for Planning Authorities* published by the Department of the

Environment, Heritage and Local Government in 2006. These guidelines are in turn based on detailed recommendations set out in the Department of Trade and 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 "*Wind Energy Development Guidelines*" publication where necessary. Planning permissions and decisions issued by An Bord Pleanála and / or the local authority in relation to wind energy sites in the wider area are also reviewed here.

12.2.2.4.1 The Assessment and Rating of Noise from Wind Farms – ETSU-R-97

As stated previously the core of the noise guidance contained within the Wind Energy Development Guidelines is based on the 1996 ETSU publication The Assessment and Rating of Noise from Wind Farms (ETSU-R-97).

ETSU-R-97 calls for the control of wind turbine noise by the application of noise limits at the nearest noise sensitive properties. ETSU-R-97 considers that absolute noise limits applied at all wind speeds are not suited to wind turbine developments and recommends that noise limits should be set relative to the existing background noise levels at noise sensitive locations. A critical aspect of the noise assessment of wind energy proposals relates to the identification of baseline noise levels through on-site noise surveys.

ETSU-R-97 states on page 58, "…*absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question*…". Therefore, the noise contribution from all wind turbine development in the area should be included in the assessment.

The ETSU-R-97 guidance allows for a higher level of turbine noise operation at properties that have an involvement in the project, both as a higher fixed level of 45 dB L_{A90} and/or a higher level above the prevailing background noise level.

12.2.2.4.2 Wind Energy Development Guidelines for Planning Authorities

Section 5.6 of the *Wind Energy Development Guidelines for Planning Authorities* published by the Department of the Environment, Heritage and Local Government (2006) addresses noise and outlines the appropriate noise criteria in relation to 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 Guidelines give 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 chapter the various issues identified in this extract have been incorporated into our assessment.

"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 benefits. 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."

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.

In summary, the Wind Energy Development Guidelines outlines the following guidance to identify appropriate wind turbine noise criteria curves at noise sensitive locations:

- An appropriate absolute limit level in the range of 35 – 40 dB L_{A90} for quiet daytime environments with background noise levels of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher), for daytime environments with background noise levels of not less than 30 dB $L_{A90,10min}$ and;
- 43 dB $L_{A90,10min}$ for night time periods.

While the caveat of an increase of 5dB(A) above background for night-time operation is not explicit within the current guidance it is commonly applied in noise assessments prepared and is detailed in numerous examples of planning conditions issued by local authorities and An Bord Pleanála.

12.2.2.4.3 Institute of Acoustics Good Practice Guide

The original ETSU-R-97 concepts underwent a thorough standardisation and modernisation in 2013 with the Institute of Acoustics publication of A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (IOA GPG) including 6 Supplementary Guidance Notes. These documents bring together the combined experience of acoustic consultants in the UK and Ireland in the application of the assessment methods. Numerous improvements in the accuracy and robustness are described the treatment of wind shear and the general adaptation to larger wind turbines. The guidance contained within IOA GPG, and its Supplementary Guidance Notes are considered to represent best practice and have been adopted for this assessment.

The IOA GPG states, that at a minimum continuous baseline noise monitoring should be carried out at the nearest noise sensitive locations for typically a two-week period and should capture a representative sample of wind speeds in the area (i.e., cut in speeds to wind speed of rated sound power of the proposed turbine). Background noise measurements (i.e., $L_{A90,10min}$) should be related to wind speed measurements that are collated at the site of the wind turbine development. Regression analysis is then conducted on the data sets to derive background noise levels at various wind speeds to establish the appropriate day and night time noise criterion curves.

Noise emissions associated with the wind turbines can be predicted in accordance with ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation (1996). This is a noise prediction standard that considers noise attenuation offered, amongst others, by distance, ground absorption, directivity, and atmospheric absorption. Noise predictions and contours are typically prepared for various wind speeds and the predicted levels are compared against the relevant noise criterion curve to demonstrate compliance with the appropriate noise criteria.

Where noise predictions indicate that reductions in noise emissions are required to satisfy any adopted criteria, consideration can be given to detailed downwind analysis and operating turbines in low noise mode, which is typically offered by modern wind turbine units.

For guidance on the methodology for the background noise survey and operation impact assessment for wind turbine noise the IOA GPG has been adopted.

The IOA GPG states that cumulative noise exceedances should be avoided and where existing or permitted development is at the noise limit, any new turbine noise sources should be designed to be 10 dB below the limit value.

Section 5.1 of the relevant IOA GPG states the following:

> "*5.1.1 ETSU-R-97 states at page 58, "…absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question…"*
>
> *5.1.2 The HMP Report states that "If an existing wind farm has permission to generate noise levels up to ETSU-R-97 limits, planning permission noise limits set at any future neighbouring wind farm would have to be at least 10 dB lower than the limits set for the existing wind farm to ensure there is no potential for cumulative noise impacts to breach ETSU-R-97 limits (except in such cases where a higher fixed limit could be justified)". Such an approach could prevent any further wind farm development in the locality, and a more detailed analysis can be undertaken on a case by case basis.*
>
> *5.1.3 As with the assessment of noise for all wind farm developments, sequential steps need to be taken, but such steps require more detailed attention due to the added complexity of cumulative noise impacts. The advice of the EHO could be invaluable to this part of the assessment."*
>
> *Cumulative impact assessment necessary*
>
> *5.1.4 During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.*
>
> *5.1.5 Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary."*

Note that comment on cumulative noise effect with forestry activity is presented in Section 12.7.

12.2.2.4.4 Future Potential Guidance Changes

In December 2019, the Draft Revised Wind Energy Development Guidelines December 2019 were published for consultation and therefore have yet to be finalised. It is important to note that as part of the public consultation several concerns in relation to the proposed approach have been expressed by various parties and it is the opinion of the authors of this assessment that the document does not outline a best practice approach in terms of the assessment of wind turbine noise. Specific concerns expressed by a cross party group of interested professionals can be reviewed at:

https://www.ioa.org.uk/wind-energy-development-guidelines-wedg-consultation-irish-department-housing-planning-community-and

The following statement is of note from the above submission:

> "*a number of acousticians working in the field have raised serious concerns over the significant amount of technical errors, ambiguities and inconsistencies in the content of the draft WEDG and these were highlighted during the consultation process by a group of acousticians*"

Therefore, in line with best practice the assessment presented in the EIAR is based on the current guidance outlined in the Wind Energy Development Guidelines for Planning Authorities (2006) and has been supplemented with guidance from ESTU-R-97 and the IOA GPG and its supplementary guidance notes.

If updated Wind Energy Guidelines are published during the application process for the proposed project it is anticipated that any relevant changes affecting the noise will be addressed through an appropriate planning condition, or where a supplementary assessment is necessary, through provision of additional information.

12.2.2.4.5 World Health Organization (WHO) Noise Guidelines for the European Region

The WHO Environmental Noise Guidelines for the European Region (2018) provide guidance on protecting human health from exposure to environmental noise. They set health-based recommendations based on average environmental noise exposure of several sources of environmental noise, including wind turbine noise. Recommendations are rated as either 'strong' or 'conditional'. A strong recommendation, "*can be adopted as policy in most situations*" whereas a conditional recommendation, "*requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply*".

The objective of the WHO Environmental Noise Guidelines for the European Region is to provide recommendations for protecting human health from exposure to environmental noise from transportation, wind farm and leisure sources of noise. The guidelines present recommendations for each noise source type in terms of L_{den} and L_{night} levels above which there is risk of adverse health risks.

In relation to wind turbine noise, the WHO Guideline Development Group (GDG) state the following:

"For average noise exposure, the GDG conditionally recommends reducing noise levels produced by wind turbines below 45 dB L_{den}, as wind turbine noise above this level is associated with adverse health effects.

No recommendation is made for average night noise exposure L_{night} of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.

To reduce health effects, the GDG conditionally recommends that policy-makers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another."

As stated within the same WHO document, the quality of evidence used for this research is stated as being 'Low', the recommendations are therefore conditional.

The WHO Environmental Noise Guidelines aim to support the legislation and policy-making process on local, national, and international level, thus shall be considered by Irish policy makers for any future revisions of Irish National Guidelines.

There is potential increased uncertainty due to the parameter used by the WHO for assessment of exposure (i.e., L_{den}), which it is acknowledged may be a poor characterisation of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes, as stated below, from within Environmental Noise Guidelines:

"Even though correlations between noise indicators tend to be high (especially between L_{Aeq}-like indicators) and conversions between indicators do not normally influence the correlations between the noise indicator and a particular health effect, important assumptions remain when exposure to wind turbine noise in Lden is converted from original sound pressure level values. The conversion requires, as variable, the statistical distribution of annual wind speed at a particular height, which depends on the type of wind turbine and meteorological conditions at a particular geographical location. Such input variables may not be directly applicable for use in other sites. They are sometimes used without specific validation for a particular area, however, because of practical limitations or lack of data and resources. This can lead to increased uncertainty in the assessment of the relationship between wind turbine noise exposure and health outcomes. Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes."

…Further work is required to assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region."

It is considered that the conditional WHO recommended average noise exposure level (i.e. 45 dB L_{den}) if applied, as target noise criteria for an existing or proposed wind turbine development in Ireland, should be done with caution. The conditional WHO recommendation for average noise exposure level (i.e., 45 dB L_{den}) may be a poor characterisation of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes.

12.2.2.5 Special Characteristics

12.2.2.5.1 Infrasound/Low Frequency Noise

Low Frequency Noise is noise that is dominated by frequency components less than approximately 200 Hz whereas Infrasound is typically described as sound at frequencies below 20 Hz. In relation to Infrasound, the following extract from the EPA document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)* (EPA, 2011) is noted here:

> *"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."*

With respect to infrasonic noise levels below the hearing threshold, the World Health Organisation (WHO) document *Community Noise* (WHO, 1995) has stated that:

> *"There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects."*

The Environmental Noise Guidelines (WHO, 2018) states the following in relation to infrasound from wind turbines:

> *Wind turbines can generate infrasound or lower frequencies of sound than traffic sources. However, few studies relating exposure to such noise from wind turbines to health effects are available. It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, particularly when windows are closed.*

In 2010, the UK Health Protection Agency published a report entitled *Health Effects of Exposure to Ultrasound and Infrasound, Report of the independent Advisory Group on Non-ionising Radiation*. The exposures considered in the report related to medical applications and general environmental exposure. The report notes:

> *"Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.*
>
> *For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects."*

The UK Institute of Acoustics Bulletin in March 2009 included a statement of agreement between acoustic consultants regularly employed on behalf of wind farm developers, and conversely acoustic consultants regularly employed on behalf of community groups campaigning against wind farm developments (IAO JS2009). The intent of the article was to promote consistent assessment practices, and to assist in restricting wind farm noise disputes to legitimate matters of concern. The article notes the following with respect to infrasound:

> *"Infrasound is the term generally used to describe sound at frequencies below 20 Hz. At separation distances from wind turbines which are typical of residential locations the levels of infrasound from wind turbines are well below the human perception level. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles.*
>
> *Sounds at frequencies from about 20 Hz to 200 Hz are conventionally referred to as low-frequency sounds. A report for the DTI in 2006 by Hayes McKenzie concluded that neither infrasound nor low frequency noise was a significant factor at the separation distances at which people lived. This was confirmed by a peer review by a number of consultants working in this field. We concur with this view."*

The article concludes that:

> *"from examination of reports of the studies referred to above, and other reports widely available on internet sites, we conclude that there is no robust evidence that low frequency noise (including 'infrasound') or ground -borne vibration from wind farms, generally has adverse effects on wind farm neighbours".*

A report released in January 2013 by the South Australian Environment Protection Authority namely, *Infrasound levels near windfarms and in other environments* (EPA, 2013)[1] found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

The study included several houses in rural and urban areas, both adjacent to and away from a wind farm, and measured the levels of infrasound with the wind farms operating and switched off.

There were no noticeable differences in the levels of infrasound under all these different conditions. In fact, the lowest levels of infrasound were recorded at one of the houses closest to a wind farm, whereas the highest levels were found in an urban office building.

The EPA's study concluded that the level of infrasound at houses near wind turbines was no greater than in other urban and rural environments, and stated that:

> *"The contribution of wind turbines to the measured infrasound levels is insignificant in comparison with the background level of infrasound in the environment."*

A German report[2], titled "*low frequency noise incl. infrasound from wind turbines and other sources*" presents the details of a measurement project which ran from 2013. The report was published by the State Office for the Environment, Measurement and Nature Conservation of

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1 EPA South Australia, 2013, Wind farms https://www.epa.sa.gov.au/files/477912_infrasound.pdf

2 Report available at https://www4.lubw.baden-wuerttemberg.de/servlet/is/262445/low-frequency_noise_incl_infrasound.pdf?command=downloadContent&filename=low-frequency_noise_incl_infrasound.pdf

the Federal State of Baden-Württemberg in 2016 and concluded the following in relation to infrasound from wind turbines:

> *"The measured infrasound levels (G levels) at a distance of approx. 150 m from the turbine were between 55 and 80 dB(G) with the turbine running. With the turbine switched off, they were between 50 and 75 dB(G). At distances of 650 to 700 m, the G levels were between 55 and 75 dB(G) with the turbine switched on as well as off.*
>
> *"For the measurements carried out even at close range, the infrasound levels in the vicinity of wind turbines – at distances between 150 and 300 m – were well below the threshold of what humans can perceive in accordance with DIN 45680 (2013 Draft)[3]"*
>
> *"The results of this measurement project comply with the results of similar investigations on a national and international level."*

In conclusion, there is a significant body of evidence to show that the infrasound associated with wind turbines will be below perceptibility thresholds and typically in line with existing baseline levels of infrasound within the environment.

12.2.2.5.2 Amplitude Modulation

In the context of this assessment, amplitude modulation (AM) is defined in the IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) document *A Method for Rating Amplitude Modulation in Wind Turbine* (IOA, 2016) 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 (BPF) of the turbine rotor(s)."*

It is now generally accepted that there are two mechanisms which can cause amplitude modulation:

- 'Normal' AM, and;
- 'Other' AM (sometimes referred to 'Excessive' AM).

In both cases, the result is a regular fluctuation in amplitude at the Blade Passing Frequency (BPF) of the wind turbine blades (the rate at which the blades of the turbine pass a fixed point). For a three-bladed turbine rotating at 20 rpm, this equates to a modulation frequency of 1 Hz.

'Normal' AM — An observer at ground level close to a wind turbine will experience 'blade swish' because of the directional characteristics of the noise radiated from the trailing edge of the blades as it rotates towards and then away from the observer.

This effect is reduced for an observer on or close to the turbine axis, and therefore would not generally be expected to be significant at typical separation distances between turbines and NSLs, at least on relatively level sites.

3 DIN 45680:2013-09 – Draft "Measurement and assessment of low-frequency noise immissions" November 2013

The RenewableUK AM project (RenewableUK, 2013) has coined the term 'normal' AM (NAM) for this inherent characteristic of wind turbine noise, which has long been recognised and was discussed in ETSU-R-97 in 1996.

'Other' AM — In some cases AM is observed at large distances from a wind turbine (or turbines). The sound is generally heard as a periodic 'thumping' or 'whoomphing' at relatively low frequencies.

On sites where it has been reported, occurrences appear to be occasional, although they can persist for several hours under some conditions, dependent on atmospheric factors, including wind speed and direction.

It was proposed in the RenewableUK 2013 study that the fundamental cause of this type of AM is transient stall conditions occurring as the blades rotate, giving rise to the periodic thumping at the blade passing frequency.

Transient stall represents a fundamentally different mechanism from blade swish and can be heard at relatively large distances, primarily downwind of the rotor blade.

The RenewableUK AM project report adopted the term 'Other AM' (OAM) for this characteristic. The terms 'enhanced' or 'excess' AM (EAM) have been used by others, although such definitions do not distinguish between the source mechanisms and presuppose a 'normal' level of AM, presumably relating back to blade swish as described in ETSU-R-97.

The initials 'AM' in the remainder of this chapter refer to Other AM as described above.

Frequency of Occurrence of AM

Research by Salford University commissioned by the Department of Environment Food and Rural Affairs (DEFRA), the Department of Business, Enterprise and Regulatory Reform (BERR) and the Department of Communities and Local Government (CLG) investigated the issue of AM associated with wind turbine noise. The results were reviewed and published in the report 'Research into Aerodynamic Modulation of Wind Turbine Noise' (2007). The broad conclusions of this report were that aerodynamic modulation was only considered to be an issue at four, and a possible issue at a further eight, of 133 sites in the UK that were operational at the time of the study and considered within the review. At the four sites where AM was confirmed as an issue, it was considered that conditions associated with AM might occur between about 7 and 15% of the time. It also emerged that for three out of the four sites the complaints have subsided, in one case due to the introduction of a turbine control system. The research has shown that AM is a rare and unlikely occurrence at operational wind farms.

It should be noted that AM is associated with wind turbine operation and it is not possible to predict an occurrence of AM at the planning stage. It should also be noted that it is a rare event associated with a limited number of wind farms. While it can occur, it is the exception rather than the rule.

RenewableUK Research Document states the following in relation to matter:

Page 68 Module F "even on those limited sites where it has been reported, its frequency of occurrence appears to be at best infrequent and intermittent."

