11. NOISE AND VIBRATION

11.1 Introduction

11.1.1 Background and Objectives

This chapter of the EIAR describes the assessment undertaken of the potential noise and vibration impacts associated with the proposed Slieveacurry Renewable Energy Development (the 'Proposed Development'). The Proposed Development will comprise 8. no. wind turbines with an overall ground-to-blade tip height in the range of 175 metres maximum to 173 metres minimum; blade length in the range of 75 metres maximum to 66.5 metres minimum; and hub height in the range of 108.5 metres maximum to 100 metres minimum, a full description of the Proposed Development is provided in Chapter 4 of this EIAR.

Noise and vibration impact assessments have been prepared for both the operational, construction and decommissioning phases of the Proposed Development at identified noise sensitive location (NSL's) in the vicinity. To inform this assessment, background noise levels have been measured at five representative NSL's in the vicinity of the Proposed Development site.

Two other wind turbine developments with the potential for cumulative noise impacts have been identified and considered as part of this assessment. These are the operational Slievecallan Wind Farm and the proposed Coor Shanavogh Wind Farm. In line with best practice guidance the cumulative impact of these other developments has been included in the operational noise impact assessment. Further details on these other developments is provided in Chapter 2 of this EIAR. The baseline environment, potential direct, indirect and cumulative impacts of replanting lands on noise has been assessed in the Section 10 of Appendix 4-3 Assessment of Forestry Replacement Lands.

11.1.2 Statement of Authority

This chapter has been prepared by Dermot Blunnie of AWN Consulting Ltd:

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. The chapter has been reviewed by Mike Simms 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 and of the Institution of Engineering and Technology. Mike has worked in the field of acoustics for over 19 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.

11.2 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 vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of Sound Pressure Levels (SPL) is 0dB (for the threshold of hearing) to 120dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10dB increase in SPL. It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 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 250Hz. In order to rank the SPL of various noise sources, the measured level is 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. SPL's measured using 'A-weighting' are expressed in terms of dB(A).

An indication of the level of some common sounds on the dB(A) scale is presented in Figure 11-1.

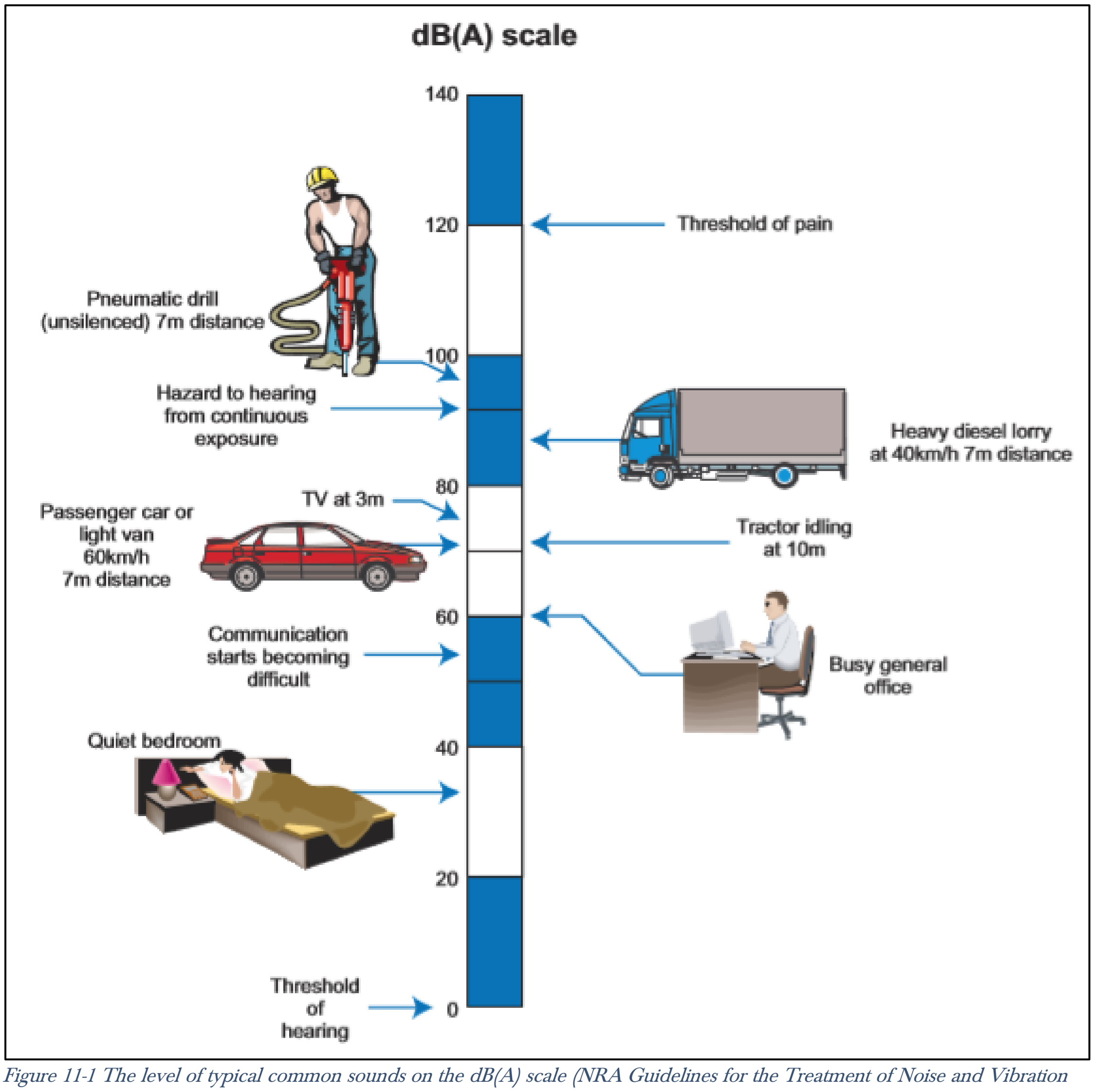


Figure 11-1 The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)

For a glossary of terms used in this chapter please refer to Appendix 11-1.

11.3 Assessment Methodology

The assessment of impacts for the Proposed Development has been undertaken with reference to the most appropriate guidance documents relating to environmental noise and vibration which are set out in Section 11.3.2.

In addition to the specific guidance documents outlined in this chapter, the Environmental Impact Assessment (EIA) guidelines listed in Section 1.7.2 of Chapter 1 were considered and consulted for the purposes of preparing this EIAR chapter.

The methodology adopted for this noise impact assessment 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 NSL's surrounding the Proposed Development;
- Undertake predictive calculations to assess the potential impacts associated with the construction and decommissioning phase of the Proposed Development at the nearest NSL's;
- Undertake predictive noise calculations to assess the potential impacts associated with the operational phase of the Proposed Development at NSL's; evaluate the potential noise and vibration impacts and effects.
- Specify mitigation measures to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the Proposed Development; and
- Describe the significance of the residual noise and vibration effects associated with the Proposed Development.

11.3.1 EPA Description of Effects

The significance of effects of the Proposed Development shall be described in accordance with the EPA guidance document Draft *Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), (EPA, 2017)*. Details of the methodology for describing the significant of the effects are provided in Table 1-2 of Chapter 1: Introduction.

The effects associated with the Proposed Development are described with respect to the EPA guidance in the relevant sections of this chapter.

11.3.2 Guidance Documents and Assessment Criteria

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

11.3.2.1 Construction and Decommissioning Phase

11.3.2.1.1 *Construction 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 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.*

The approach adopted here calls for the designation of a noise sensitive location into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. This then sets a threshold noise value that, if exceeded at the facade of residential receptors, (construction noise only), indicates a potential significant noise impact is associated with the construction activities.

Table 11-1 sets out the values which, if exceeded, potentially signify a significant effect as recommended by BS 5228 – 1. These levels relate to construction noise only.