Page 6 Module F *"It has also been the experience of the project team that, even at those wind farm sites where AM has been reported or identified to be an issue, its occurrence may be relatively infrequent. Thus, the capture of time periods when subjectively significant AM occurs may involve elapsed periods of several weeks or even months."*

Page 61 Module F *"There is nothing at the planning stage that can presently be used to indicate a positive likelihood of OAM occurring at any given proposed wind farm site, based either on the site's general characteristics or on the known characteristics of the wind turbines to be installed."*

Assessment of AM

Research and Guidance in the area is ongoing with recent publications being issued by the Institute of Acoustics (IOA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, A Method for Rating Amplitude Modulation in Wind Turbine Noise (August 2016) (The Reference Method). The document proposes an objective method for measuring and rating AM. The AMWG does not propose what level of AM is likely to result in adverse community response or propose any limits for AM. The purpose of the group is simply to use existing research to develop a Reference Methodology for the measurement and rating of amplitude modulation. At present there is no method for predicting AM at any particular location before turbines begin operation due to the general features of a site or the known attributes of a particular turbine. Further details on mitigation measures in the event of AM are presented in Section 12.5.2.1.

The definition of any limits of acceptability for AM, or consideration of how such limits might be incorporated into a wind farm planning condition, is outside the scope of the AMWG's work and is currently the subject of a separate UK Government funded study.

Where it occurs, AM is typically an intermittent occurrence, therefore assessment may involve long-term measurements. The 'Reference Method' for measuring AM outlined in the IOA AMWG document will provide a robust and reliable indicator of AM and yield important information on the frequency and duration of occurrence, which can be used to evaluate different operational conditions including mitigation, in the unlikely event that amplitude modulation occurs.

12.2.2.5.3 Comment on Health Impacts

The National Health and Medical Research Council

The relevant Australian authority on health issues, the National Health and Medical Research Council (NHMRC), conducted a comprehensive independent assessment of the scientific evidence on wind farms and human health. The findings are contained in the NHMRC Information Paper: Evidence on Wind Farms and Human Health 2015, which concluded:

> *"After careful consideration and deliberation, NHMRC concluded that there is no consistent evidence that wind farms cause adverse health effects in humans. This finding reflects the results and limitations of the direct evidence and also takes into account the relevant*

available parallel evidence on whether or not similar noise exposure from sources other than wind farms causes health effects"

Health Canada

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014[4]. The study was initiated in 2012 specifically to gather new data on wind farms and health. The study considered physical health measures that assessed stress levels using hair cortisol, blood pressure and resting heart rate, as well as measures of sleep quality. More than 4,000 hours of wind turbine noise measurements were collected and a total of 1,238 households participated.

No evidence was found to support a link between exposure to wind turbine noise and any of the self-reported illnesses. Additionally, the study's results did not support a link between wind turbine noise and stress, or sleep quality (self-reported or measured). However, an association was found between increased levels of wind turbine noise and individuals reporting of being annoyed.

New South Wales Health Department

In 2012, the New South Wales (NSW) Health Department provided written advice to the NSW Government that stated existing studies on wind farms and health issues had been examined and no known causal link could be established.

NSW Health officials stated that fears that wind turbines make people sick are 'not scientifically valid'. The officials wrote that there was no evidence for 'wind turbine syndrome', a collection of ailments including sleeplessness, headaches and high blood pressure that some people believe are caused by the noise of spinning blades.

The Australian Medical Association

The Australian Medical Association put out a position statement, *Wind Farms and Health* 2014[5]. The statement said:

> *"The available Australian and international evidence does not support the view that the infrasound or low frequency sound generated by wind farms, as they are currently regulated in Australia, causes adverse health effects on populations residing in their vicinity. The infrasound and low frequency sound generated by modern wind farms in Australia is well below the level where known health effects occur, and there is no accepted physiological mechanism where sub-audible infrasound could cause health effects."*

Journal of Occupational and Environmental Medicine

The review titled, Wind Turbines and Health: A Critical Review of the Scientific Literature was published in the Journal of Occupational and Environmental Medicine, 2014. An independent

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4 Health Canada 2014, Wind Turbine Noise and Health Study: Summary of Results. Available at https://www.canada.ca/en/health-canada/services/environmental-workplace-health/noise/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html

5 Australian Medical Association, 2014, Wind farms and health. Available https://ama.com.au/position-statement/wind-farms-and-health-2014

review of the literature was undertaken by the he Department of Biological Engineering of the Massachusetts Institute of Technology (MIT). The review took into consideration health effects such as stress, annoyance and sleep disturbance, as well as other effects that have been raised in association with living close to wind turbines. The study found that:

> *"No clear or consistent association is seen between noise from wind turbines and any reported disease or other indicator of harm to human health."*

The report concluded that living near wind farms does not result in the worsening of the quality of life in that particular region.

Summary

The peer reviewed research outlined in the preceding sections supports that there are no direct negative health effects on people with long term exposure to wind turbine noise. Please refer to Chapter 5 Population and Human Health of the EIAR for further details of potential health impacts associated with the proposed project.

12.2.2.6 Operational Phase Vibration

Vibration generated from the operation of a wind turbine unit will decrease rapidly with distance. Typically, at 100 m from a 1 MW turbine unit the level of vibration associated with a turbine is the order of 10^{-5} mm/s.

A report from Germany published by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016, "*low frequency noise incl. infrasound from wind turbines and other sources*" conducted vibration measurements study for an operational Nordex N117 – 2.4 MW wind turbine. The report concluded that at distances of less than 300 m from the turbine vibration levels had dropped so far that they could no longer be differentiated from the background vibration levels.

The shortest distance from any turbine in the proposed project to the nearest NSL is approximately 925 m (approximate distance from turbine T16 to NSL ref. H066), with a distance of >880m to the curtilage. At that distance, the level of vibration will be significantly below any thresholds for perceptibility. Therefore, vibration criteria have not been specified for the operational phase of the proposed project.

12.2.2.7 Decommissioning Noise and Vibration

The guidance for construction noise and vibration assessment described above also applies to the decommissioning phase of the project at the end of the service life of the proposed project.

12.2.3 Assessment Methodology

12.2.3.1 Background Noise Survey

A background noise survey was undertaken to determine typical background noise levels at representative NSLs surrounding the project site. The background noise survey was conducted through installing unattended sound level meters at 8 no. representative locations in the surrounding area.

All measurement data collected during the background noise surveys has been carried out in accordance with the IOA GPG and accompanying Supplementary Guidance Note 1: *Data Collection* (2014) discussed in the following Section.

12.2.3.1.1 Choice of Measurement Locations

The noise monitoring locations were identified by preparing a preliminary noise model contour at an early stage of the assessment. Locations were selected generally on proximity to the proposed wind turbines. The selection of the noise monitoring locations was informed by a site visit and supplemented by reviewing aerial images of the study area and other online sources of information (e.g., Google Earth and OSI Maps).

The co-ordinates for selected locations for the noise monitoring are outlined in Table 12-4 and depicted on the map in Figure 12-2.

Table 12-4: Noise Measurement Co-ordinates

Location Ref.	Location I.D.	Co-ordinates (ITM)	
		Easting	Northing
NML-1 A	H255	584,146	900,558
NML-2 C	H362	583,926	898,980
NML-3 F	H065/H066	583,370	902,188
NML-4 G	H135	582,893	902,661
NML-5 J	H127	588,681	901,894
NML-6 K	H225	585,585	898,752
NML-7 L	H363	583,342	900,114
NML-8 X	H060	585,749	905,377

Site visits by survey personnel were carried out during the morning and afternoon time; during these visits, primary noise sources contributing to noise build-up were noted. In respect of night-time periods, when noise due to traffic on local roads, agricultural activities and other sources tend to reduce, there was no indication of any significant local night-time sources of noise at any location.

No significant sources of vibration were noted at any of the survey locations.

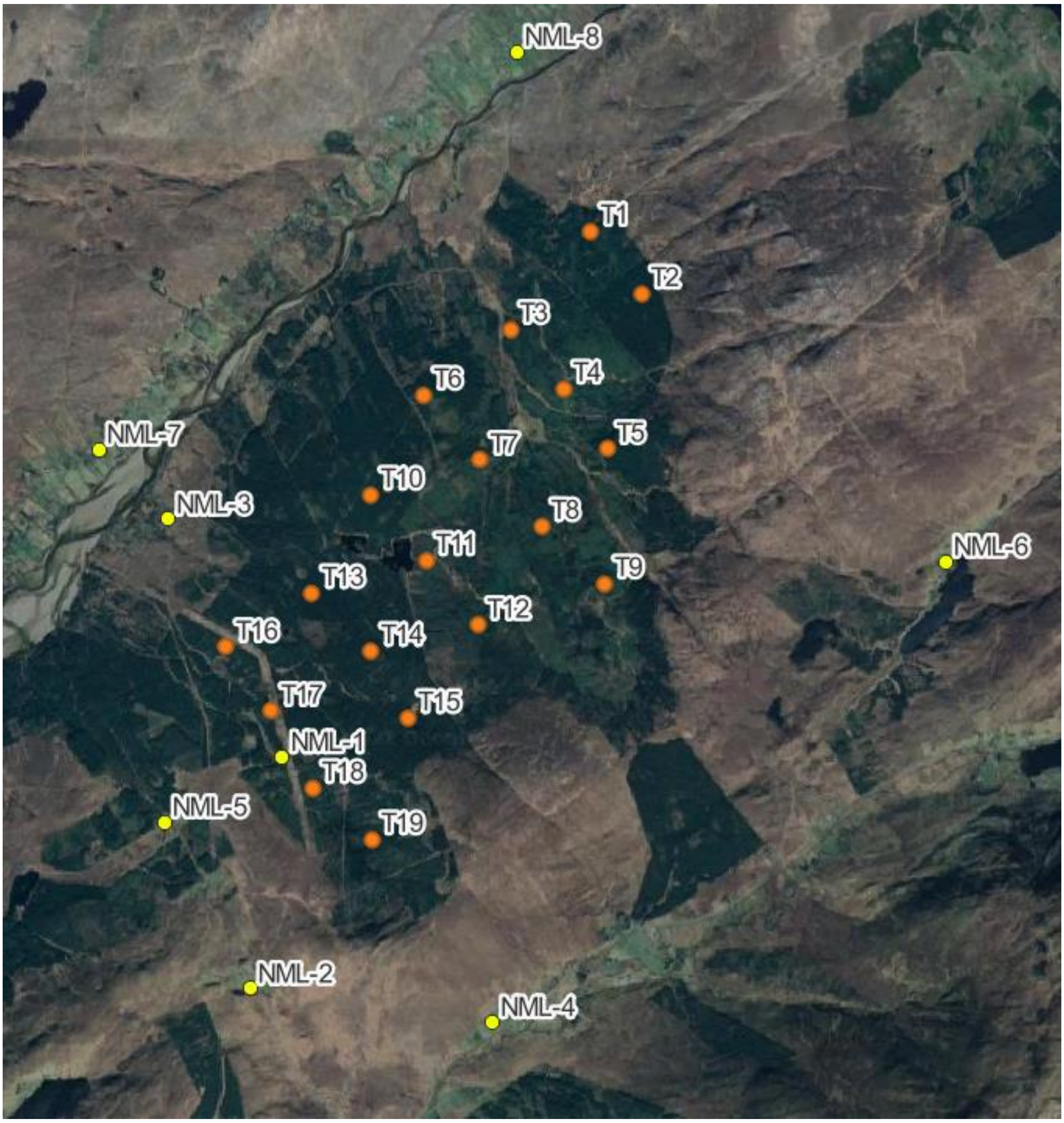

Figure 12-2: Noise Monitoring Locations

Figure 12-3 to Figure 12-8 illustrate the installed noise monitoring kits at each location.

12.2.3.1.2 Location NML1 (H255)

At NML1, the noise monitor was positioned some 60 m to the east of location H255, near the forested are within the applicant's lands. The location was noted to be quiet with very little road traffic audible, the main source of noise was low-level wind generated noise in the surrounding foliage.

Figure 12-3: Noise Monitoring Installation – Location A – yellow ellipse shows location of noise meter

12.2.3.1.3 Location NML2 (H362)

At NML2, the noise monitor was positioned in and open area to the northwest of the dwelling. The location was noted to be quiet with very little road traffic noise or other sources audible.

Figure 12-4: Noise Monitoring Installation – NML-2

12.2.3.1.4 Location NML3 (H065/H066)

At NML3, the noise monitor was positioned in an open area between dwelling H065 and H066 field to the north of the dwelling and farm to avoid influence from noise sources in and around the dwelling and farm. This location is distant from roads and noise levels were low.

Figure 12-5: Noise Monitoring Installation – NML-3

12.2.3.1.5 Location NML4 (H135)

At NML4, the noise monitor was positioned in the garden of the dwelling. Vehicle movements on the local L1783 road were audible.

Figure 12-6: Noise Monitoring Installation – NML-4

12.2.3.1.6 Location NML5 (H127)

At NML5, the noise monitor was positioned in the garden of the dwelling. Vehicle movements on the local road were audible.

Figure 12-7: Noise Monitoring Installation – NML-5 - yellow ellipse shows location of noise meter

12.2.3.1.7 Location NML6 (H225)

At NML6, the noise monitor was positioned in an open field to the rear of the dwelling. Vehicle movements on the R250 road were audible.

Figure 12-8: Noise Monitoring Installation – NML-6

12.2.3.1.8 Location NML7 (H363)

At NML7, the noise monitor was positioned in an open area to the side of the dwelling. The location was noted to be quiet with very little road traffic audible, the main source of noise was low-level wind generated noise in the surrounding foliage.

Figure 12-9: Noise Monitoring Installation – NML-7

12.2.3.1.9 Location NML8 (H060)

At NML4, the noise monitor was positioned in the garden of the dwelling. Vehicle movements on the local L1783 road were audible.

Figure 12-10: Noise Monitoring Installation – NML-8

12.2.3.1.10 Measurement Periods

The survey duration was typically 4 weeks, or until such time that enough data points were captured at each survey locations. Section 2.9.1 of the IOA GPG states:

> *"The duration of a background noise survey is determined only by the need to acquire sufficient valid data over the range of wind speeds (and directions, if relevant). It is unlikely that this requirement can be met in less than 2 weeks."*

AWN conducted an ongoing review of the survey data at regular intervals to establish when adequate data had been captured.

Noise measurements were conducted at relevant monitoring locations over the following periods:

Table 12-5: Noise Measurement Periods

Location Ref.	Location I.D.	Start Time	End Time
NML-1 A	H255	2 July 2021	26 Sept 2021
NML-2 C	H362	2 July 2021	12 Aug 2021
NML-3 F	One location representing H065/H066	1 July 2021	22 July 2021
		3 Sept 2021	29 Sept 2021
NML-4 G	H135	20 Oct 2021	9 Dec 2021
NML-5 J	H127	20 Oct 2021	8 Dec 2021
NML-6 K	H225	23 July 2021	24 Sept 2021
NML-7 L	H363	20 Oct 2021	9 Dec 2021
NML-8 X	H060	20 Oct 2021	11 Dec 2021

A variety of wind speed and weather conditions were encountered over the survey periods in question. As an indication to this, Figure 12-11 and Figure 12-12 shows the distribution of wind speed and direction recorded for all periods of day and night for the period between 2 July to 26 Sept 2021 and 20 Oct to 9 Dec 2021 respectively. The wind speed data presented below relates to a turbine hub height of 125 m which is the maximum hub height in the turbine range.

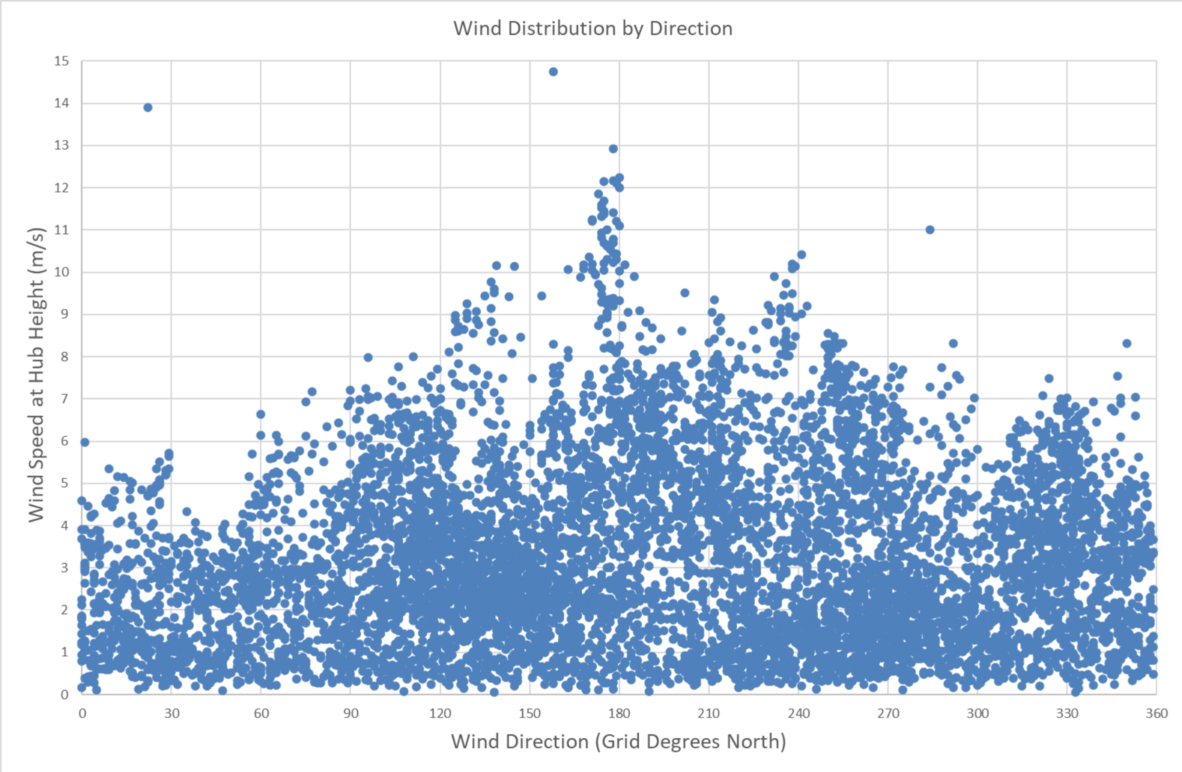

Figure 12-11: Distribution of Wind Speeds and Direction at Met Mast (2 July to 26 Sept 2021)

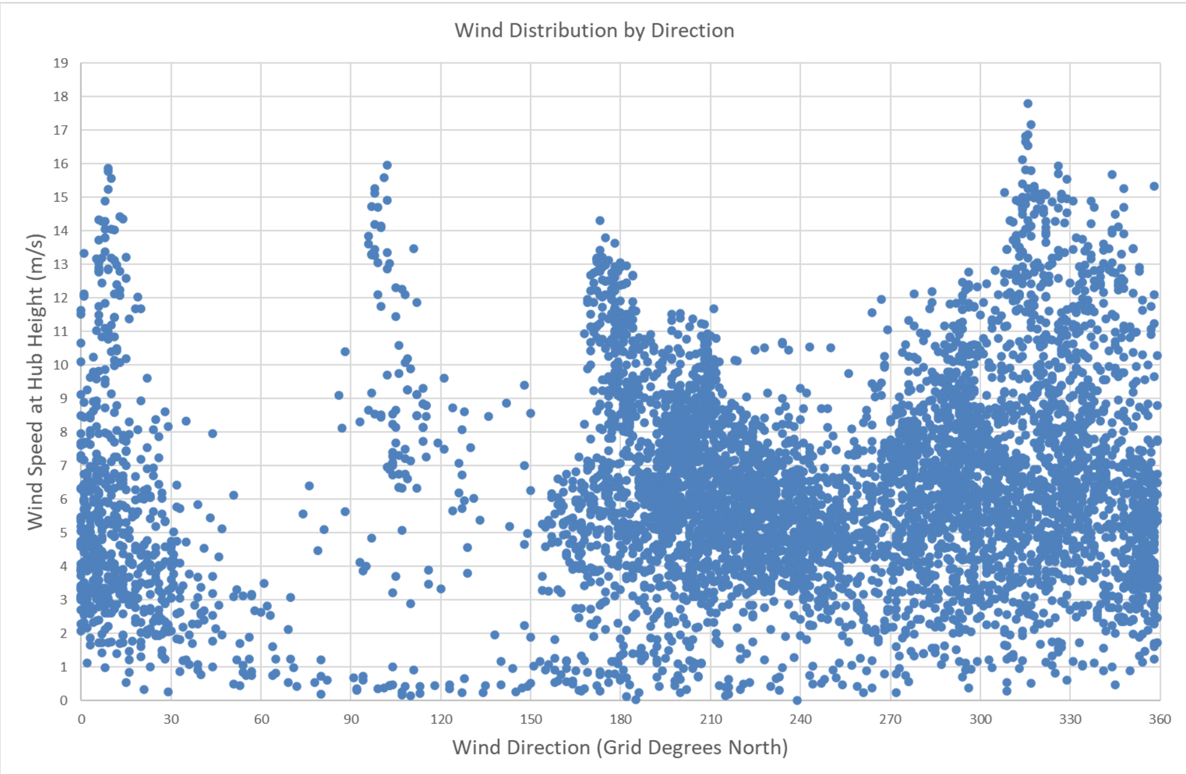

Figure 12-12: Distribution of Wind Speeds and Direction at Met Mast (20 Oct to 9 Dec 2021)

It is confirmed that survey periods were of sufficient duration to measured adequate data to determine a suitable representation of typical background at all locations in accordance with guidance contained within the IOA GPG.

12.2.3.1.11 Instrumentation

The following instrumentation was used at the various locations:

Table 12-6: Noise Measurement Instrumentation

Location	Equipment	Serial Number
NML-1 A	Rion NL-52	998409
NML-2 C	Rion NL-52	1076328
NML-3 F	Rion NL-52	575785
		575782
NML-4 G	Rion NL-52	1076328
NML-5 J	Rion NL-52	186667
NML-6 K	Rion NL-52	186667
NML-7 L	Rion NL-52	998409
NML-8 X	Rion NL-52	575782

Before, after and during each survey period, the measurement instrument was checked and calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator. The calibration drifts were noted, and the maximum drifts are detailed in Table 12-6 above. Relevant calibration certificates are presented in Appendix 12.2.

Rainfall was monitored using two rain gauges installed at Location NML-1, NML-5 and NML-8. The rainfall data allows for the identification of periods of rainfall so that they can be removed from the noise monitoring data sets, in line with best practice, when calculating the prevailing background noise levels at the various locations.

Wind speed measurements were obtained from an onsite met mast with anemometers situated at 75m and 55.7 m. The location of the met mast is provided in Table 12-7.

Table 12-7: Met Mast Location

Co-ordinates (ITM)	
Easting	Northing
583241	901079

12.2.3.1.12 Measurement Procedure

Measurements were conducted at all locations over the survey periods outlined in Table 12-6. Data samples for all measurements (noise, rainfall, and wind) were logged continuously at 10-minute interval periods for the duration of the survey. The $L_{Aeq,10min}$ and $L_{A90,10min}$ noise parameters were measured in this instance and 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. Description of the observed noise environment at each of the monitoring locations is presented below.

12.2.3.1.13 Consideration of Wind Shear

As part of a robust wind farm noise assessment due consideration should be given to the issue of wind shear. It is standard procedure to reference noise data to standardised 10 metre wind speed. The issue of wind shear has been considered in this assessment and followed relevant guidance as outlined in the IOA GPG. This guidance presents the following equations in relation to the derivation of a standardised wind speed at 10 m above ground level:

Equation A: Shear Exponent Profile

This uses the following equation:

$$U = U_{ref}\left[\frac{H}{H_{ref}}\right]^{m}$$

Where:

U	calculated wind speed.
U_{ref}	measured wind speed.
H	height at which the wind speed will be calculated.
H_{ref}	height at which the wind speed is measured.
m	shear exponent.

Equation B: Roughness Length Shear Profile

This uses the following equation:

$$U_1 = U_2\frac{\ln(H_1/z)}{\ln(H_2/z)}$$

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.

Any reference to wind speed in the following sections of this chapter should be understood to be the standardised 10 m height wind speed reference unless otherwise stated.

12.2.3.1.14 Atypical Noise Data

The data sets have been filtered to remove issues such as the dawn chorus and the influence of other atypical noise sources. An example of atypical sources would be short, isolated periods of raised noise levels attributable to local sources, agricultural activity, boiler flues, operation of gardening equipment etc. In addition, sample periods affected by rainfall or when rainfall resulted in prolonged periods of atypical noise levels have also been screened form the data sets.

12.2.3.1.15 Assessment Periods

The results presented in the following sections refer to the noise data collated during 'quiet periods' of the day and night as defined in the IOA GPG. These periods are defined as follows:

- Daytime Amenity hours are:
    - all evenings from 18:00 to 23:00hrs;
    - Saturday afternoons from 13:00 to 18:00hrs, and;

  - all day Sunday from 07:00 to 18:00hrs.
- Night time hours are 23:00 to 07:00hrs.

The assessment methods outlined above are in line with the guidance contained in the IOA GPG.

12.2.3.2 Construction Noise Calculations

A variety of items of plant will be used for the purposes of site preparation, construction, and site works. There will be vehicular movements to and from the site that will make use of existing roads. There is the potential for generation of significant levels of noise from these activities.

Due to the nature of construction activities, it is difficult to calculate the actual magnitude of emissions to the local environment in the absence of a detailed construction programme. The standard best practice approach is to predict typical noise levels at the NSLs using guidance set out in British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*. Construction noise predictions have been carried out using guidance set out in BS 5228-1.

The methodology adopted for the assessment of construction noise is to analyse the various elements of the construction phase in isolation. For each element, the typical construction noise sources are assessed along with typical sound pressure levels and spectra from BS 5228-1 at various distances from these works.

12.2.3.3 Operational Noise Calculations

A series of computer-based prediction models have been prepared to quantify the potential turbine noise level associated with the operational phase of the proposed project on the receiving environment. This section discusses the methodology behind the noise modelling process and presents the results of the modelling exercise.

12.2.3.3.1 DGMR iNoise V2022 Enterprise

The selected software, DGMR *iNoise Enterprise*, calculates noise levels in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation*, (ISO, 1996).

iNoise is a proprietary noise calculation package for computing noise levels and propagation of noise sources. iNoise calculates noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated considering a range of factors affecting the propagation of sound, including:

- the magnitude of the noise source in terms of A weighted sound power levels (LWA);
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- Attenuation due to atmospheric absorption; and
- Meteorological effects such as wind gradient, temperature gradient and humidity (these have significant impacts at distances greater than approximately 400 m).

12.2.3.3.2 Input Data and Assumptions

Information available for the site was inputted into the iNoise noise modelling software using the ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors: General method of calculation*. The input data and assumptions made are described in the following sections.

12.2.3.3.3 Noise-sensitive Locations

The IOA GPG states that the study area should at least include the predicted 35 dB L_{A90} noise contour. In this instance the study area extends to 2 km from the boundary of the proposed project. Appendix 12.6 presents the noise contours for the proposed project at 9 m/s standardised wind speed, for the upper end of the turbine range. The set of 541 noise-sensitive locations included in this noise assessment extends well beyond the 35 dB L_{A90} noise contour.

12.2.3.3.4 Proposed Turbine Layout

Table 2-1 in Chapter 2 (Description of the Proposed Project) of this EIAR details the co-ordinates of the turbines of the proposed project that are considered in this assessment.

12.2.3.3.5 Proposed Turbine Details

In order to assess all scenarios within the range of possible turbine technologies and dimensions, the following list of turbines have been considered:

- GE GE-164 @ 112m hub height;
- Nordex N163 @ 118m hub height;
- Vestas V162 @ 104m hub height;
- Enercon E160 @ 120m hub height;
- GE GE-158 @ 121m hub height;
- SG SG155-6.6 @ 112.5m hub height;
- Vestas V150 @ 125m hub height, and
- Nordex N149 @ 125m hub height;

The dimensions of the above turbines all vary but are all within the proposed range of dimensions as described in Chapter 2 of this EIAR (Description of the Proposed Project). In terms of dimensions the range of turbines listed above is summarised as:

- Tip height of between 185m to 200m (taking 192.5m as the centre point, this equates to a flexibility of ± 4%)
- Hub height of between 104m to 125m (taking 114.5m, as the centre point, this equates to a flexibility of ± 10%)
- Rotor diameter of between 149m to 164m (taking 156.5m, as the centre point, this equates to a flexibility of ± 5%).

In terms of predicting noise levels at noise-sensitive locations however, the turbine technology is described by two parameters:

- The hub height, and
- The sound power level.

In accordance with the IOA GPG, sound power levels for each of the turbines listed above, referred to wind speeds at standardised 10 m height are presented in Table 12-8 and Figure 12-13.

Table 12-8: L_{WA} Levels for various hub heights

Wind Speed (m/s at 10m Standardised Height)	dB LWA							
	GE164	N163	V162	E160	GE158	SG155	V150	N149
3	94.2	94.2	94.2	95.1	94.2	93.2	92.8	94.0
4	95.9	95.9	95.8	100.3	96.0	98.4	96.3	95.5
5	100.0	100.1	99.8	104.8	100.2	103.1	100.6	100.3
6	103.6	103.7	103.4	106.8	103.7	105.0	104.1	104.7
7	104.3	104.3	104.3	106.8	104.3	105.0	104.8	105.6
8	104.3	104.3	104.3	106.8	104.3	105.0	104.9	105.6
9	104.3	104.3	104.3	106.8	104.3	105.0	104.9	105.6

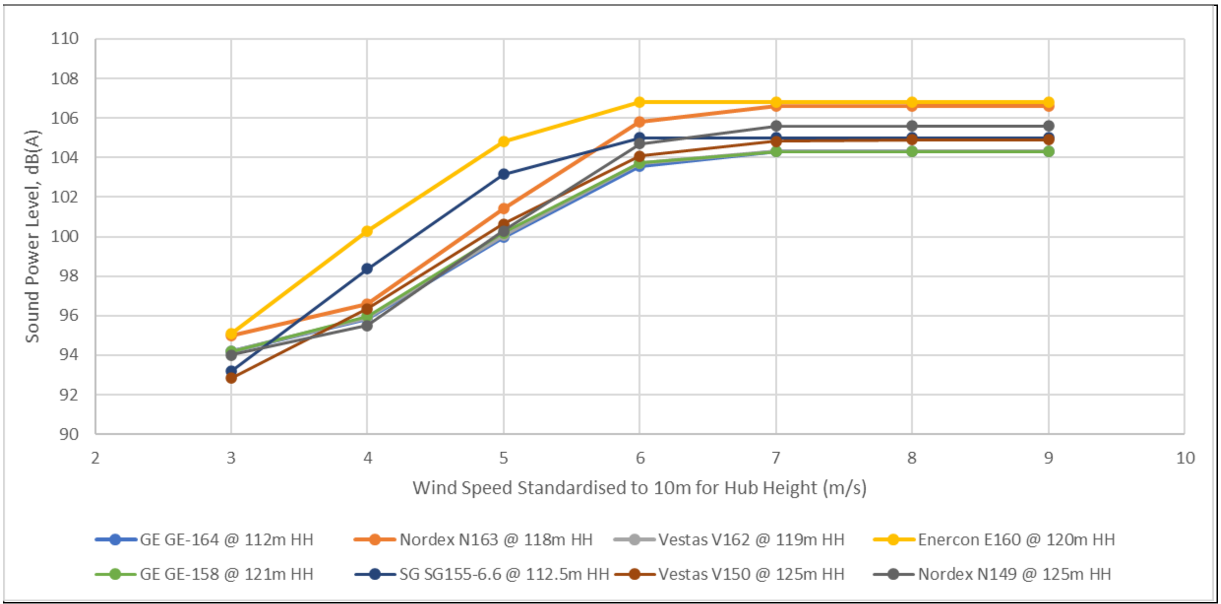

Figure 12-13: Sound Power Levels of each of eight turbines under consideration

The turbine with the highest sound power levels is the Enercon E160 at a hub height of 120m. This is considered the upper end of the range of turbines listed above.

The turbine with the lowest sound power levels varies depending on the wind speed; the lower end of the range of turbines is considered to be the following:

- 3 m/s: Vestas V150 at 125m hub height
- 4 m/s: Nordex N149 at 125m hub height
- 5 m/s: Vestas V162 at 104m hub height
- 6 m/s: Vestas V162 at 104m hub height
- 7 m/s: Vestas V162 at 104m hub height
- 8 m/s: Vestas V162 at 104m hub height
- 9 m/s: Vestas V162 at 104m hub height

In order to assess the range of possible turbine technologies and dimensions listed above, noise levels have been predicted for both the upper end and lower end of the turbine range. Hence, this assessment covers all scenarios within the turbine range regardless of which model is selected.

The manufacturer's turbine sound power levels outlined in Table 12-8 are each derived based on measurements in terms of the L_{Aeq} acoustic parameter. In accordance with best practice guidance contained within the Institute of Acoustics Good Practice Guide (IOA GPG), an allowance for uncertainty in the measurement of turbine source levels of +2 dB is applied in modelling to all turbine sound power levels presented in the tables above.

Moreover, as explained below in Section 12.2.2.4, appropriate guidance is couched in terms of a L_{A90} criterion. Best practice guidance in the IOA GPG states that "*L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB*". Therefore, a 2 dB reduction has been applied to the noise model output. All predicted noise levels in this chapter are presented in terms of L_{A90}, i.e., this reduction of 2 dB is applied in the noise prediction modelling.

Best practice specifies that should any tonal component be present, a penalty shall be added to the predicted noise levels. The level of this penalty is described in ETSU-R-97 and is related to the level by which any tonal components exceed audibility. For the purposes of this assessment a tonal penalty has not been included within the predicted noise levels. A warranty will be provided by the manufacturers of the selected turbine to ensure that the noise output will not require a tonal noise correction under ETSU-R-97.

12.2.3.3.6 Modelling Calculation Parameters[6]

Prediction calculations for turbine noise have been conducted in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation*, 1996.

In terms of calculation a ground attenuation factor (general method) of 0.5 and no metrological correction were assumed for all calculations. The atmospheric attenuation outlined in Table 12-9 were used for all calculations in accordance with the guidance outlined in the IOA GPG.

Table 12-9: Atmospheric Attenuation Assumed for Noise Calculations (dB per km)

Temp (°C)	% Humidity	Octave Band Centre Frequencies (Hz)							
		63	125	250	500	1k	2k	4k	8k
10	70	0.12	0.41	1.04	1.92	3.66	9.70	33.06	118.4

12.2.3.4 Additional Information

Appendix 12.3 details the coordinates of the NSLs used in this assessment. Noise predictions were prepared in respect of the various operational turbine wind speeds at these locations.

12.3 EXISTING ENVIRONMENT

This section of the report documents the typical background noise levels measured in the vicinity of the NSLs in closest proximity to the proposed project site.

12.3.1 Background Noise Levels

The following sections present an overview and results of the noise monitoring data obtained from the background noise survey in accordance with the methodology discussed in Section 12.2.3.1.