Table 11-1 Example Threshold of Potential Significant Effect at Dwellings

Assessment category and threshold value period (T)	Threshold values, $L_{Aeq,T}$ 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.

This assessment method is only valid for residential properties. For the appropriate period (e.g. daytime) the ambient noise level is determined and rounded to the nearest 5 dB. In this instance, with the rural nature of the site, properties near the development have daytime ambient noise levels that typically range from 40 to 50 dB $L_{Aeq,T}$. Therefore, all properties will be afforded a Category A designation.

See Section 11.5.2 for the detailed assessment in relation to the Proposed Development. 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 have occurred.

11.3.2.1.2 Additional Vehicular Activity

For the assessment of potential noise impacts from construction related traffic along public roads and haul routes 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 11-2, taken from Section 13.7 of DMRB presents guidance as to the likely impact associated with any change in the background noise level ($L_{Aeq,T}$) at a noise sensitive receiver from construction traffic.

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;
- A total number of days exceeding 40 in any 6 consecutive months.

Table 11-2 Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2019)

Change in Sound Level	Magnitude of Impact
0	No Change
0.1 – 0.9	Negligible
1.0 – 2.9	Minor
3.0 – 4.9	Moderate
>5	Major

The DMRB guidance outlined will be used to assess the predicted increases in traffic noise levels on public roads associated with the Proposed Development and comment on the likely impacts during the construction phase.

11.3.2.1.3 Construction 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); and
- BS 5228 – *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration* (BSI, 2009+A1:2014).

BS 7385 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.

BS 5228 recommends that, for soundly constructed residential property 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 where there is existing damage these limits may be reduced by up to 50%. In addition, where continuous vibration is generated the limits discussed above may need to be reduced by 50%.

The Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document *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 11-3.

Table 11-3 Allowable Transient Vibration at Properties

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

11.3.2.2 Operational Phase

11.3.2.2.1 *Noise*

The noise assessment in this chapter has been 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.

11.3.2.2.2 *Wind Energy Development Guidelines*

Section 5.6 of the Wind Energy Development Guidelines 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 will 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 LA90, 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 lower limit 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 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. Therefore, a night time 5dB(A) above background allowance has also been adopted in the criteria for this assessment.

The ETSU-R-97 guidance (refer to Section 11.3.2.2.3) allows for a higher level of turbine noise operation at properties that have an involvement in the development, both as a higher fixed level of 45 dB L_{A90} and/or a higher level above the prevailing background noise level. In line with the ETSU-R-97 guidance a lower threshold of 45 dB $L_{A90,10min}$ has been applied to the NSL's involved with wind energy development.

The criteria have been chosen as it is in line with the intent of the relevant Irish guidance. The proposed operational noise criteria for wind turbine noise at various noise sensitive locations are presented in Section 0.

11.3.2.2.3 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.

11.3.2.2.4 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 the *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, in particular 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 turbine 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.

Assessment of Cumulative Turbine Noise Impacts

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[1] 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[2] could be invaluable to this part of the assessment."*
>
> *Cumulative impact assessment necessary*

1 HMP: Hayes McKenzie Partnership Ltd. Report on "Analysis of How Noise Impacts are considered in the Determination of Wind Farm Planning Applications" Ref HM: 2293/R1 dated 6th April 2011.
2 Environmental Health Officer

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."

11.3.2.2.5 Future Potential Guidance Change

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 a number of 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.

In the event that updated Wind Energy Guidelines are published during the application process for the Proposed Development 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.

11.3.2.2.6 World Health Organisation (WHO) Noise Guidelines for the European Region

The World Health Organisation (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 Lden, as wind turbine noise above this level is associated with adverse health effects.*
>
> *No recommendation is made for average night noise exposure Lnight 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 policymakers 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.*"

The quality of evidence used for the WHO research is stated as being 'Low', the recommendations are therefore conditional.

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.

> "*Even though correlations between noise indicators tend to be high (especially between LAeq-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 Lden or Lnight 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 therefore 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 L_{den} criteria has been adopted as part of this assessment, this is based upon the review set out above and the conclusion that the conditional WHO recommended 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.

11.3.3 Special Characteristics of Turbine Noise

11.3.3.1 Infrasound/Low Frequency Noise

Low Frequency Noise is noise that is dominated by frequency components less than approximately 200Hz whereas Infrasound is typically described as sound at frequencies below 20Hz. 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."*

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. In relation to the issue of infrasound, the article states the following:

> *"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 and Resonate Acoustics, 2013)[3] 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[4], titled "L*ow 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 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)*[5]"
>
> *"The results of this measurement project comply with the results of similar investigations on a national and international level."*

---

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

4 *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*

5 *DIN 45680:2013-09 – Draft "Measurement and Assessment of Low-frequency Noise Immissions" November 2013*

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.

11.3.3.2 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 Noise* (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, at least on relatively level sites.

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.

11.3.3.2.1 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 4, and a possible issue at a further 8, of 133 sites in the UK that were operational at the time of the study and considered within the review. At the 4 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.*"

11.3.3.2.2 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.

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 log-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.

11.3.4 Comments on Human Health Impacts

11.3.4.1 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, this report 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"*

11.3.4.2 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[6]. 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.

11.3.4.3 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.

11.3.4.4 The Australian Medical Association

The Australian Medical Association put out a position statement, *Wind Farms and Health* 2014[7]. 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*

---

6 *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*

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

> *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."*

11.3.4.5 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 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 region.

11.3.4.6 Summary

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

11.3.5 Vibration

A recent report published in Germany 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 300m from the turbine vibration levels had dropped so far that they could no longer be differentiated from the background vibration levels.

Considering the distances from nearest NSL's to any of the proposed turbines is much greater than 300m, levels of vibration will be significantly below any thresholds for perceptibility. Therefore, vibration criteria have not been specified for the operational phase of the Proposed Development.

11.3.6 Background Noise Assessment

A noise survey was undertaken to determine typical background noise levels at representative NSL's surrounding the development site. The background noise survey was conducted through installing unattended sound level meters at 5 no. representative locations in the surrounding area.

All measurement data collected during the background noise surveys has been carried out in accordance with the Institute to Acoustic's *Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (IoA GPG, 2013) and accompanying, Supplementary Guidance Note 1: Data Collection (2014) discussed in the following Section.

11.3.6.1 Choice of Measurement Locations

The noise monitoring locations were identified by preparing a preliminary cumulative turbine noise model contour at an early stage of the assessment. Any locations that fell inside the predicted 35 dB L_{A90} noise contour were considered for noise monitoring in accordance with the threshold level defined in the IoA GPG. The selection of the noise monitoring locations was informed by site visits and supplemented by reviewing aerial images of the study area and other online sources of information (e.g. Google Earth, Bing Maps, etc.).

The locations selected for the noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in Table 11-4 and illustrated in Figure 11-2.

Table 11-4 Measurement Location Coordinates

Location	NSL ID Ref	Coordinates – Irish Transverse Mercator (ITM)	
		ITM X	ITM Y
A	R001	512956	681663
B	R045	512949	679147
C	R058	510989	678700
D	R061	510742	679543
E	R007	510817	680735
LiDAR Anemometer	n/a	512924	679206

The noise monitoring locations were selected to obtain background noise levels representative of the noise environments at noise sensitive locations surrounding the site in line with best practice guidance contained in the IOA GPG.

The background noise environments away from any significant sources were typically noted to comprise distant traffic movements, activity in and around the residences and wind generated noise from nearby foliage and other typical anthropogenic sources typically found in such rural settings. Additional descriptions of the noise environments from observations made on site during installation, interim visits and collection are presented below for each monitoring location where relevant.

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. Similarly there was no perceptible source of vibration at any of the noise survey locations.

At some locations, noise from the operation of the Slievecallan Wind Turbines was audible to varying degrees depending on the conditions (wind speed and direction) and distance. It is important to note that any noise from the existing wind turbine in the area should not form part of the background noise environment at noise sensitive locations. Steps have been taken to remove any turbine noise from existing wind farms in the analysis of the background noise data, as required by Section 5.2.3 of the IoA GPG. These methods are discussed in detail in Section 11.3.6.5.