The noise environment was observed during installations, site visits to maintain equipment, and equipment collections. In general, the significant noise sources in the area were noted to

6 See Appendix 12.3 for further discussion of calculation parameters

be local and distant traffic movements, activity in and around the residences, wind generated noise from local foliage and other typical anthropogenic sources typically found in such rural settings.

This assessment incorporates consideration of the full range of turbine technologies and dimensions as listed in the preceding sections. As background noise levels are referenced to wind speeds at standardised 10 m heights according to the methodology in Section 12.2.3.1 *Consideration of Wind Shear*, the background noise levels are therefore also a function of the hub height.

In Section 12.2.3.3 Proposed Turbine Details, the hub heights of the turbines under consideration are discussed; the hub heights range from 112 m to 125 m. Taking measurement location NML-1 and the daytime period as an example, Table 12-10 presents the derived background noise levels for each case.

Table 12-10: Derived Levels of $L_{A90,10\text{-}min}$ for Location NML-1 for different hub heights

Hub Height	Derived $L_{A90,\ 10\text{-}min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
	3	4	5	6	7	8	9
112	25.7	27.3	29.3	31.8	34.6	37.6	40.6
125	25.7	27.0	28.9	31.1	33.6	36.4	39.3

As the background noise levels are lower for the higher hub height, noise criteria are based on background noise levels referenced to a hub height of 125 m throughout this chapter; this is a conservative approach to the noise assessment.