Map Legend

- EIAR Site Boundary
- Proposed Turbine Locations
- Noise Monitoring Locations
- Noise Sensitive Locations (NSL)
- Derelict Properties

Microsoft product screen shots reprinted with permission from Microsoft Corporation
Ordnance Survey Ireland Licence No. AR 0021821© Ordnance Survey Ireland/Government of Ireland

Drawing Title: Noise Monitoring Locations	
Project Title: Slieveacurry Renewable Energy Development, Co. Clare	
Drawn By: Ellen Costello	Checked By: Michael Watson
Project No.: 170224c	Drawing No.: Figure 11-2
Scale: 1:27500	Date: 29.10.2021

MKO
Planning and Environmental Consultants
Tuam Road, Galway Ireland, H91 VW84
+353 (0) 91 735611
email:info@mkoireland.ie
Website: www.mkoireland.ie

Plate 11-1 to Plate 11-10 illustrate the installed noise monitoring equipment at each location. Yellow ellipses are added to the photographs to highlight the position of the noise monitoring equipment.

11.3.6.1.1 Location A

The noise meter at Location A was positioned in an open field beside location R001. This location was judged to be representative of the typical background noise at NSL location in the surrounding area, occasional local road traffic noise was noted and turbine noise from Slievecallan was observed to be audible in the background.

Plate 11-1 Location A – Picture 1

Plate 11-2 Location A – Picture 2

11.3.6.1.2 Location B

The noise meter at Location B was positioned in the rear garden of location R045 (derelict dwelling) on the northern side of the property. The main sources of noise at this location were noted to be the Slievecallan wind turbines located to the South and occasional local traffic.

Plate 11-3 Location B – Picture 1

Plate 11-4 Location B – Picture 2

11.3.6.1.3 Location C

The noise meter at Location C was positioned in an open field adjacent to the dwelling at R058. There was a clear line of site to the existing turbines at Slievecallan Wind Farm, the nearest turbine at Slievecallan is approximately 1.7km to the south east. The turbines were noted to be audible during visits to site.

Plate 11-5 Location C – Picture 1

Plate 11-6 Location C – Picture 2

11.3.6.1.4 Location D

Location D was positioned in a field opposite the dwelling at location R061 the location was noted to be quiet with little road traffic audible; this location is off a quiet road which runs through a narrow valley (glen), which provides screening from distant noise sources. The nearest turbine at Slievecallan wind farm is located over 2.5km to the south east and the turbines were not visible or audible at the measurement location.

Plate 11-7 Location D – Picture 1

Plate 11-8 Location D – Picture 2

11.3.6.1.5 Location E

Location E was positioned in a field to the rear (south) of R007. The location was noted to be quiet with little distant road traffic audible. The nearest turbine at Slievecallan wind farm is located over 3.3km to the south east and the turbines were not visible or audible at the measurement location.

Plate 11-9 Location E – Picture 1

Plate 11-10 Location E – Picture 2

11.3.6.2 Measurement Period

Noise monitors were all installed on the 24th April 2020 however, wind speeds measurements did not commence until the 14th May 2020. The period of noise measurements used in the background noise monitoring assessment is outlined in Table 11-5. Noise monitoring at all locations was carried out on a 24-hour basis between 14 May 2020 and 12 June 2020.

Table 11-5 Measurement Period

Location	Start Date	End Date
All	14 May 2020	12 June 2020

The survey was completed when an adequate number of datasets had been measured as recommended in the IOA GPG to determine a suitable representation of the typical background noise.

11.3.6.3 Personnel and Instrumentation

AWN Consulting installed and removed the noise monitors at all locations. Battery checks and meter calibrations were carried out during the survey periods. The following instrumentation was used at each location.

Table 11-6 Instrumentation Details

Location	Equipment	Serial Number	Maximum Calibration Drift Noted between Checks
A	RION – NL-52	998411	0.0 dB
B	RION – NL-52	998412	0.0 dB

Location	Equipment	Serial Number	Maximum Calibration Drift Noted between Checks
C	RION – NL-52	998410	0.0 dB
D	RION – NL-52	586940	0.2 dB
E	RION – NL-52	998413	0.0 dB

Before and after the survey the measurement apparatus was check calibrated using a Bruell & Kjaer type 4231 Sound Level Calibrator where appropriate. Instruments were calibrated on each interim visit and any drift noted. All calibration drifts were less than ±0.2 dB and within acceptable tolerances outlined in the IOA GPG. Relevant calibration certificates are presented in Appendix 11-2.

Rain fall was monitored and logged using two Texas Instruments TR-525 console data loggers that were installed at Location B & E for the duration of the survey. The logged rainfall data allows for the identification and removal of sample periods affected by rainfall from the data sets during analysis in line with best practice when calculating the prevailing background noise levels.

Wind data was measured using a LIDAR system and the data was supplied to AWN for the analysis. The LIDAR method is one of the preferred methods for measuring wind speed and direction outlined in the IOA GPG. Appendix 11-3 presents a copy of the installation report for the LiDAR system.

11.3.6.4 Procedure

Measurements were conducted at five locations over the survey periods outlined in Table 11-5. Data samples for all measurements (noise, rainfall and wind) were logged continuously over 10-minute intervals for the duration of the survey.

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. $L_{Aeq,10min}$ and $L_{A90,10min}$ parameters were measured in this instance.

11.3.6.5 Analysis of Background 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 from the data sets. The assessment methods outlined above are in line with the guidance contained in the IoA *GPG*.

Consideration has been given to removing contributing noise from the existing wind turbines from the measured noise data. For guidance, reference has been made to Section 5.2.3 of the IOA GPG which states the following:

> *"5.2.3 In the presence of an existing wind farm, suitable background noise levels can be derived by one of the following methods:*
>
> - *switching off the existing wind farm during the background noise level survey (with associated cost implications);*
> - *accounting for the contribution of the existing wind farm in the measurement data e.g. directional filtering (only including background data when it is not influenced by*

the existing turbines e.g. upwind of the receptor, but mindful of other extraneous noise sources e.g. motorways) or subtracting a prediction of noise from the existing wind farm from the measured noise levels;

- *utilising an agreed proxy location removed from the area acoustically affected by the existing wind farm/s; or utilising background noise level data as presented within the Environmental Statement/s for the original wind farm/s (the suitability of the background noise level data should be established)."*

Two methods were adopted in the assessment, directional filtering and subtracting the predicted existing turbine noise levels from the measured data sets. Details of the method applied at each location are discussed in Section 11.4.1 along with the results of the assessment.

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.

For the purposes of this assessment, the turbine model that has been modelled is the Vestas V136 4.2MW. The turbine is a pitch regulated upwind turbine with a three-blade rotor and is representative to the type of turbine that would be installed or available on the market. Within the turbine range detailed in the drawings in Appendix 4-1, for the Vestas V136 when the maximum tip height is 175m, the maximum potential rotor diameter is 136m (68m blade length) and the maximum potential hub height is 107m.

The background noise levels are derived for each location with reference to the standardised 10m height wind speed relative to the assessment turbine, Vestas V136.

11.3.6.5.1 Consideration of Wind Shear

Wind shear is defined as the increase of wind speed with height above ground. As part of a robust wind farm noise assessment due consideration should be given to the issue of wind shear. The issue of wind shear has been considered in this assessment and followed relevant guidance as outlined in the IoA GPG. It is standard procedure to reference noise data to standardised 10 metre height wind speed.

Wind speed measurements were measured at 107m, which is the maximum hub height for the Vestas V136 which has been adopted for the noise assessment. The wind speeds were then corrected to standardised 10 metre height wind speed.