12.3.1.1 Location NML-1 (A)

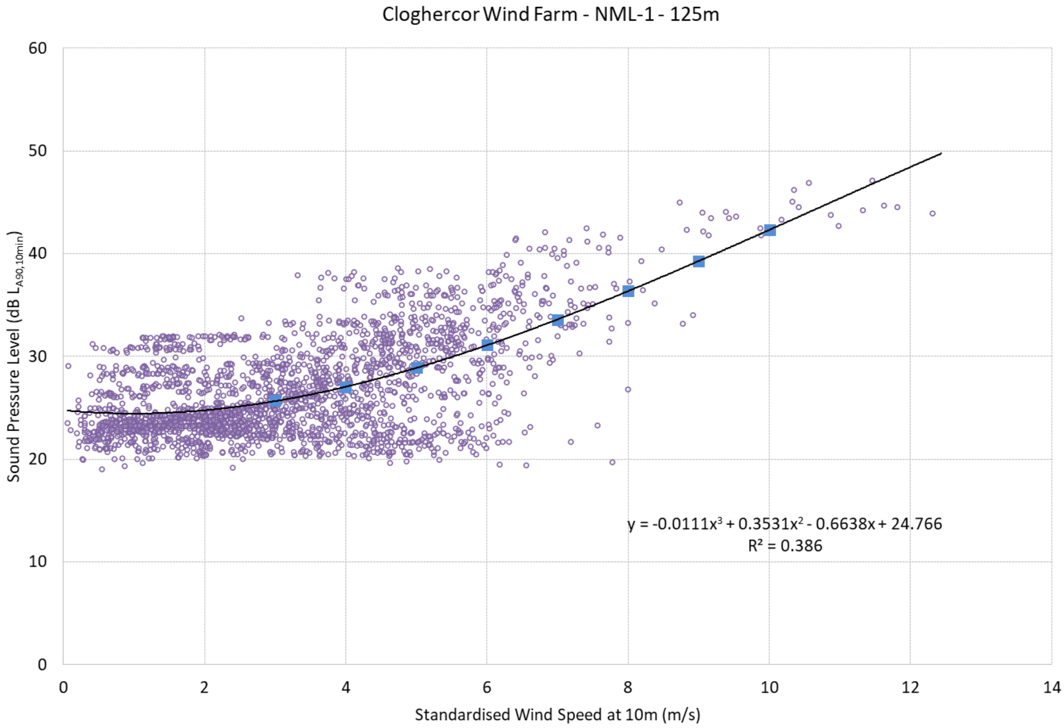

Figure 12-14: NML1 – Background Noise – Daytime Period - 125 m Hub Height

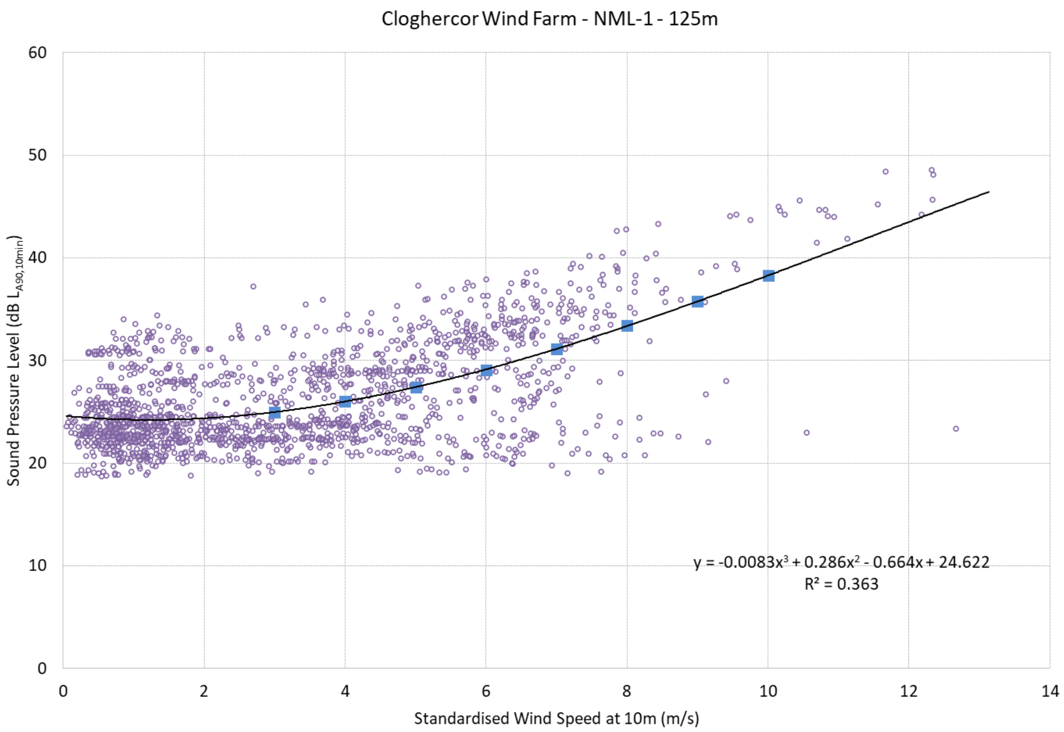

Figure 12-15: NML1 – Background Noise – Night-time Period - 125 m Hub Height

12.3.1.2 Location NML-2 (C)

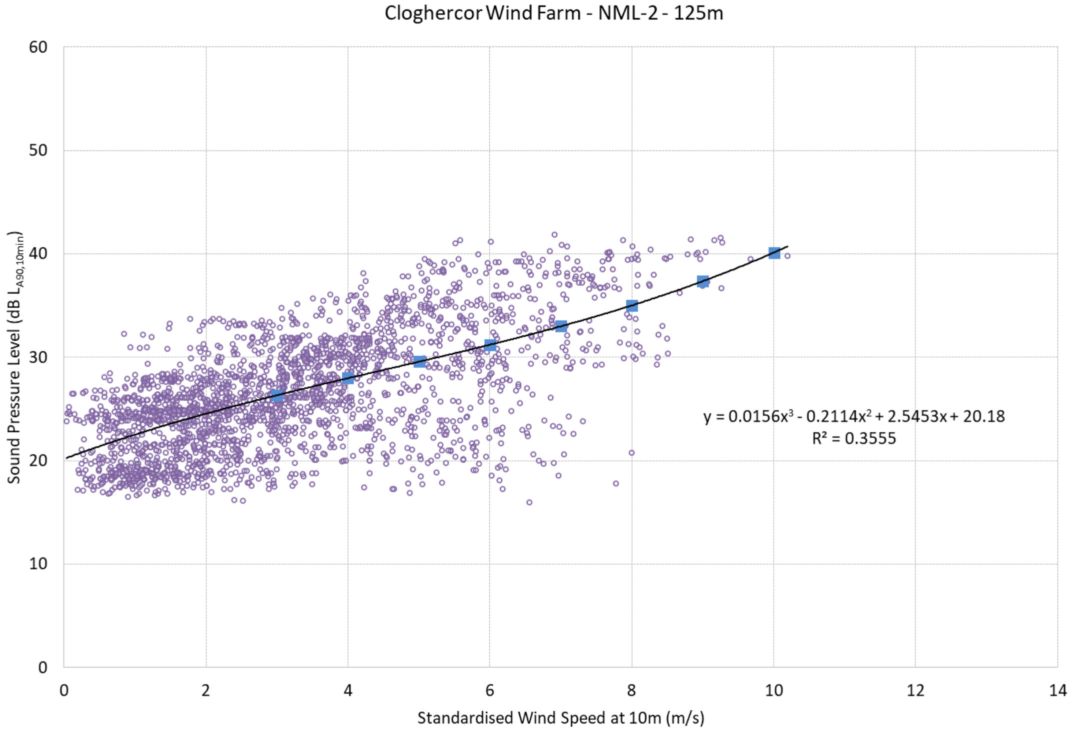

Figure 12-16: NML2 – Background Noise – Daytime Period - 125 m Hub Height

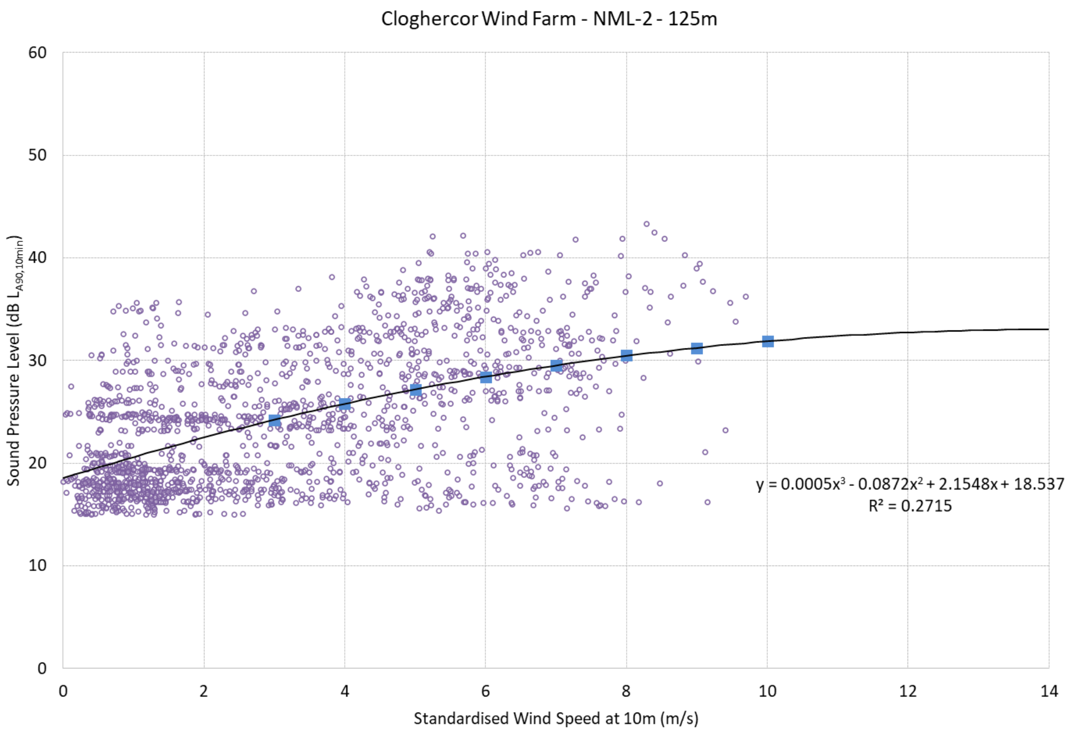

Figure 12-17: NML2 – Background Noise – Night-time Period - 125 m Hub Height

12.3.1.3 Location NML-3 (F)

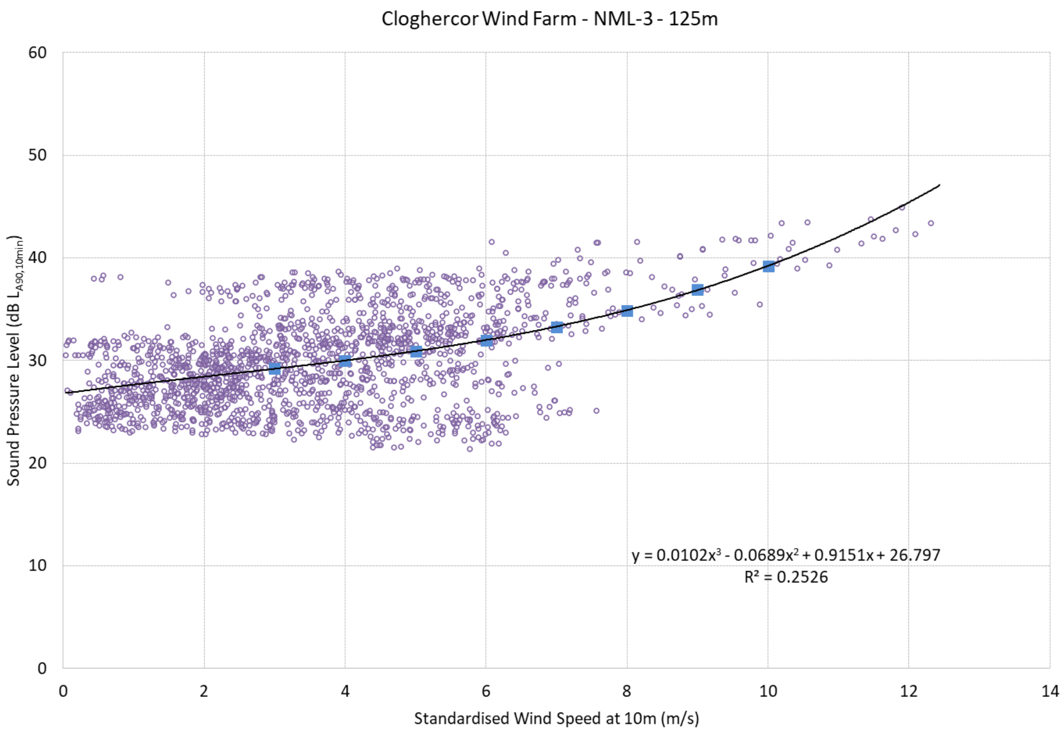

Figure 12-18: NML3 – Background Noise – Daytime Period - 125 m Hub Height

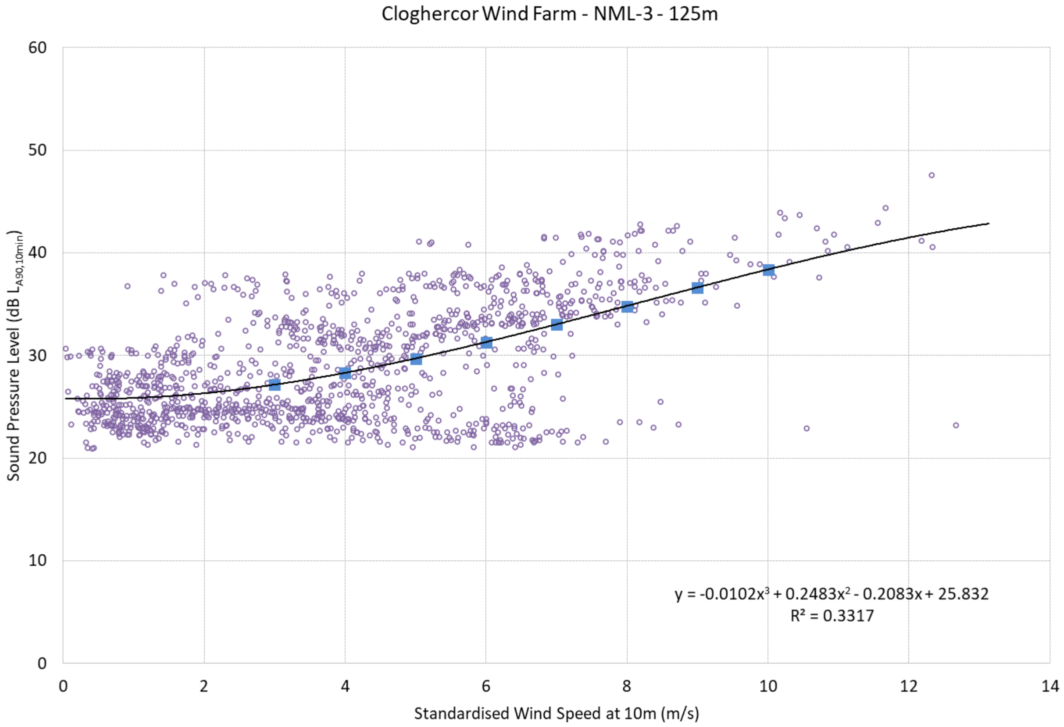

Figure 12-19: NML3 – Background Noise – Night-time Period - 125 m Hub Height

12.3.1.4 Location NML-4 (G)

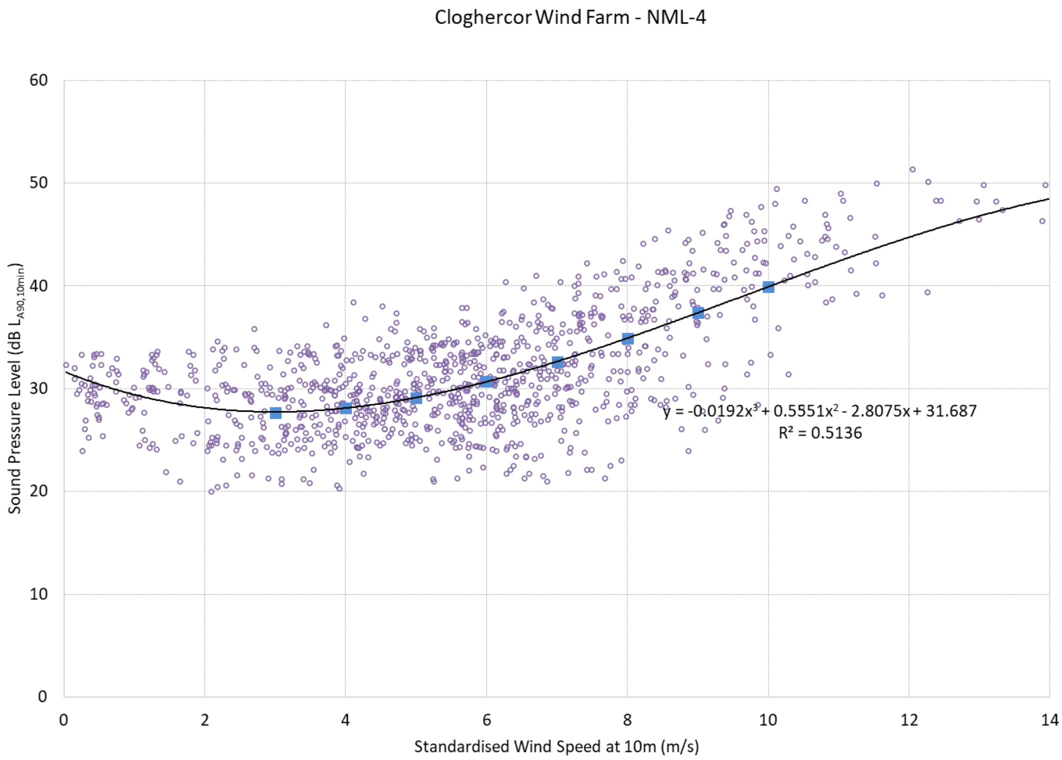

Figure 12-20: NML4 – Background Noise – Daytime Period - 125 m Hub Height

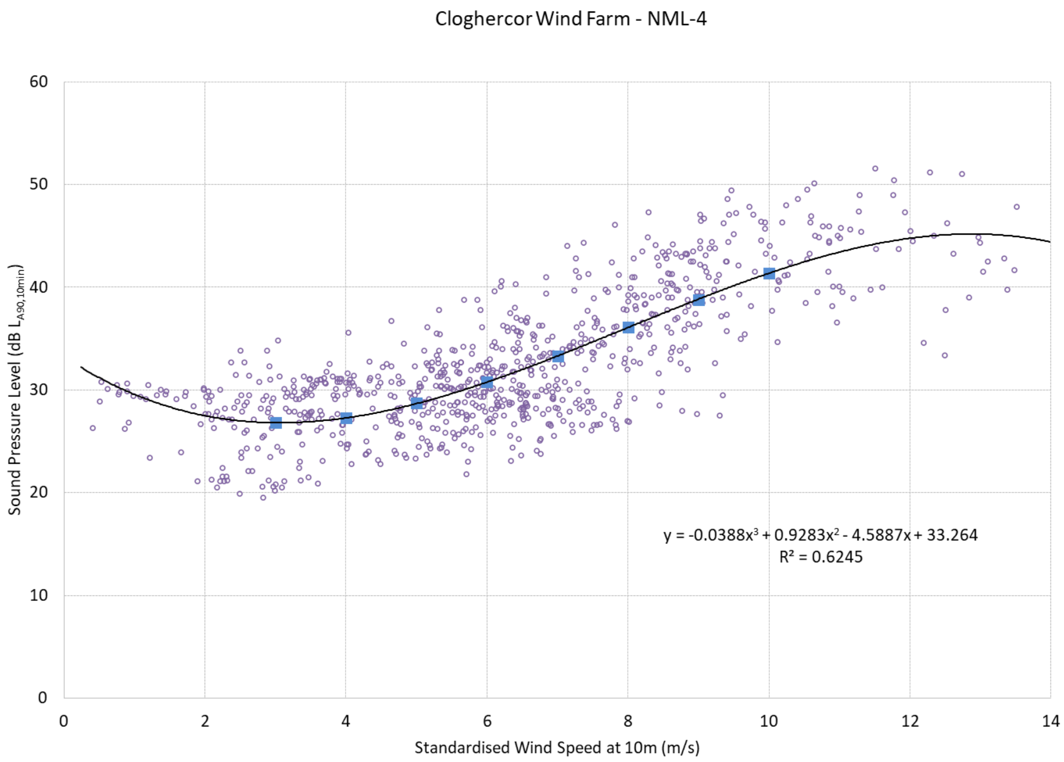

Figure 12-21: NML4 – Background Noise – Night-time Period - 125 m Hub Height

12.3.1.5 Location NML-5 (J)

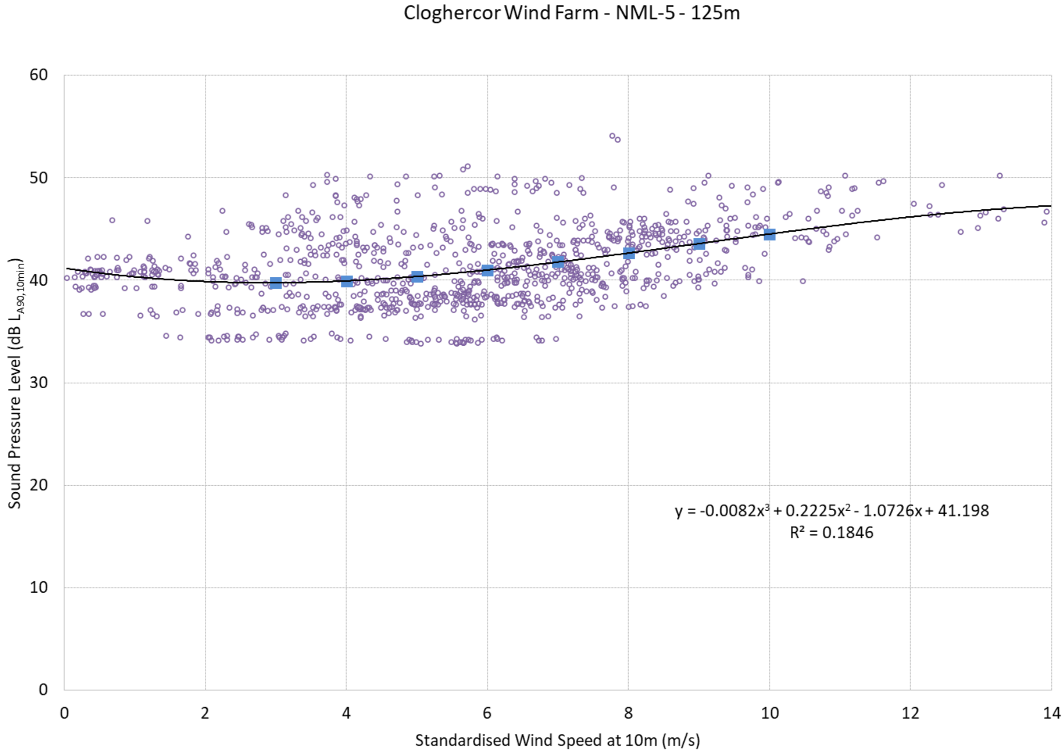

Figure 12-22: NML5 – Background Noise – Daytime Period - 125 m Hub Height

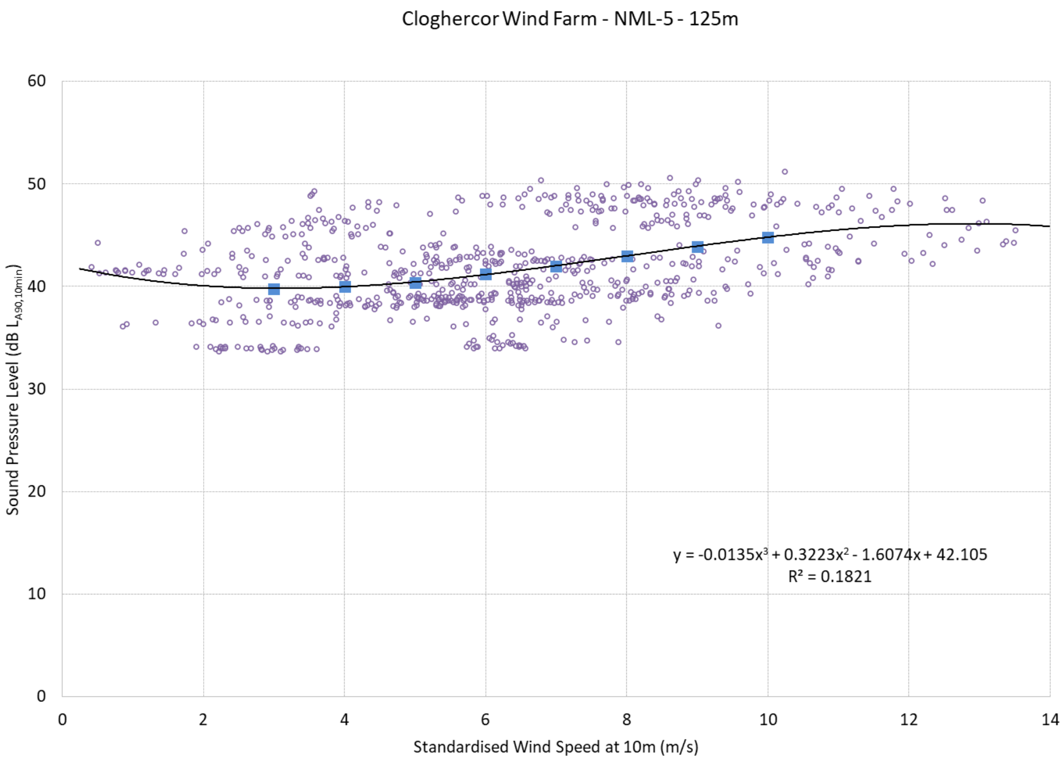

Figure 12-23: NML5 – Background Noise – Night-time Period - 125 m Hub Height

At Location NML-5, noise levels were elevated in comparison with other survey locations. It is believed that this was caused by noise from water flowing in the nearby river,

12.3.1.6 Location NML-6 (K)

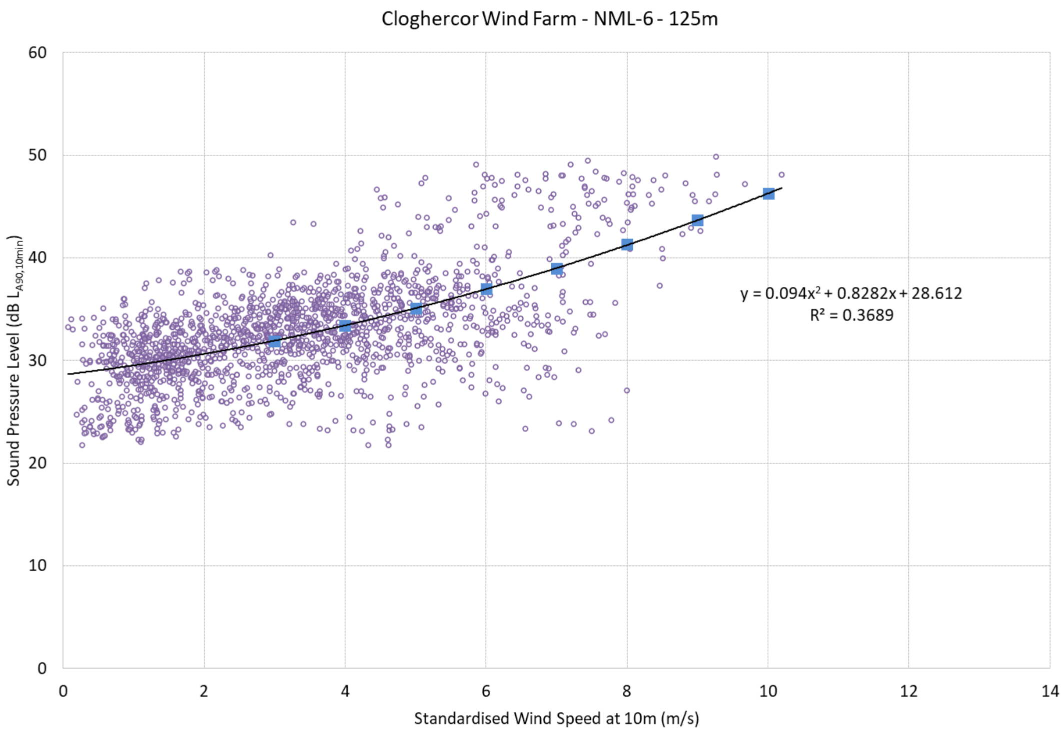

Figure 12-24: NML6 – Background Noise – Daytime Period - 125 m Hub Height

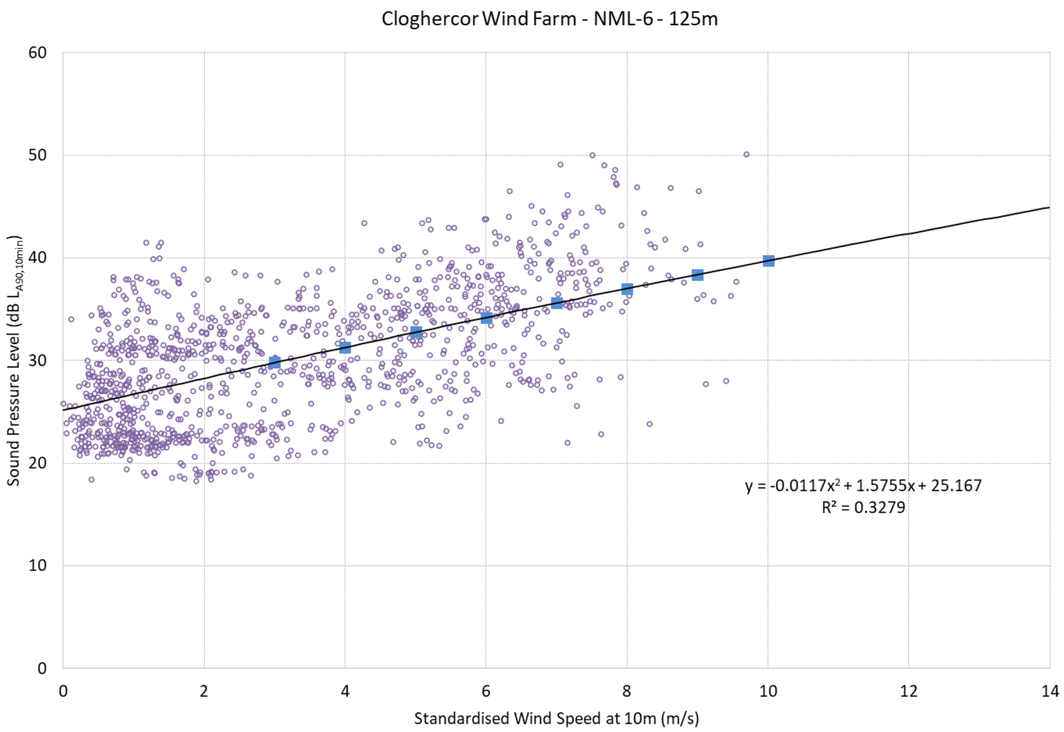

Figure 12-25: NML6 – Background Noise – Night-time Period - 125 m Hub Height

12.3.1.7 Location NML-7 (L)

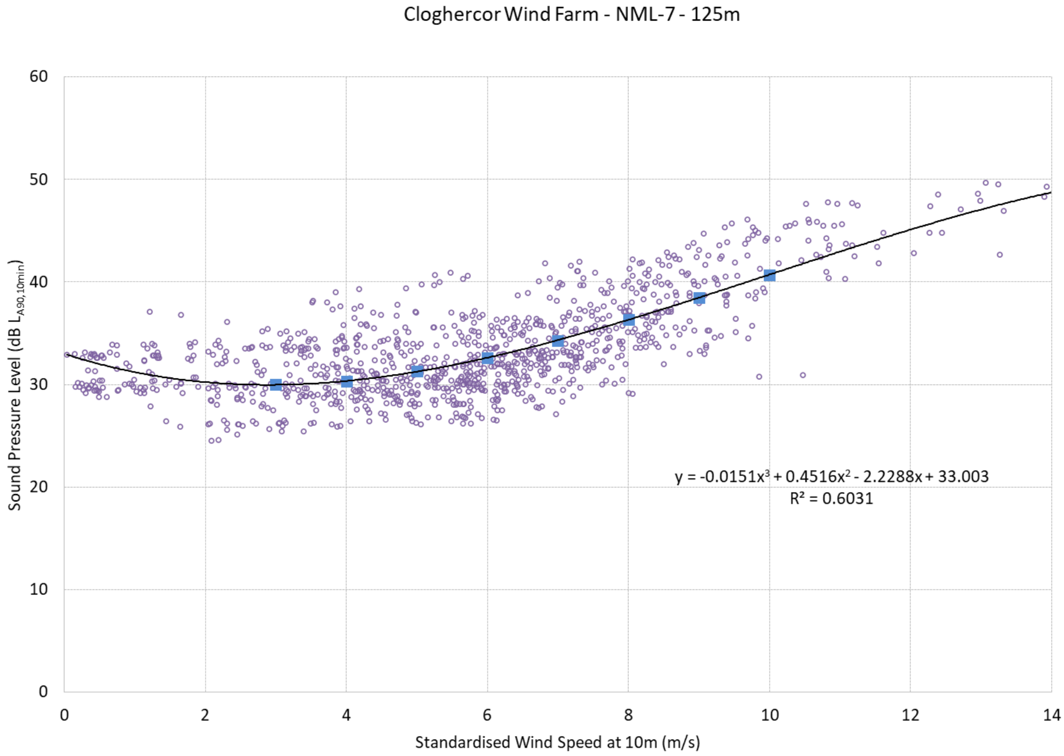

Figure 12-26: NML7 – Background Noise – Daytime Period - 125 m Hub Height

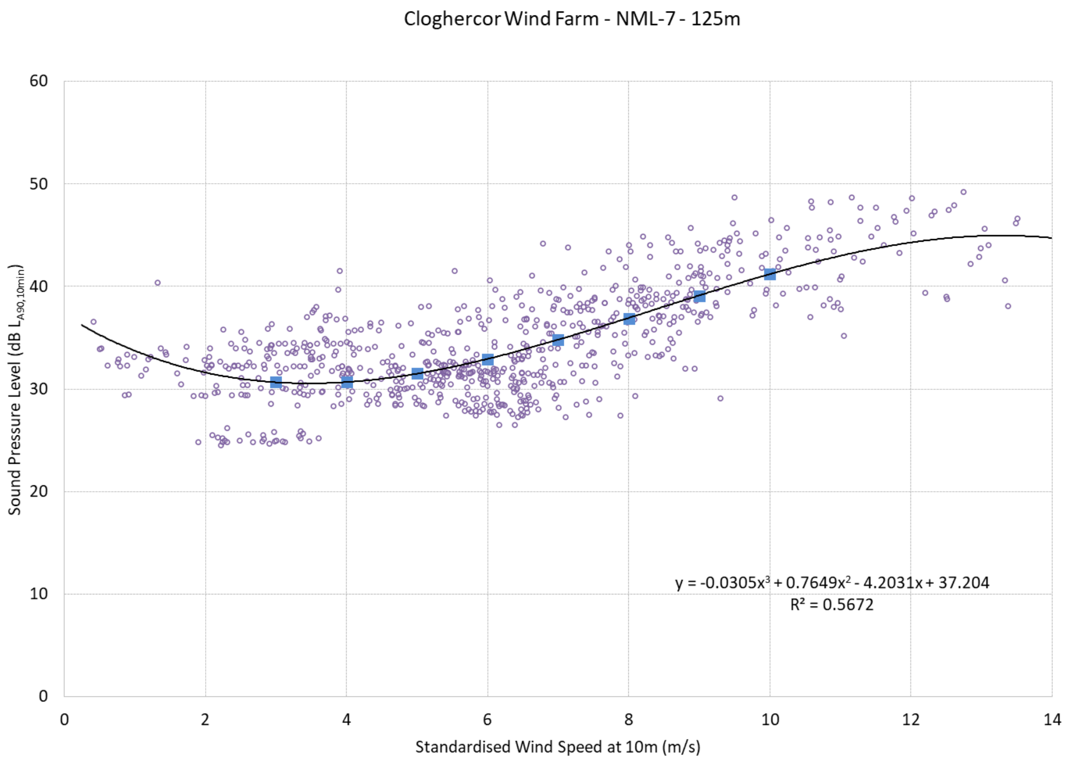

Figure 12-27: NML7 – Background Noise – Night-time Period - 125 m Hub Height

12.3.1.8 Location NML-8 (X)

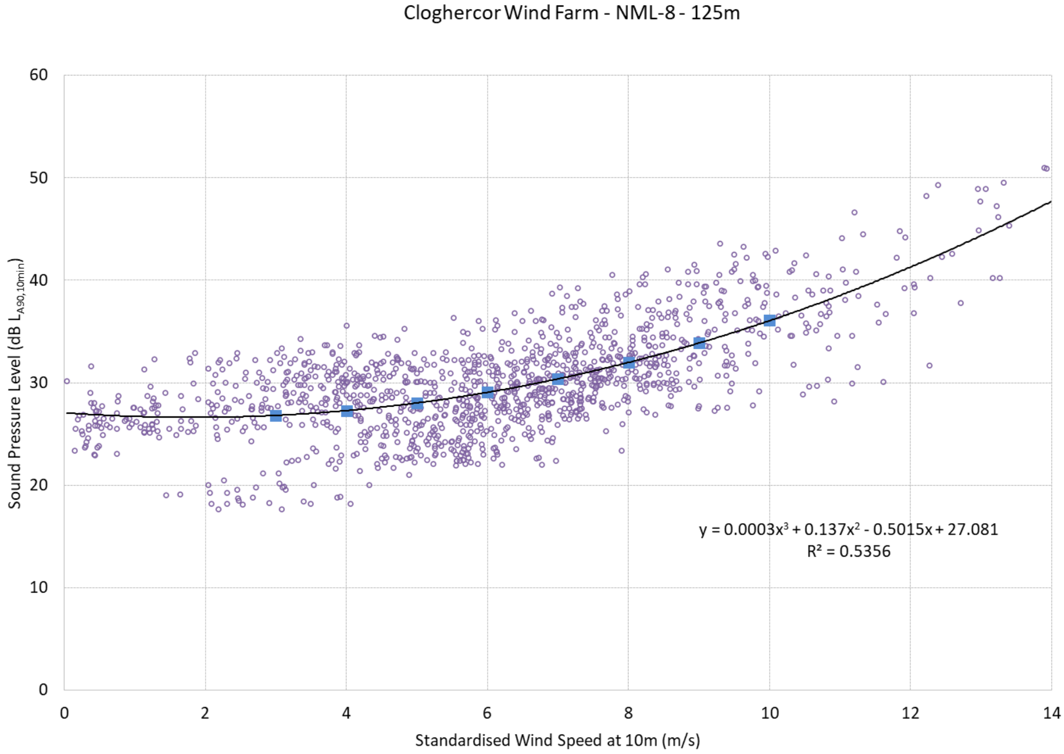

Figure 12-28: NML8 – Background Noise – Daytime Period - 125 m Hub Height

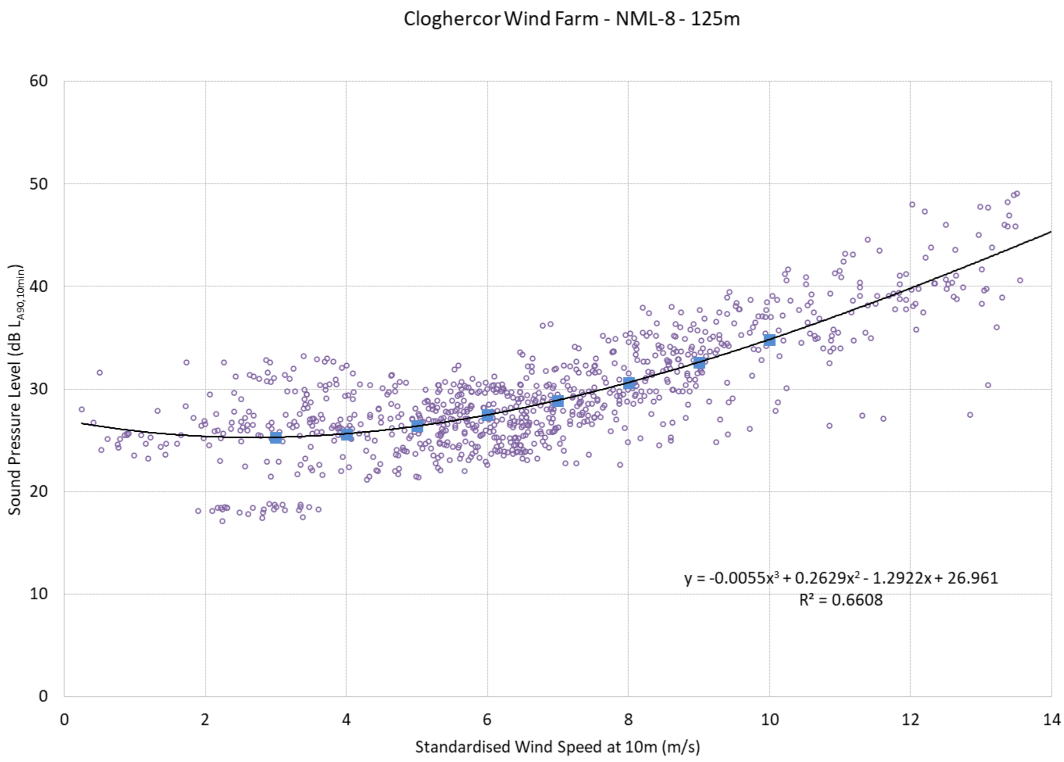

Figure 12-29: NML8 – Background Noise – Night-time Period - 125 m Hub Height

12.3.1.9 Summary

Table 12-11 presents the various derived $L_{A90,10min}$ noise levels for each of the monitoring locations for daytime quiet periods and night time periods. These levels have been derived using regression analysis carried out on the data sets in line with best practice guidance contained the IOA GPG and its SGN No. 2 *Data Collection.*

Table 12-11: Derived Levels of $L_{A90,10\text{-}min}$ for Various Wind Speeds

Location	Period	Derived $L_{A90,10\text{-}min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		3	4	5	6	7	8	9
NML-1	Day	25.7	27.0	28.9	31.1	33.6	36.4	39.3
	Night	25.0	26.0	27.4	29.1	31.1	33.4	35.8
NML-2	Day	26.3	28.0	29.6	31.2	33.0	35.0	37.4
	Night	24.2	25.8	27.2	28.4	29.5	30.5	31.2
NML-3	Day	29.2	30.0	30.9	32.0	33.3	34.9	36.9
	Night	27.2	28.3	29.7	31.3	33.0	34.8	36.6
NML-4	Day	27.7	28.1	29.1	30.7	32.6	34.9	37.4
	Night	26.8	27.3	28.7	30.8	33.3	36.1	38.8
NML-5	Day	39.8	39.9	40.4	41.0	41.8	42.7	43.6
	Night	39.8	40.0	40.4	41.2	42.0	43.0	43.9
NML-6	Day	31.9	33.4	35.1	37.0	39.0	41.3	43.7
	Night	29.8	31.3	32.8	34.2	35.6	37.0	38.4
NML-7	Day	30.0	30.3	31.3	32.6	34.3	36.3	38.5
	Night	30.7	30.7	31.5	32.9	34.8	36.9	39.1
NML-8	Day	26.8	27.3	28.0	29.1	30.4	32.0	33.9
	Night	25.3	25.6	26.4	27.5	28.9	30.6	32.6

It is noted that the baseline noise survey was carried out during a period of restrictions of movement due to the COVID-19 pandemic, and that traffic movements and hence noise levels may have been lower than usual. Due to the site location, this is unlikely to have any real effect as traffic noise is not a dominant source in background. The potential effect of this is that the background and baseline noise levels would be lower than normal, which results in the noise assessment being slightly conservative. Wind-generated noise in foliage surrounding the measurement equipment and noise-sensitive locations would have been representative of conditions at the survey locations.

12.3.1.10 Wind Turbine Noise Criteria

With respect to the relevant guidance documents outlined in Section 12.2.2.4, noise criteria curves have been identified for the proposed project. The criteria curves have been derived following a detailed review of the background noise data conducted at the nearest NSLs.

This set of criteria has been derived in line with the intent of the relevant Irish guidance and best practice guidance (as described in Section 12.2.2.4) it is comparable to noise planning conditions applied to similar sites previously granted planning permission by An Bord Pleanála and local planning authorities in Ireland. For the proposed project, it is considered that a lower daytime threshold of 40 dB $L_{A90,10\text{-}min}$ for low noise environments where the background noise is less than 30 dB(A) would be appropriate in respect of the following points:

- The EPA document '*Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)*' proposes a daytime noise criterion of 45 dB(A) in 'areas of low background noise'. Accounting for the difference in the noise parameters, the proposed lower threshold here, this is more than 3 dB more stringent than this level.
- It is reiterated that the 2006 Wind Energy Development Guidelines states that *"An appropriate balance must be achieved between power generation and noise impact."* Based on a review of other national guidance (i.e. EPA NG4) in relation to acceptable noise levels in areas of low background noise it is considered that the criteria adopted as part of this assessment are robust.

In summary, the operational noise limits proposed for the project are:

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

Day and night time noise criteria curves have been determined and are presented in the relevant sections of this chapter.

Table 12-12 outlines the operational noise criteria that are applicable to this assessment. The lowest baseline noise levels measured at each of the various monitoring locations as part of the baseline noise survey have been used in this process in order to adopt a worst-case approach in the derivation of the noise criteria curves.

Table 12-12:Proposed Noise Criteria Curves

Location	Period	Turbine Noise limits $L_{A90, 10-min}$ Levels (dB) at Various Standardised 10 m Height Wind Speeds						
		3	4	5	6	7	8	9
NML-1 A	Day	40	40	40	45	45	45	45
	Night	43	43	43	43	43	43	43
NML-2 C	Day	40	40	40	45	45	45	45
	Night	43	43	43	43	43	43	43
NML-3 F	Day	40	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43
NML-4 G	Day	40	40	40	45	45	45	45
	Night	43	43	43	43	43	43	44.4
NML-5 J	Day	45	45	45.4	46.1	46.9	47.8	48.8
	Night	44.8	45	45.5	46.3	47.2	48.2	49.1
NML-6 K	Day	45	45	45	45	45	46.8	49.5
	Night	43	43	43	43	43	43	44.1
NML-7 L	Day	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	44.6
NML-8 X	Day	40	40	40	40	45	45	45
	Night	43	43	43	43	43	43	43
Envelope	Day	40	40	40	40	45	45	45
	Night	43	43	43	43	43	43	43

12.4 POTENTIAL EFFECTS

12.4.1 Do Nothing Effects

If the project is not progressed the existing noise environment will remain largely unchanged. Traffic noise is currently a noise source in the vicinity of some road networks in the area. In the absence of the proposed project increases in traffic volumes on the local road network would be expected over time and would likely result in slight increases in the overall ambient and background noise levels in the area.

12.4.2 Potential Effects – Construction Phase

Construction noise prediction calculations have been conducted using the methodology outlined in Section 12.2.2.1. The noise levels referred to in this section are indicative only and are intended to demonstrate that it will be possible for the contractor to comply with current best practice guidance. The predicted "worst case" levels are expected to occur for only short periods of time at a very limited number of properties. Construction noise levels will be lower than these levels for most of the time at most properties in the vicinity of the proposed project.

There are several stages and elements associated with the construction phase of the proposed project which will include the following:

- Construction of turbines and hardstand areas.
- Construction of substation
- Cabling and grid connections.
- Operation of borrow pits.
- Construction of internal roads.
- Work to Turbine Delivery Route.

Detailed information is included in Chapter 2: Description of the Proposed Project.

In general, the distances between the construction activities associated with the proposed project and the nearest NSLs are such that there will be no significant noise and vibration impacts at NSLs. The following sections present an assessment of the main stages of the construction phase that have the potential for associated noise and vibration impacts, all other stages and elements are considered not to have significant noise and vibration impacts at NSLs.

Construction activities will be carried out during normal daytime working hours (i.e., weekdays 0700 – 1800hrs and Saturdays 0700 – 1400hrs). However, to ensure that optimal use is made of good weather periods or at critical periods within the programme (e.g., concrete pours) or to accommodate delivery of large turbine component along public routes it could be necessary on occasion to work outside of these hours. Any such out of hours working will be agreed in advance with Donegal County Council.

12.4.3 Construction Phase

12.4.3.1 General Construction – Turbines and Hardstands

12.4.3.1.1 Noise

Several noise sources that would be expected on a construction site of this nature have been identified and predictions of the potential noise emissions calculated at the closest sensitive receptor. In this instance the closest noise-sensitive receptor is Location H066, which is situated approximately 925 m (>880 m from the curtilage) from the proposed turbine T16.

Table 12-13 outlines the typical construction noise levels associated with the proposed works for this element of the construction. Calculations in this and the following construction noise tables have assumed an on-time of 66% for each item of plant i.e., that the item is operational for 8 hours over a 12-hour assessment period.

Table 12-13: Typical Wind Farm Turbine Construction Noise Emission Levels

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dB $L_{Aeq,T}$)[7]	Predicted Noise Level (dB $L_{Aeq,T}$) at distance (m)
			925
HGV Movement (C.2.30)	Removing spoil and transporting fill and other materials.	79	32
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	30
Excavator Mounted Rock Breaker (C9.12)	Rock Breaking.	85	38
Piling Operations (C.12.14)	Piling Foundations (if required).	89	42
General Construction (Various)	All general activities plus deliveries of materials and plant	84	37
Dumper Truck (C.4.4)	Moving fill	76	29
Mobile Telescopic Crane (C.4.39)	Turbine construction	77	30
Dewatering Pumps (D.7.70)	If required.	80	33
JCB (D.8.13)	For services, drainage and landscaping.	82	35
Vibrating Rollers (D.8.29)	Road surfacing.	77	30
Total		--	46

At 925 m from the works the predicted noise levels from construction activities are in the range of 29 to 42 dB $L_{Aeq,T}$ with a total worst-case cumulative construction level of the order of 46 dB $L_{Aeq,T}$. In all instances the predicted noise levels at the nearest NSLs are below the appropriate criteria outlined in Table 12-1 (Category A - 65 dB $L_{Aeq,T}$ during daytime periods). This assessment is considered representative of worst-case construction noise levels at NSLs.

There is no item of plant that would be expected to give rise to noise levels that would be considered out of the ordinary or in exceedance of the levels outlined in Table 12-1 and this finding is valid should all items of plant operate simultaneously.