The IoA GPG presents the following equations in relation to the derivation of a standardised wind speed at 10m above ground level:

Roughness Length Shear Profile: $U_1 = U_2 \text{ x } [(\ln(H_1 \div z))/ (\ln(H_2 \div z))]$

Where:

H_1 The height of the wind speed to be calculated (10m)

H_2 The height of the measured or calculated HH wind speed.

U_1 The wind speed to be calculated.

U_2 The measured or calculated HH 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 this chapter should be understood to be the standardised 10m height wind speed reference unless otherwise stated.

11.3.7 Turbine Noise Calculations

A series of computer-based prediction models have been prepared to quantify the cumulative noise level associated with the operation of the existing, permitted, and Proposed Developments. This section discusses the methodology for the noise modelling process.

11.3.7.1 Noise Modelling Software

Proprietary noise calculation software was used for the purposes of this impact assessment. 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 (L_{WA});
- 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 impact at distances greater than approximately 400m).

11.3.7.2 Input Data and Assumptions

The calculation settings, input data and any assumptions made in the assessment are described in the following sections. Additional information relating to the noise model inputs and calculation settings is provided in Appendix 11-4.

11.3.7.2.1 *Turbine Details*

Table 11-7 details the co-ordinates of the 8 no. proposed turbines that are being considered in this assessment.

Table 11-7 Proposed Slieveacurry Wind Turbine Co-ordinates

Turbine Ref.	Coordinates – Irish Transverse Mercator (ITM)	
	ITM X	ITM Y
T01	511,790	680,787
T02	512,456	680,814
T03	511,518	680,283
T04	512,074	680,308
T05	512,851	680,510
T06	512,391	679,844
T07	511,487	679,203
T08	511,996	679,451

For the purposes of this assessment, the turbine type that has been modelled for the development site is the Vestas V136 4.2MW. The turbine is a pitch regulated upwind turbine with a three-blade rotor and is representative to the type of turbine that would be installed or available on the market.

Calculations have been performed for the Vestas V136for the Proposed Development i.e. the adopted turbine for the purpose of this assessment.

While the noise profiles of the Vestas V136[8] wind turbine has been used for the purposes of this assessment, the actual turbine to be installed on the site will fall within the turbine range detailed in the drawings included in Appendix 4-1 and will be the subject of a competitive tender process and could include turbines not amongst the turbine models currently available. Any references to the Vestas V136 turbines in this assessment must be considered in the context of the above and should not be interpreted to mean that it is the only make or model of wind turbine that could be used for the Proposed Development.

The details of the final selection of turbine make and model within the turbine range detailed in Section 4.1 of Chapter 4 Description of the Proposed Development and the drawings included in Appendix 4-1 will be confirmed to Clare County Council and will include an updated noise assessment to confirm that the noise emissions comply with the noise criteria as per best practice guidance outlined in Section 11.4.2 and/or the relevant operational criteria associated with the grant of planning permission.

Sound power levels (L_{WA}) have been supplied for the Vestas V136 turbine under consideration. Table 11-8 details the noise emission values used for noise modelling of the proposed Slieveacurry turbines.

For the purposes of all predictions presented in this report to account for various uncertainties in the measurement of turbine source levels, a +2 dB uncertainty factor has been added to the turbine noise emission values in line with guidance for wind turbine noise assessment contained in the IOA GPG unless otherwise stated below.

[8] *Vestas Wind Systems A/S Document Ref – DMS no.: 0067-4732_03 dated 2018-05-03. Noise emission values for the Power Optimized (PO1) 4.2MW turbine with Serrated Trailing Edge (STE) blades have been used in this assessment for standard operation mode. The full manufacturer's data is not presented in this chapter for commercial reasons and associated non-disclosure agreements with the manufacturer.*

Table 11-8 L_{wa} Spectra Used for Prediction Model – Slieveacurry Turbine Noise Emissions for Vestas V136.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
3	72.2	80.1	85.0	86.9	85.8	81.6	74.5	64.3	91.7
4	75.8	83.8	88.6	90.5	89.3	85.1	77.9	67.6	95.3
5	81.0	88.9	93.8	95.6	94.4	90.2	83.0	72.7	100.4
6	84.5	92.2	96.9	98.7	97.6	93.5	86.6	76.5	103.6
7	84.9	92.5	97.2	99.0	97.9	93.8	86.9	76.9	103.9
8	85.0	92.6	97.2	99.0	97.9	93.8	87.0	77.1	103.9
≥9	85.2	92.6	97.2	99.0	97.9	93.9	87.2	77.6	103.9

Table 11-9 below details the noise emission values used for noise modelling of the Slievecallan turbines. The installed turbine model at this site is the Nordex N90/2500[9] with hub height of 80m. The noise emission data has been taken information from AWN's database using data for this turbine type.

Table 11-9 L_{wa} Spectra Used for Prediction Model – Slievecallan Turbine Noise Emissions for Nordex N90/2500

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
3	78.7	82.8	87.2	87.6	86.1	85.0	81.0	73.4	93.5
4	82.7	86.8	91.2	91.6	90.1	89.0	85.0	77.4	97.5
5	86.2	90.3	94.7	95.1	93.6	92.5	88.5	80.9	101.0
6	89.2	93.3	97.7	98.1	96.6	95.5	91.5	83.9	104.0
7	90.2	94.3	98.7	99.1	97.6	96.5	92.5	84.9	105.0
≥8	90.7	94.8	99.2	99.6	98.1	97.0	93.0	85.4	105.5

An uncertainty factor of +1.5 dB has been included for the Nordex N90/2500 turbines in the calculations in line with the manufacturer's data.

Table 11-10 details the noise emission values used for noise modelling of the proposed Coor Shanavogh Wind Farm. The turbine model used in the EIS for the development was the Enercon E-82 E2 2.3MW, for the noise modelling assessment for this EIAR the noise emission for the Enercon E-82 E3 turbine with a hub height of 85m has been used, it is noted that the emission for this type of turbine are higher than the emission from the E-82 E2 2.3MW turbine. The noise emission data has been taken information from AWN's database using data for this turbine type.

---

[9] *Nordex technical report Ref: F008_144_A04_EN Revision 00 2013-10-07.*

Table 11-10 L_{wa} Spectra Used for Prediction Model – Coor Shanavogh Turbine Noise Emissions for Enercon E-82 E3

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
4	73.6	80.1	84.8	90.3	92.7	87.5	76.6	69.3	96.0
5	75.6	82.1	86.8	92.3	94.7	89.5	78.6	71.3	98.0
6	79.6	86.1	90.8	96.3	98.7	93.5	82.6	75.3	102.0
7	82.6	89.1	93.8	99.3	101.7	96.5	85.6	78.3	105.0
≥8	83.6	90.1	94.8	100.3	102.7	97.5	86.6	79.3	106.0

As outlined, appropriate guidance is couched in terms of a L_{A90} criterion. The provided turbine noise in Table 11-8 to Table 11-10 is referenced in terms of the L_{Aeq} parameter. Best practice guidance contained within the IoA GPG states that *"L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB".* Therefore, in accordance with best practice guidance, a 2 dB reduction has been applied to the prediction calculations in this assessment.

Best practice specifies that a penalty should be added to the predicted noise levels, where any tonal component is present. The level of this penalty is described and is related to the level by which any tonal components exceed audibility. For this assessment, on review of the noise emission data, 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 best practice guidance.

Appendix 11-4 presents additional technical information relating to the turbine noise model inputs and the turbine location coordinates for other turbines.

11.3.7.3 Consideration of Wind Direction and Noise Propagation

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 development 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 issue, 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° ±80°).

Figure 11-3 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°).