Moreover, the construction noise assessment presented here covers any turbine within the proposed range; the construction methods are not affected by the choice of turbine technology or dimensions.

12.4.3.1.2 Vibration

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

7 All plant noise levels are derived from BS5228: Part 1

12.4.3.1.3 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case effects at the nearest noise sensitive locations associated with construction of turbines and hardstanding areas are described below.

Quality	*Significance*	*Duration*
Negative	Not significant	Short-term

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.4.3.2 Construction of Internal Site Roads

It is proposed to construct new and to upgrade existing internal roads to access the various parts of the project. Review of the track layout has identified that the nearest NSL to any point along the proposed track is H066 at a distance of 350 m. All other locations are at greater distances with the majority at significantly greater distances. The full description of the new and upgraded roads is outlined in Chapter 16 of the EIAR, *Traffic and Transport*.

12.4.3.2.1 Noise

Table 12-14 outlines the typical construction noise levels associated with the proposed works for this element of the construction. Calculations have assumed an on-time of 66% for each item of plant i.e., that the item is operational for 8 hours over a 12-hour assessment period.

Table 12-14:Indicative Noise Levels from Construction Plant at Various Distances from the New Internal Access Track Works

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dB $L_{Aeq,T}$)[8]	Highest Predicted Noise Level at Stated Distance from Edge of Works(dB $L_{Aeq,T}$)
		350 m
HGV (C.2.30)	79	46
Excavator Mounted Rock Breaker (C9.12)	85	52
Vibration Rollers (D.8.29)	77	44
Total	--	54

The table shows that at 350 m, noise levels are well within the construction noise criteria in Table 12-1 and therefore the impact is not significant. As these works will progress along the route the worst-case predicted impacts will reduce.

There are no items of plant or construction activities that would be expected to give rise to noise levels that would be considered out of the ordinary or in exceedance of the levels outlined in Table 12-1. It is concluded that while there may be significant noise impacts predicted at some noise-sensitive locations nearest the internal site roads, and therefore no specific mitigation measures are required.

8 All plant noise levels are derived from BS5228: Part 1

12.4.3.2.2 Vibration

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

12.4.3.2.3 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case effects at the nearest noise sensitive locations associated with construction of internal site roads are described below.

Quality	*Significance*	*Duration*
Negative	Not Significant	Temporary

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.4.3.3 Accommodation works along the Turbine Delivery Route.

The turbine delivery route uses the N56 from Killybegs Port and then the R262 to reach the site. At certain points along the route, accommodation works at bends and junctions (and a blade changeover area) are required to facilitate the safe transport of large turbine components. Full details are in Chapter 16 of the EIAR, Traffic and Transport.

12.4.3.3.1 Noise

Noise-sensitive locations are located at various distances from junction accommodation works areas. Construction works associated with junction accommodation works will be the dominant source of noise at the nearest noise sensitive locations when they occur. Table 12-15 outlines the typical construction noise levels associated with the proposed works for this element of the construction at various distances from the works. Calculations have assumed an on-time of 66% for each item of plant i.e., that the item is operational for 8 hours over a 12-hour assessment period.

Table 12-15:Indicative Noise Levels from Construction Plant at Various Distances from the Junction Accommodation Works

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dB $L_{Aeq,T}$)[9]	Highest Predicted Noise Level at Stated Distance from Edge of Works(dB $L_{Aeq,T}$)				
		20 m	30 m	40 m	50 m	60 m
HGV Movement (C.2.30)	79	71	65	62	60	58
Tracked Excavator (C.4.64)	77	69	63	60	58	56
Dumper Truck (C.4.4)	76	68	62	59	57	55
Vibrating Rollers (D.8.29)	77	69	63	60	58	56
Total	--	75	69	66	64	62

The table shows that at distances beyond 50m, noise levels are within the construction noise criteria in Table 12-1 and therefore the impact is not significant. At short distances there is the

[9] All plant noise levels are derived from BS5228: Part 1

potential for significant noise impact to occur but as each section of the junction accommodation works are localised, the duration of any impact will be brief.

12.4.3.3.2 Vibration

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

12.4.3.3.3 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case effects at the nearest noise sensitive locations associated with construction of internal site roads are described below.

Quality	*Significance*	*Duration*
Negative	Significant	Temporary – of the order of 1 week

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.4.3.4 Borrow Pits

To inform this aspect of the proposal a comparative noise assessment has been prepared and is outlined in the following paragraphs. Two situations have been considered as follows:

- Scenario A Blasting operation
- Scenario B Rock breaking operation

In terms of these activities please note the following:

- A mobile crusher will operate on site for both options.
- In Scenario B two rock breakers will be in use on site during daytime periods.
- For the purposes of this assessment, we have assumed the plant is working simultaneously in the vicinity of all proposed borrow pit locations indicated in Table 12-16.
- Table 12-17 outlines the assumed noise levels for the plant items as extracted from BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.
- If the blasting option is undertaken, it is estimated that some 6 to 10 blasts will be required over a 6 to 8-week period. It is expected that no more than 1 blast would occur in a single working day.

Table 12-16: Proposed Borrow Pit Locations

Borrow Pit Ref	Co-ordinates (ITM)	
	Easting	Northing
1	584036	901676
2	584704	901378
3	586183	902831
4	586233	903796

Table 12-17: Plant Noise Emissions

Item	BS 5228 Ref.	Sound Pressure Level at 10m from Source, dB(A)
Excavator	Tracked Excavator (C2.21)	71
Stockpiling bulk material	Dozer (C8.9)	74
Loading into crusher	Shovel (C.10.5)	80
Crushing	Tracked Semi-Mobile Crusher (C.9.14)	90
Stockpiling crushed material	Dozer (C8.9)	74
Loading into crusher	Shovel (C.10.5)	80
Loading Dumpers	Dump Truck (C.9.20)	90
Transport	HGV Movement (C.2.30)	79
Generator	Diesel Generator (C.6.39)	65
Rock Breaking	Excavator-mounted Rock Breaker C9.12	85

A construction noise model has been prepared to consider the expected noise emissions from the proposed construction works for the two scenarios outlined above. A percentage on-time of 66% has been assumed for the noise calculations. The results at the 10 no. NSLs with the highest predicted noise levels is presented in Table 12-18

Table 12-18: Prediction Noise Levels from Borrow Pit Activity at Nearest NSLs

Scenario A		Scenario B	
Location Ref.	$L_{Aeq,T}$	Location Ref.	$L_{Aeq,T}$
H255	51	H255	53
H224	50	H224	52
H067	50	H067	51
H414	49	H414	51
H068	49	H064	51
H064	49	H535	51
H384	49	H068	51
H535	49	H384	50
H065	48	H065	50
H066	48	H066	50

Review of the results contained in Table 12-18.confirms the following:

- Predicted construction noise levels for both Scenario A and B are well within the relevant construction noise criteria (65 dB $L_{Aeq,T}$). It is assumed that construction works at the borrow pit will only occur during daytime periods only (07:00 to 19:00hrs).
- The blasting proposal results in lower levels of construction noise as the rock breaking plant is not required to operate to the same extent in this scenario. Predicted noise levels are lower at all assessed locations for Scenario A.
- It is accepted that the individual blast events will be audible at certain locations which may result in slight impacts. Blast events will be designed and controlled such that the best practice limits values outlined in the mitigation section of this chapter are not exceeded.

12.4.3.4.1 Vibration

Due to the distance from the proposed works to NSLs, and the duration of any potential impact on any single dwelling, significant vibration effects are not expected.

12.4.3.4.2 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case effects at the nearest NSLs associated with the operation of borrow pits are described below.

Quality	*Significance*	*Duration*
Negative	Slight	Short-term

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.4.3.5 Substation Construction

12.4.3.5.1 Noise

The substation is to be located at coordinates E584556 N900808. The nearest NSLs to the proposed substation are H335 and H522 at a distance of the order of 1.3 km to the southwest. As a worst-case example assuming the same construction activities as outlined in Table 12-13, it is predicted that the likely worst-case potential noise levels from construction activities associated with the substation will be in the order of 43 dB $L_{Aeq,T}$ at the nearest NSL. This level of noise is well within the construction noise criterion outlined in Table 12-1.

12.4.3.5.2 Vibration

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

12.4.3.5.3 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive locations associated with construction of the substation are described below.

Quality	*Significance*	*Duration*
Negative	Not Significant	Temporary

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.4.3.6 Construction Traffic

This section of the report has been prepared in order to review potential noise impacts associated with construction traffic on the local road network. Chapter 16 of this EIAR presents an assessment of traffic and transportation and reference has been made to this chapter to inform the following discussion. The following situations are commented upon here:

- Average construction traffic flows, which apply for the majority of the construction period, and
- Peak construction traffic flows, which apply to more intense periods of construction activity such as concrete poring of turbine bases.

Based on information in Table 16-5 of Chapter 16 Traffic and Transport, changes in traffic noise levels associated with the additional traffic for each of the construction situations listed above have been calculated for three routes: L6483, R252 and the R250. Table 12-19 presents a summary of the traffic noise calculations.

Table 12-19: Estimated Changed to Traffic Noise Levels due to Construction

Construction Activity	Route	Existing	Existing + Construction Traffic	Increase in Noise Level
Average	L6483	8	78	+9.9
	R252	2077	2147	+0.1
	R250	1801	1871	+0.2
Peak	L6483	8	166	+13.2
	R252	2077	2235	+0.3
	R250	1801	1959	+0.4

For the R252 and R250 routes, the increases in noise levels due to construction traffic is predicted to be less than 1 dB average and peak construction situations. With respect to the assessment criteria outlined in Section 12.2.2.3, the magnitude of this impact is negligible.

Due to the very low existing traffic volumes along the local road L6483, the additional traffic during the construction periods would indicate increases of more than 10 dB along this route. However, the predicted noise levels due to existing plus construction traffic at 10m distance from the road edge are:

- 57 dB $L_{Aeq,1hr}$ for average construction traffic flows, and
- 61 dB $L_{Aeq,1hr}$ for peak construction traffic flows.

These values are within the criterion of 65 dB LAeq,1hr for construction noise presented in Section 12.2.2.1.

It is therefore concluded that there will be no significant noise impacts associated with the additional traffic generated during the construction phase of the proposed project and therefore no specific mitigation measures are required.

12.4.3.6.1 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case associated effects at the nearest NSLs associated with this aspect of the construction phase are described below.

Quality	*Significance*	*Duration*
Negative	Not Significant	Short-term

The above effects should be considered in terms that the effect is variable and that this assessment considers the locations of the greatest potential impact.

12.4.4 Operational Phase

12.4.4.1 Assessment of Wind Turbine Noise

The predicted noise levels for the proposed project have been calculated for all noise sensitive locations identified within the study area.

A worst-case omni-directional assessment has been completed assuming all noise sensitive locations are downwind of all turbines at the same time and noise predictions have been made using the ISO 9613-2 standard which represents worst-case conditions favourable to noise propagation (typically downwind propagation from source to receiver and/or downward refraction under temperature inversions).

The results of the noise prediction models have been compared against the turbine noise limits that have been assigned to each of the NSLs in accordance with the criteria set out in Section 12.3.1.10.

12.4.4.1.1 Upper End of Wind Turbine Range

The predicted noise levels at various wind speeds for the Enercon E160, which represents the upper end of the turbine range, are compared against the noise criteria curves in Table 12-20, for the set of five locations where exceedances are noted: H064, H065, H066, H224, and H535. At all other locations, noise levels are within the noise criteria curves. See Appendix 12.4 for the complete set of predicted noise levels for the Enercon E160.

Table 12-20: Review of Noise Levels at NSLs with exceedances for the upper end of turbine range

House	Parameter	Derived $L_{A90, 10\text{-}min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		3	4	5	6	7	8	9
H064	Predicted	28.7	33.9	38.4	40.4	40.4	40.4	40.4
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.4	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H065	Predicted	28.4	33.6	38.1	40.1	40.1	40.1	40.1
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.1	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H066	Predicted	28.4	33.6	38.1	40.1	40.1	40.1	40.1
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.1	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H224	Predicted	28.6	33.8	38.3	40.3	40.3	40.3	40.3
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.3	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H535	Predicted	28.9	34.1	38.6	40.6	40.6	40.6	40.6

House	Parameter	Derived $L_{A90, 10-min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		3	4	5	6	7	8	9
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.6	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--

12.4.4.1.2 Lower End of Wind Turbine Range

Noise predictions have also been carried out for the lower end of the turbine range. In this instance, due to the lower sound power level, no exceedances of the noise criteria curves are noted. Predicted noise levels for the same five locations (H064, H065, H066, H224, and H535) are presented in Table 12-21. See Appendix 12.5 for the complete set of predicted noise levels for the lower end of the turbine range.

Table 12-21: Review of Noise Levels at NSLs at the lower end of the turbine range

House	Parameter	Derived $L_{A90, 10-min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		3	4	5	6	7	8	9
H064	Predicted	27.1	28.6	34.0	37.6	38.5	38.4	38.3
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H065	Predicted	26.8	28.4	33.7	37.3	38.2	38.2	38.0
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H066	Predicted	26.8	28.3	33.6	37.3	38.2	38.1	38.0
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H224	Predicted	26.9	28.5	33.9	37.5	38.4	38.4	38.3
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H535	Predicted	27.2	28.7	34.1	37.7	38.6	38.6	38.4
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--

12.4.4.1.3 Consideration of Wind Direction and Noise Propagation

This section discusses additional considerations in respect of the predicted noise levels for the upper end of the wind turbine range, the Enercon E160.

When considering noise impacts of wind turbines, the effects of propagation in different wind directions should be considered. The day to day operations of the proposed project will not result in a worst-case condition of all noise locations being downwind of all turbines at the same time i.e. omni-directional predictions. Therefore, to address this, a review of expected noise levels downwind of the turbines has been prepared for various wind directions in accordance with the IoA GPG Guidance.

For any given wind direction, a property can be assigned one of the following classifications in relation to turbine noise propagation:

- Downwind (i.e. 0° ±80°);
- Crosswind (i.e. 90° ±10° and 270° ±10°);
- Upwind (i.e. 180° ±70°).

Figure 12-30 illustrates the directivity attenuation factor that has been applied to turbines when considering noise propagation in downwind conditions (downwind is represented by 0° with upwind being 180°).

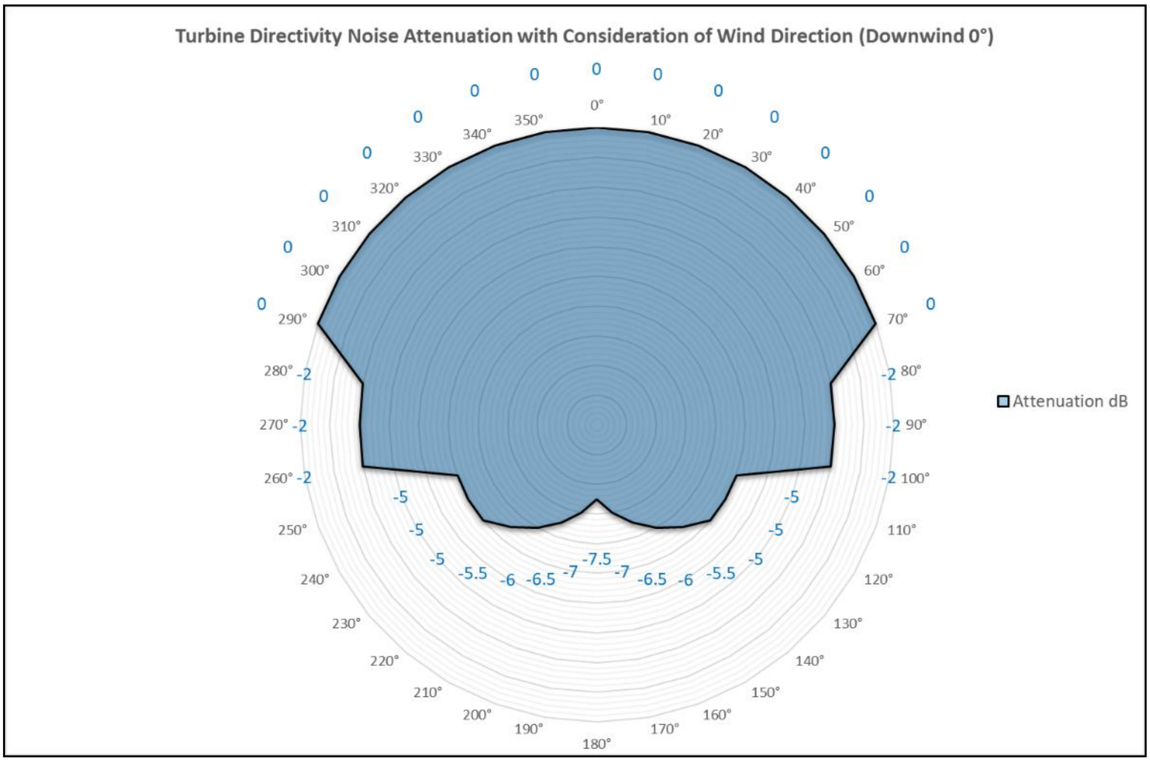

Figure 12-30: Directivity Attenuation Factor

Directional noise prediction models have been developed to identify the number and magnitude of exceedances to the noise criteria. The noise levels for the locations H064, H065, H066, H224, and H535 are presented in Table 12-22 for the east and Table 12-23 for the southeast wind direction sector.

Table 12-22:Review of Noise Levels at NSLs in the East wind direction sector.

House	Parameter	Derived $L_{A90, 10\text{-}min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		3	4	5	6	7	8	9
H064	Predicted	28.5	33.7	38.2	40.2	40.2	40.2	40.2
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.2	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H065	Predicted	28.4	33.6	38.1	40.1	40.1	40.1	40.1
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.1	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H066	Predicted	28.4	33.6	38.1	40.1	40.1	40.1	40.1
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.1	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H224	Predicted	28	33.2	37.7	39.7	39.7	39.7	39.7
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H535	Predicted	28.6	33.8	38.3	40.3	40.3	40.3	40.3
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.3	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--

Table 12-23: Review of Noise Levels at NSLs in the Southeast wind direction sector.

House	Parameter	Derived $L_{A90, 10\text{-}min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		3	4	5	6	7	8	9
H064	Predicted	28.7	33.9	38.4	40.4	40.4	40.4	40.4
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.4	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H065	Predicted	28.4	33.6	38.1	40.1	40.1	40.1	40.1
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.1	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H066	Predicted	28.4	33.6	38.1	40.1	40.1	40.1	40.1
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.1	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H224	Predicted	28.6	33.8	38.3	40.3	40.3	40.3	40.3
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.3	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H535	Predicted	28.9	34.1	38.6	40.6	40.6	40.6	40.6
	Daytime Criterion	40	40	40	40	45	45	45
	Daytime Excess	--	--	--	0.6	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--

Following review of the exceedances of the criteria in the east and southeast wind direction sectors, the following comments are presented.

In the east wind direction sector, exceedances are noted at four NSLs; In the southeast wind direction sector, exceedances are noted at five NSLs. It is reiterated that this initial review has considered a turbine operating in standard mode.

Wind turbines can be programmed to run in reduced modes of operation (or low noise modes) in order to achieve noise criteria during certain periods (i.e. day or night) and in specific wind conditions (i.e. wind speed and direction). The turbine technology that has been assumed for this assessment offers various low noise modes of operation which typically will have an associated energy output reduction.

Operating the turbines in reduced modes is generally referred to as curtailment and in the context of this EIAR is a proven effective mitigation to ensure noise limits are complied with. A detailed curtailment strategy matrix will be finalised as part of the detailed design for the selected turbine technology to achieve the noise criteria at each of the noise sensitive locations. To demonstrate the principle of curtailment, a typical curtailment strategy matrix has been developed and is presented in Table 12-24 for south-easterly to address the exceedance listed in these wind direction sectors.

Table 12-24:Indicative Turbine Curtailment Matrix for South and Southeast Wind Directions.

Wind Direction Sector	Period	Derived $L_{A90, 10\text{-}min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		3	4	5	6	7	8	9
Southeast	Day	--	--	--	T10: -1dB T13: -2dB T16: -1dB	--	--	--
	Night	--	--	--	--	--	--	--

With the implementation of the above or similar it is not considered that a significant effect is associated with the operation of this project, since the predicted noise levels associated with the proposed project will be within the relevant best practice noise criteria curves for wind farms, irrespective of which turbine is selected within the turbine range.

While noise levels at low wind speeds will increase due to the proposed project the predicted levels will remain low, albeit a new source of noise will be introduced into the soundscape. Due to the distance of the turbine of the proposed project and the nearest NSLs, the level of turbine noise from the proposed project is relatively low and well below the noise criterion curves identified.

The above discussion of the effect of wind direction and curtailment applies to the Enercon E160, which is upper end of the wind turbine sound power level range. In the case of the lower end of the wind turbine sound power levels, as the there is no exceedance of the noise criteria curves for the omni-directional predicted noise levels (Table 12-23), there is no requirement for mitigation measures in respect of noise. Thus, at the lower end of the turbine range, no mitigation measures are necessary; whereas at the upper end of the turbine range, a curtailment scheme such as that presented in Table 12-24 will be required to maintain the wind turbine noise levels within the noise criteria. The assessment has considered the range of turbine technologies and dimensions, and the noise criteria can therefore be met in all cases.

12.4.4.1.4 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case associated effects at the nearest NSLs associated with the operation of the wind farm is described below.

Quality	*Significance*	*Duration*
Negative	Moderate	Long-term

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.4.4.2 Substation Noise

Details of the proposed substation are described in Chapter 2 of the EIAR (Description of the Proposed Project). The substation will typically be operational 24/7, and the noise impact at the nearest NSL has been assessed to identify the potential greatest impact associated with the operation of the Substation at the nearest NSL.

As part of the proposed project, the substation will be operational on a continuous basis. The noise emission level associated with a typical substation that would support a development of this nature is the order of 93 dB(A) L_w.

Noise prediction calculations for the operation of the 110kV substation have been undertaken in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation* (1996). The predicted noise level from the operation of the substation at the nearest NSL is 25 dB $L_{Aeq,T}$ is H255. That at the nearest NSL outside the proposed project site is 19 dB(A) at H119. This level of noise would be unlikely to be audible at the nearest NSL, and it is concluded that there will be no significant noise emissions from the operation of the substation at any NSL.

12.4.4.2.1 Description of Effects

With respect to the EPA's criteria for description of effects, the potential worst-case associated effects at the nearest NSLs associated with the operation of the proposed substation is described below.

Quality	*Significance*	*Duration*
Neutral	Not significant	Long-term

12.4.5 Decommissioning Phase

In relation to the decommissioning phase, similar overall noise levels as those calculated for the construction phase would be expected, as similar tools and equipment will be used. See Section 12.4.2 for predicted noise levels. Considering that in all aspects of the construction and decommissioning, the predicted noise levels are expected to be below the appropriate Category A value (i.e. 65 dB $L_{Aeq,T}$) at all NSLs for the decommissioning phase, the impact is not significant.

12.5 MITIGATION MEASURES

The assessment of potential impacts has demonstrated that the proposed project is expected to comply with the identified criteria for both the construction and operational phases of the project. However, to ameliorate any noise and vibration effects, a schedule of noise control measures has been formulated for both construction and operational phases.

12.5.1 Construction Phase

Regarding construction activities, reference shall be made to BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise, which offers detailed guidance on the control of noise and vibration from construction activities. It is proposed that various practices be adopted during construction as required, including the following:

- limiting the hours during which site activities likely to create high levels of noise or vibration are permitted.
- establishing channels of communication between the contractor/applicant, Local Authority, and residents.
- appointing a site representative responsible for matters relating to noise and vibration.
- monitoring typical levels of noise and vibration during critical periods and at sensitive properties; and

- keeping the surface of the site access tracks even to mitigate the potential for vibration from lorries.

Furthermore, a variety of practicable noise control measures will be employed. These include:

- regular maintenance and servicing of machinery.
- selection of plant with low inherent potential for generation of noise and/ or vibration.
- placing of noisy / vibratory plant as far away from sensitive properties as permitted by site constraints

12.5.1.1 Noise

The contract documents shall specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures when deemed necessary to comply with the recommendations of BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*. The following list of measures will be considered, where necessary, to ensure compliance with the relevant construction noise criteria:

- No plant used on site will be permitted to cause an on-going public nuisance due to noise.
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract.
- Compressors will be attenuated models, fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.
- Any plant, such as generators or pumps, which is required to operate before 07:00hrs or after 19:00hrs will be surrounded by an acoustic enclosure or portable screen.
- During the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Table 12-1 using methods outlined in BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 7:00hrs and 18:00hrs Mondays to Fridays and to between 7:00hrs and 14:00hrs on Saturdays. However, to ensure that optimal use is made of good weather period or at critical periods within the programme (i.e., concrete pours) or to accommodate delivery of large turbine component along public routes it could be necessary on occasion to work outside of these hours.

Where rock breaking is employed, the following measures will be employed, where necessary, to mitigate noise emissions from these activities:

- Fit suitably designed muffler or sound reduction equipment to the rock breaking tool to reduce noise without impairing machine efficiency.
- Ensure all leaks in air lines are sealed.
- Erect acoustic screen between compressor or generator and noise sensitive area. When possible, line of sight between top of machine and reception point needs to be obscured.
- Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation.

Air overpressure from a blast is difficult to control because of its variability, however, much can be done to reduce the effect. A reduction in the amount of primer cord used, together with the adequate burial of any that is above the ground, can give dramatic reduction to air overpressure intensities especially in the audible frequency range. Most complaints are likely to be received from an area downwind of the blast site, and therefore, if air blast complaints are a continual problem, blasting during unfavourable weather conditions will be postponed. As air blast intensity is a function of total charge weight, then a reduction in the total amount of explosives used can also reduce the air overpressure value.

Further guidance will be obtained from the recommendations contained within BS 5228: Part 1 and the European Communities (Construction Plant and Equipment) (Permissible Noise Levels) Regulations 1988 in relation to blasting operations.

The methods which will be used to minimise effects consist of the following:

- Restriction of hours within which blasting can be conducted (e.g., 09:00 – 18:00hrs).
- A publicity campaign undertaken before any work and blasting starts (e.g., 24 hours written notification).
- The firing of blasts at similar times to reduce the 'startle' effect.
- On-going circulars informing people of the progress of the works.
- The implementation of an onsite documented complaints procedure.
- The use of independent monitoring by external bodies for verification of results.
- Trial blasts in less sensitive areas to assist in blast designs and identify potential zones of influence.

With the application of the mitigation measures described above, it is not expected that a significant impact will occur at noise-sensitive locations due to construction activity.

12.5.1.2 Vibration

It is recommended that vibration from construction activities be limited to the values set out in Table 12-2. It should be noted that these limits are not absolute but provide guidance as to magnitudes of vibration that are very unlikely to cause cosmetic damage. Magnitudes of vibration slightly greater than those in the table are normally unlikely to cause cosmetic damage, but construction work creating such magnitudes should proceed with caution. Where there is existing damage these limits may need to be reduced by up to 50%.

It is not expected that piling is required; however, based on the large distances between locations where piling would take place and the nearest NSLs, no significant impact will be experienced. Therefore, no mitigation measures are proposed.

As blasting is required, the following mitigation measures will be employed to control the impact during blasts:

- Trial blasts will be undertaken to obtain scaled distance analysis.
- Ensuring appropriate burden to avoid over or under confinement of the charge.
- Accurate setting out and drilling.
- Appropriate charging.
- Appropriate stemming with appropriate material such as sized gravel or stone chipping.
- Delay detonation to ensure small maximum instantaneous charges.
- Decked charges and in-hole delays.
- Blast monitoring to enable adjustment of subsequent charges.
- Good blast design to maximise efficiency and reduce vibration.
- Avoid using exposed detonating cord on the surface.

12.5.2 Operational Phase

An assessment of the operational noise levels has been undertaken in accordance with best practice guidelines and procedures as outlined in Section 12.2.2.4 of this chapter.

The findings of the assessment confirmed that the predicted operational noise levels from the proposed project will be within the relevant best practice noise criteria. Therefore, no specific mitigation measures are required.

12.5.2.1 Amplitude Modulation

In the event that a complaint which indicates potential amplitude modulation (AM) associated with turbine operation, the operator will employ an independent acoustic consultant to assess the level of AM in accordance with the methods outlined in the Institute of Acoustics (IOA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, Institute of Acoustics IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group Final Report: A Method for Rating Amplitude Modulation in Wind Turbine Noise (9 August 2016) or subsequent revisions.

The measurement method outlined in the IOA AMWG document, known as the 'Reference Method', will provide a robust and reliable indicator of AM and yield important information on the frequency and duration of occurrence, which can be used to evaluate mitigation requirements.

These mitigation measures, if required, will consist of the implementation of operational controls for the relevant turbine type, which will include turbine curtailment and/or stopping turbines under specific operational conditions.

12.5.3 Decommissioning Phase

The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those proposed for the construction phase of development, i.e., as per Section 12.5.1.

12.5.4 Monitoring

Commissioning noise surveys will be undertaken to ensure compliance with any noise conditions applied to the project. In the unlikely instance that an exceedance of these noise criteria is identified, the assessment guidance outlined in the IOA GPG and Supplementary Guidance Note 5: Post Completion Measurements (July 2014) should be followed, and relevant corrective actions will be taken. For example, implementation of noise operational modes resulting in curtailment of turbine operation can be implemented for specific turbines in specific wind conditions to ensure predicted noise levels are within the relevant noise criterion curves/planning conditions. Such curtailment can be applied using the wind farm SCADA system without undue effect on the wind turbine

12.6 RESIDUAL EFFECTS

This section summarises the likely residual noise and vibration effects associated with the proposed project following the implementation of mitigation measures.

12.6.1 Construction Phase

During the construction phase of the project there will be some effect on nearby NSLs due to noise emissions from site traffic and other construction activities. However, given the distances between the main construction works and nearby NSLs and the fact that the construction phase of the development is temporary in nature, it is expected that the various noise sources will not be excessively intrusive. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that the noise and vibration effect is kept to a minimum.

With respect to the EPA's criteria for description of effects, in terms of these construction activities, the potential worst-case associated effects at the nearest NSLs associated with the various elements of the construction phase are described below.

12.6.1.1 General Construction – Turbines and Hardstands

Quality	*Significance*	*Duration*
Negative	Not significant	Short-term

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.6.1.2 Construction of Internal Site Roads

Quality	*Significance*	*Duration*
Negative	Not Significant	Temporary

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.6.1.3 Construction of Junction Accommodation Works

Quality	*Significance*	*Duration*
Negative	Significant	Brief

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.6.1.4 Borrow Pits

Quality	*Significance*	*Duration*
Negative	Slight	Temporary

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.6.1.5 Substation Construction

Quality	*Significance*	*Duration*
Negative	Not Significant	Temporary

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.6.1.6 Construction Traffic

Quality	*Significance*	*Duration*
Negative	Not Significant	Short-Term

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.6.2 Operational Phase

12.6.2.1 Wind Turbine Operation

The predicted noise levels associated with the proposed project will be within best practice noise criteria curves recommended in line with Irish guidance 'Wind Energy Development Guidelines for Planning Authorities', it is not considered that a significant effect is associated with the proposed project.

While noise levels at low wind speeds will increase due to the proposed project and specifically the operation of the turbines, the predicted levels will remain low, albeit new sources of noise will be introduced into the soundscape.

The predicted residual operational turbine noise effects are summarised as follows at the closest NSLs to the site, which apply to the range of wind turbine technologies assessed in this chapter:

Quality	*Significance*	*Duration*
Negative	Moderate	Long-term

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

For most of the locations assessed here the effect of the operational turbines are as follows:

Quality	*Significance*	*Duration*
Negative	Not significant	Long-term

The above effects should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

12.6.2.2 Substation Operation

In relation to the proposed substation location the associated effect at the closest NSLs is summarised as follows:

Quality	*Significance*	*Duration*
Negative	Not Significant	Long-term

12.6.3 Vibration

There are no expected sources of vibration associated with the operational phase of the proposed project. In relation to vibration the associated effect is summarised as follows:

Quality	*Significance*	*Duration*
Neutral	Imperceptible	Long-term

12.7 CUMULATIVE EFFECTS

A list of projects which have been considered for cumulative impacts is presented in Section 4.3.3 of Chapter 4 of this EIAR (Planning, Policy & Development Context). There is no other project of scale in the area which could, if constructed or operated at the same time as the proposed project, lead to a significant cumulative effect.

The nearest wind farm is Loughderryduff, at some 4.5 km to the southwest; due to the distance between Loughderryduff wind farm at the proposed project, there is no potential for significant cumulative noise impacts.

Other potential sources of noise in the cumulative context are the ongoing surrounding commercial forest management activities on Coillte-owned lands including felling and replanting of trees. Noise from commercial forest management will be managed in line with the operational conditions of the felling licence and therefore no long-term cumulative noise impacts are anticipated between the proposed project in combination with commercial forestry activities.

12.8 CONCLUSION

When considering a proposed project of this nature, the potential noise and vibration effects on the surroundings must be considered for two stages: the short-term construction phase and the long-term operational phase.

The assessment of construction noise and vibration and has been conducted in accordance best practice guidance contained in BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise and BS 5228-2:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Vibration. Subject to good working practice as recommended in the EIAR Chapter, noise associated with the construction phase is not expected to exceed the recommended limit values. The associated noise and vibration are not expected to cause any significant effects.

Based on detailed information on the site layout, turbine noise emission levels and turbine height, worst-case turbine noise levels have been predicted at NSLs for a range of operational wind speeds. The predicted noise levels associated with the proposed project will be within best practice noise limits recommended in Irish guidance, therefore it is not considered that a significant effect is associated with the proposed project. A range of possible turbine technologies has been considered; the conclusions in respect of the environmental noise effects apply to the range of wind turbine technologies assessed in this chapter and all scenarios in the wind turbine range.

Noise from the proposed substation has also been assessed and found to be within the adopted criteria.

No significant vibration effects are associated with the operation of the site.

In summary, the noise and vibration impact of the proposed project is not significant in the context of current national guidance.

REFERENCES

- EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports May 2022 (EPA, 2022)
- Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document Guidelines for the Treatment of Noise and Vibration in National Road Schemes (NRA, 2004)
- BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration (BSI, 1993).
- United Kingdom Highways Agency (UKHA) Design Manual for Roads and Bridges (DMRB) Sustainability & Environment Appraisal LA 111 Noise and Vibration Revision 2 (UKHA 2020)
- ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation, (ISO, 1996).Reference No. 1
- Institute of Acoustics: A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (2013)
- Wind Energy Development Guidelines" published by the Department of the Environment, Heritage and Local Government 2006
- Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) "The Assessment and Rating of Noise from Wind Farms" (1996).
- BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise
- BS 5228: 2014 & A1 2014 – Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 2: Vibration.
- ISO 1996: 2017: Acoustics — Description, measurement and assessment of environmental noise.