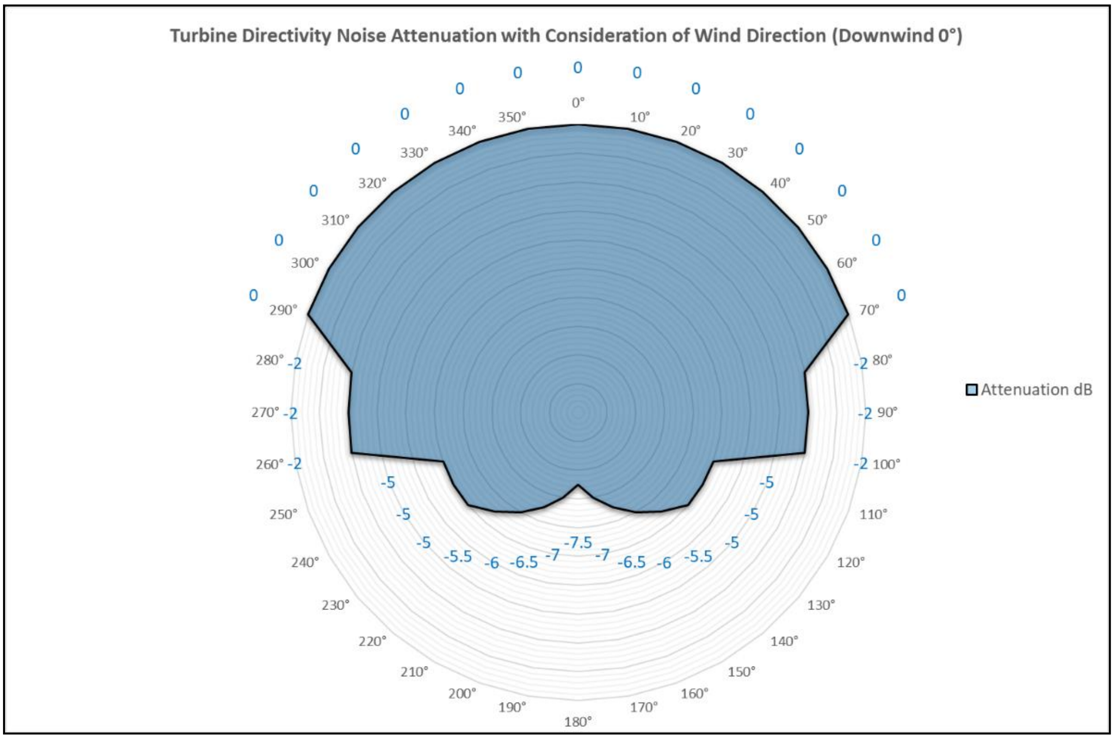


Figure 11-3 Turbine Directivity Attenuation with Consideration of Wind Direction

11.3.7.4 Assessment of Turbine Noise Levels

The predicted cumulative turbine noise level from the Proposed Development and existing wind farm development will be compared against the derived turbine noise limits for the assessment and any exceedances of the limits will be identified. Where necessary, appropriate mitigation measures will be outlined. Considering the distance between the Proposed Development and the Coor Shanavogh Wind Farm the cumulative contributions from this site is considered to be negligible however due to the proximity of the Slievecallan Wind farm to the Proposed Development there are cumulative contributions between both sites. Both Slievecallan and Coor Shanavogh wind farms are included in the cumulative noise model.

11.3.8 Assessment of Construction Impacts

The potential impacts of the construction phase noise and vibration in addition to the potential impacts from additional vehicular activity on public roads will be assessed in accordance with best practice guidance as outlined in 11.3.2.1.

11.4 Receiving Environment

This stage of the assessment was to determine typical background noise levels in the vicinity of the noise sensitive locations (NSL's) in proximity to the Proposed Development. The methodology for the assessment is outlined in 11.3.6 and the results of the assessment are outlined in the following sections.

A variety of wind speed and weather conditions were encountered over the survey period outlined in Section 11.3.6.2. Figure 11-4 illustrates the distributions of wind speed and wind direction standardised to 10 metre height, over the baseline noise survey period detailed in Table 11-5.

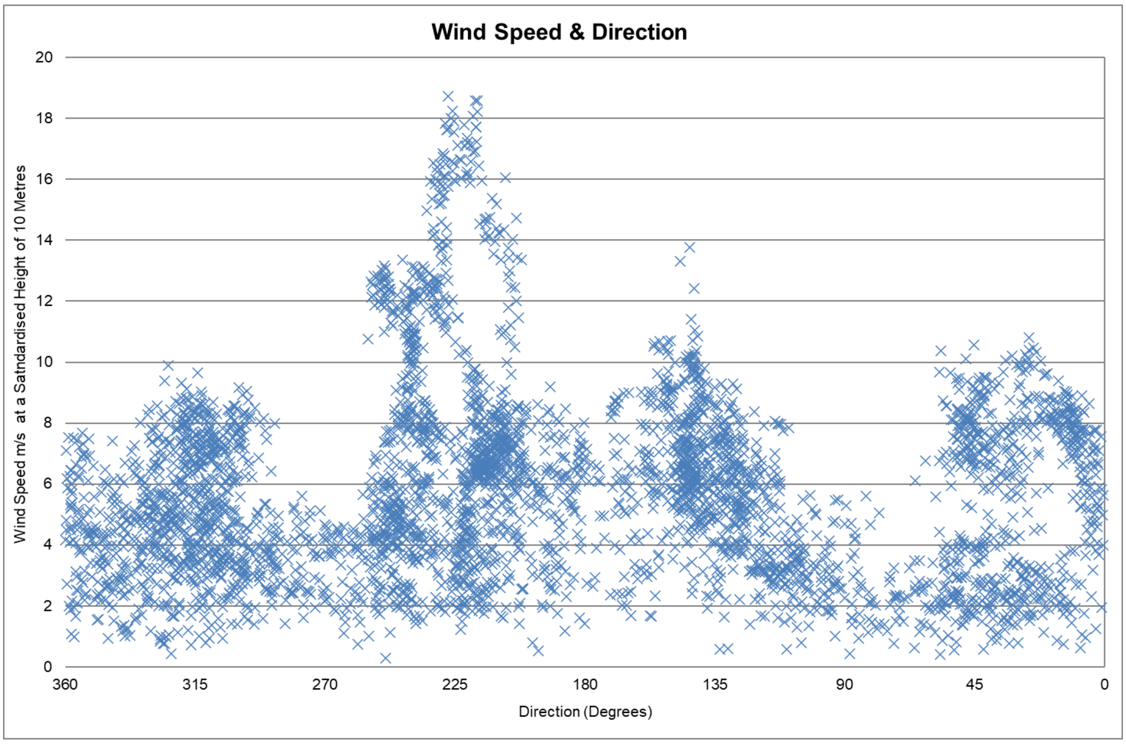


Figure 11-4 Distributions of Wind Speeds and Directions Over the Survey Period

11.4.1 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 set out in Section 11.3.6 and 11.3.6.5. For each location two graphs are presented: one shows the screened noise datasets used to derive the daytime background noise levels and the other shows the night time datasets.

11.4.1.1 Location A

Location A lies to the north of the Proposed Development wind turbines and is over 3km north from the nearest operational turbines at Slievecallan Wind Farm. Figure 11-5 and Figure 11-6 present the measured background noise levels at Location A. The data has been filtered to include only wind directions between 90 and 270 degrees (east through south, to west), which represents downwind conditions from the Proposed Development wind turbines. These wind directions are also representative of downwind conditions from the operational Slievecallan turbines. Therefore, the measured noise levels at Location A, potentially include a slight contribution from the Slievecallan turbines.

For daytime periods, the predicted turbine noise levels at R001 from the Slievecallan turbines have been subtracted from the measured noise levels to derive the background noise levels in accordance with the guidance discussed in Section 11.3.6.5 This is considered the most conservative approach for the background noise assessment at this location as the predicted levels from Slievecallan are worst-case. The resulting background noise levels are presented in Table 11-11 in Section 11.4.1.6.

For night time periods the measured downwind levels (wind directions between 90 and 270) and the predicted downwind levels due to Slievecallan were effectively equal, in these situations it is not possible to logarithmically subtract the predicted contribution from the Slievecallan turbines from the measured levels. Therefore for night time periods the measured noise levels in upwind conditions i.e. between 270 and 90 degrees (west through north, to east), have been used to determine the night time background noise levels at R001. It was observed in the data that the background levels derived for night time in upwind conditions were approximately 1 dB quieter that the levels derived for downwind conditions. The contribution from the Slievecallan turbines in upwind conditions at location R001 is not significant and it is not required to subtract the predicted contribution from the measured upwind levels when using directional filtering in this instance.

11.4.1.1.1 Daytime Quiet Periods

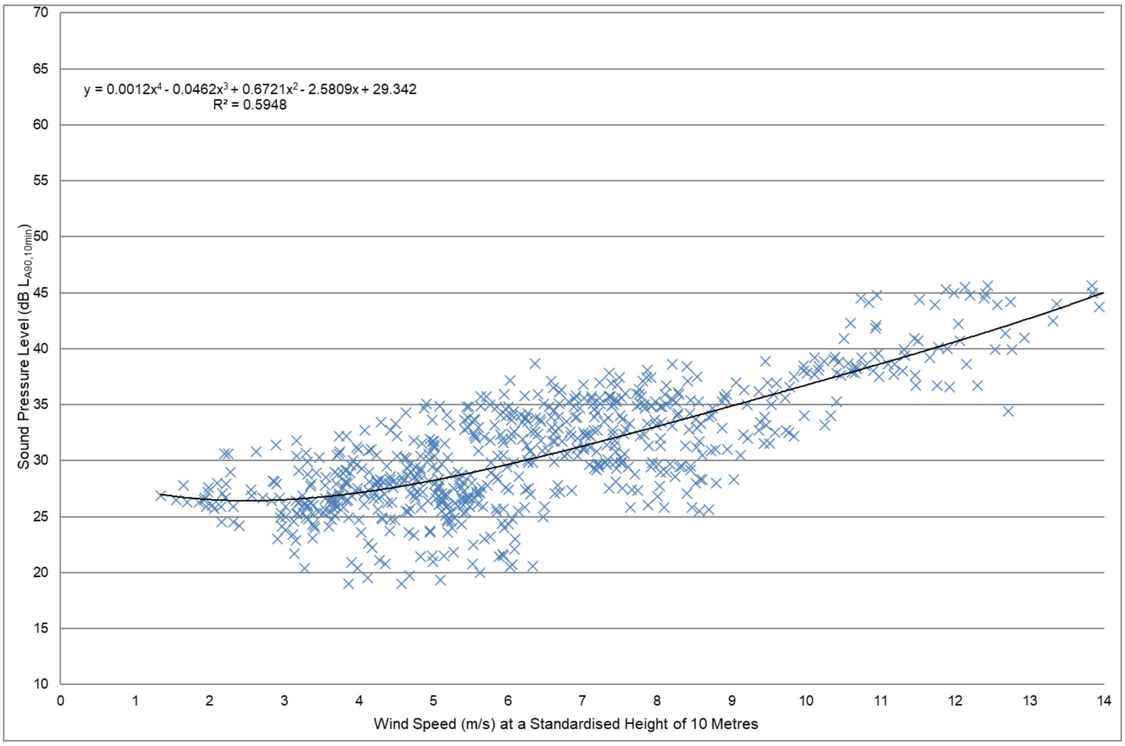


Figure 11-5 Location A - Background Noise Levels dB $L_{A90,\ 10\ min}$ – Daytime wind directions between 90 and 270 Degrees

11.4.1.1.2 Night-time Quiet Periods

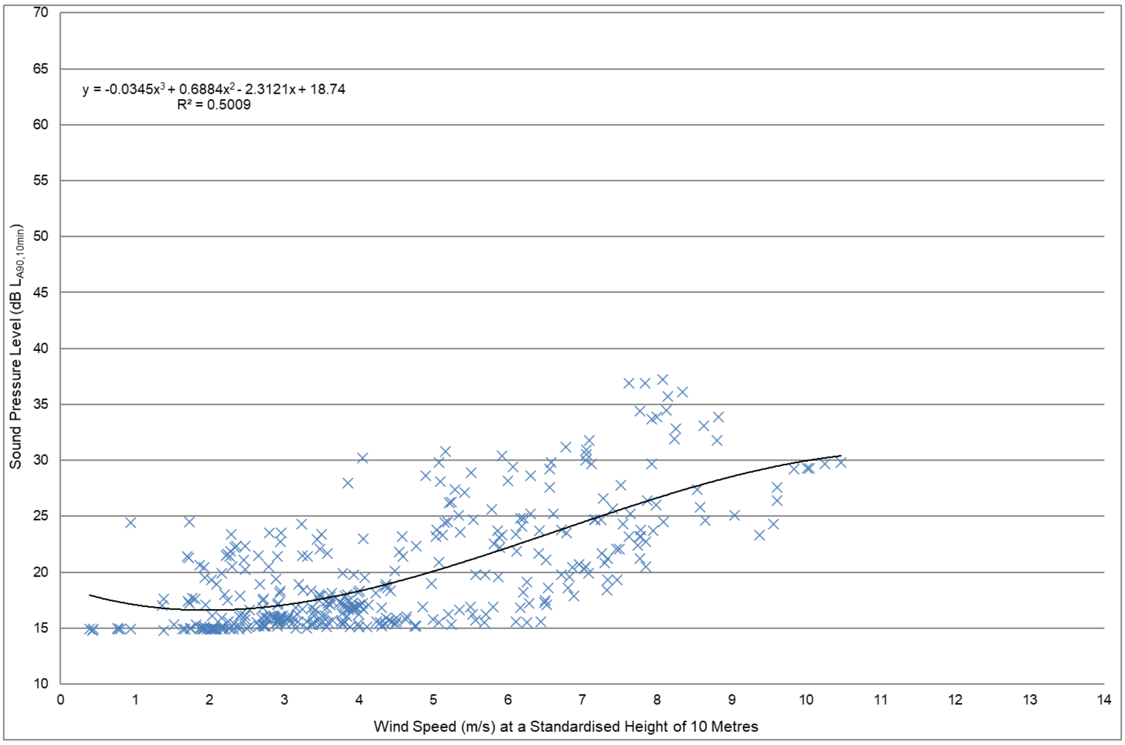


Figure 11-6 Location A - Background Noise Levels dB $L_{A90,\ 10\ min}$ –Nigh-time wind directions between 270 and 90 Degrees

11.4.1.2 Location B

Location B lies to the south of the Proposed Development turbines and to the north of the Slievecallan wind turbines therefore, it is located between the two sites. The Slievecallan turbines are closer to Location B than the turbines of the Proposed Development. Figure 11-7 and Figure 11-8 present the measured background noise levels at Location B. For daytime and night time periods, the data has been filtered to include only wind directions between 315 and 45 degrees, which represents downwind conditions from the Proposed Development. These wind directions are representative of upwind conditions from the operational Slievecallan turbines. Due to the proximity of Location B to the Slievecallan turbines the measured upwind noise levels potentially include a contribution from the Slievecallan turbines. The predicted turbine noise levels at R045 from the Slievecallan turbines have been subtracted from the measured noise levels to derive the background noise levels in accordance with the guidance discussed in Section 11.3.6.5. The resulting background noise levels are presented in Table 11-11 in Section 11.4.1.6.

11.4.1.2.1 *Daytime Quiet Periods*

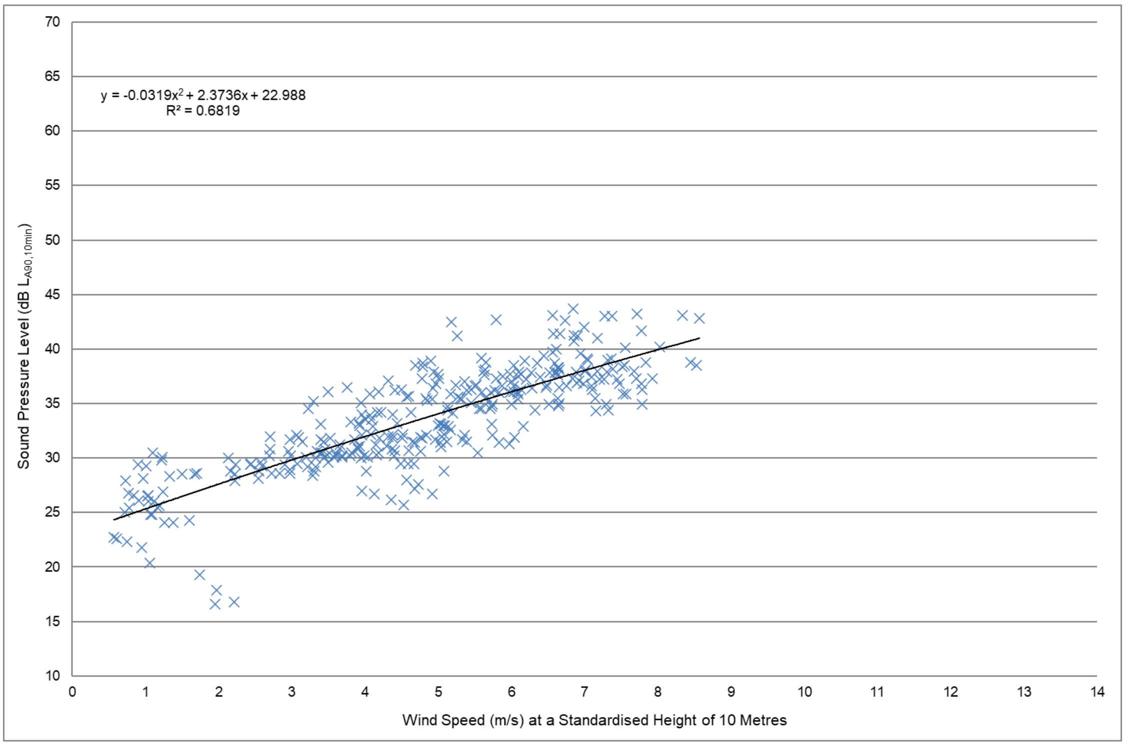


Figure 11-7 Location B - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime wind directions between 315 and 45 Degrees

11.4.1.2.2 *Night-time Quiet Periods*

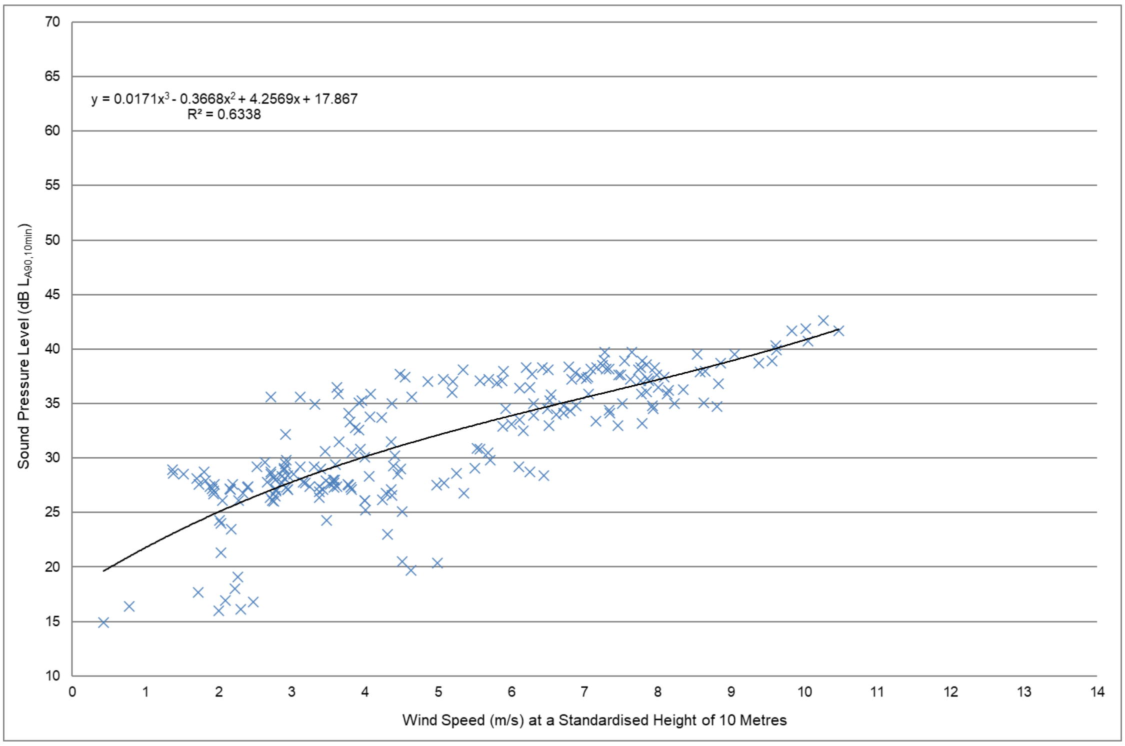


Figure 11-8 Location B - Background Noise Levels dB $L_{A90,\ 10\ min}$ –Night-time wind directions between 315 and 45 Degrees

11.4.1.3 Location C

Location C lies to the southwest of the Proposed Development turbines and to the northwest of the Slievecallan wind turbines. The nearest Slievecallan turbine is approximately 1.6km distance from Location C. Figure 11-9 and Figure 11-10 present the measured background noise levels at Location C. For daytime and night time periods, the data has been filtered to include only wind directions between 225 and 45 degrees, which represents downwind conditions from the Proposed Development. These wind directions are representative of upwind conditions from the operational Slievecallan turbines. Due to the proximity of Location C to the Slievecallan turbines the measured upwind noise levels potentially include a contribution from the Slievecallan turbines. The predicted turbine noise levels at R058 from the Slievecallan turbines have been subtracted from the measured noise levels to derive the background noise levels in accordance with the guidance discussed in Section 11.3.6.5. The resulting background noise levels are presented in Table 11-11 in Section 11.4.1.6.

11.4.1.3.1 Daytime Quiet Periods

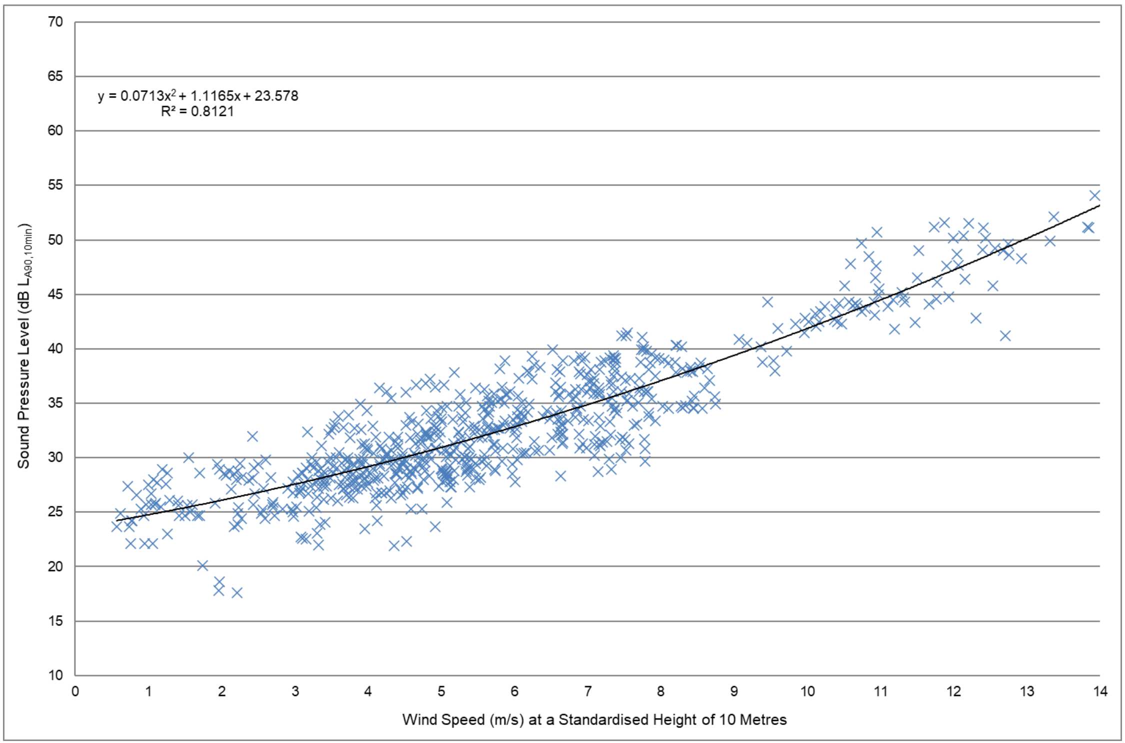


Figure 11-9 Location C - Background Noise Levels dB $L_{A90,\ 10\ min}$–Daytime wind directions between 225 and 45 Degrees

11.4.1.3.2 Night-time Quiet Periods

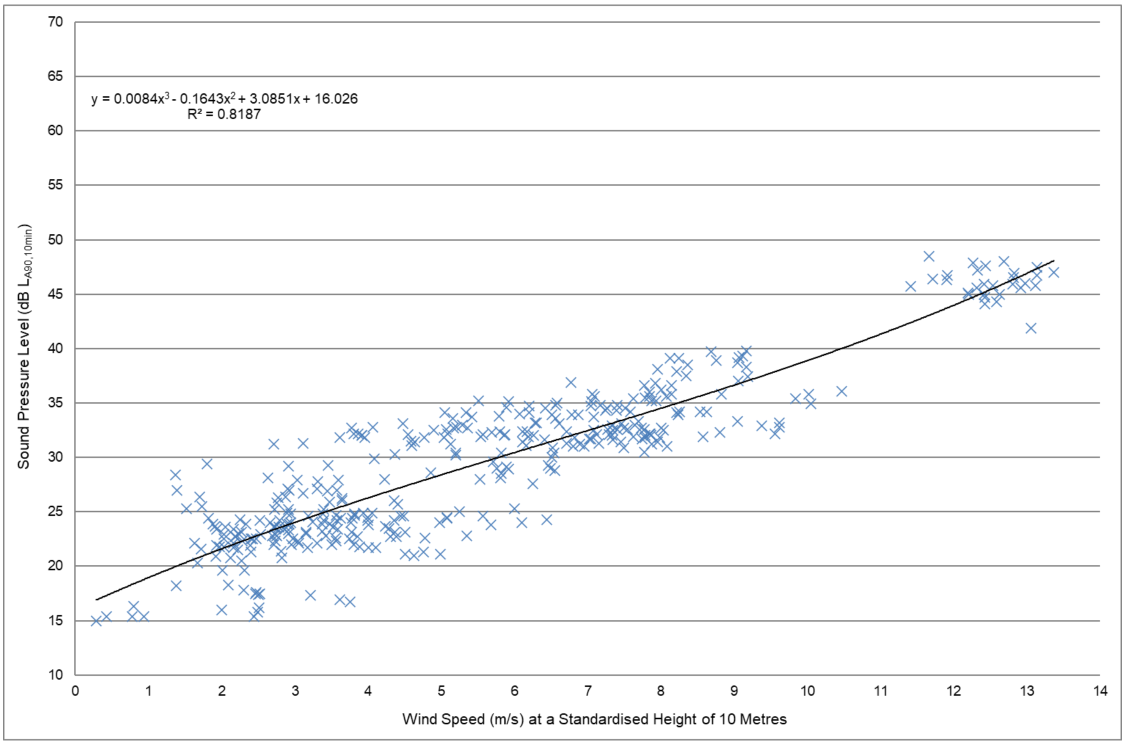


Figure 11-10 Location C - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night-time wind directions between 225 and 45 Degrees

11.4.1.4 Location D

Location D lies to the west of the Proposed Development turbines and to the northwest of the Slievecallan wind turbines. The nearest Slievecallan turbine is approximately 2.5km distance from

Location D. Figure 11-11 and Figure 11-12 present the measured background noise levels at Location D. For daytime and night-time periods, the data has been filtered to include only wind directions between 0 and 180 degrees, which represents downwind conditions from the Proposed Development. These wind directions are also representative of downwind conditions from the operational Slievecallan turbines. Therefore, the measured noise levels at Location D potentially include a slight contribution from the Slievecallan turbines. The predicted levels from Slievecallan at the measurement location are considered worst-case due to the prediction methodology used in the assessment i.e. favourable conditions for noise propagation and the allowance for uncertainty in the prediction calculations. The predicted turbine noise levels at R061 from the Slievecallan turbines have been subtracted from the measured noise levels to derive the background noise levels in accordance with the guidance discussed in Section 11.3.6.5. The resulting background noise levels are presented in Table 11-11 in Section 11.4.1.6.

11.4.1.4.1 *Daytime Quiet Periods*

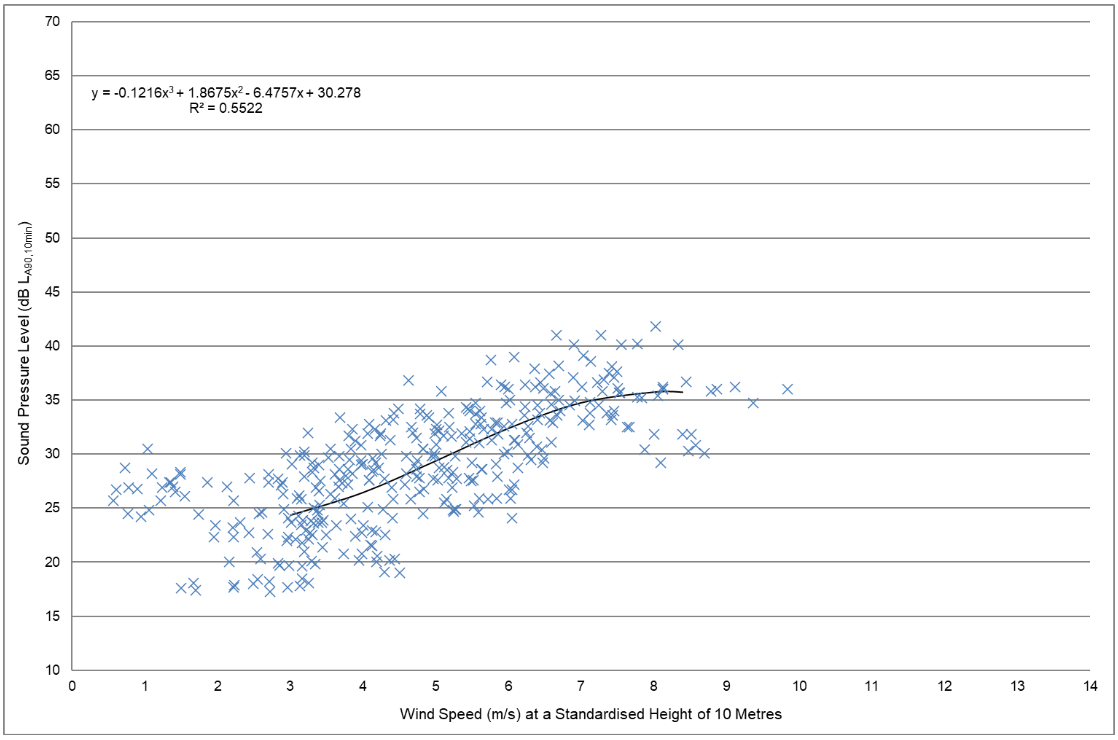


Figure 11-11 Location D - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime wind directions between 0 and 180 Degrees

11.4.1.4.2 Night-time Quiet Periods

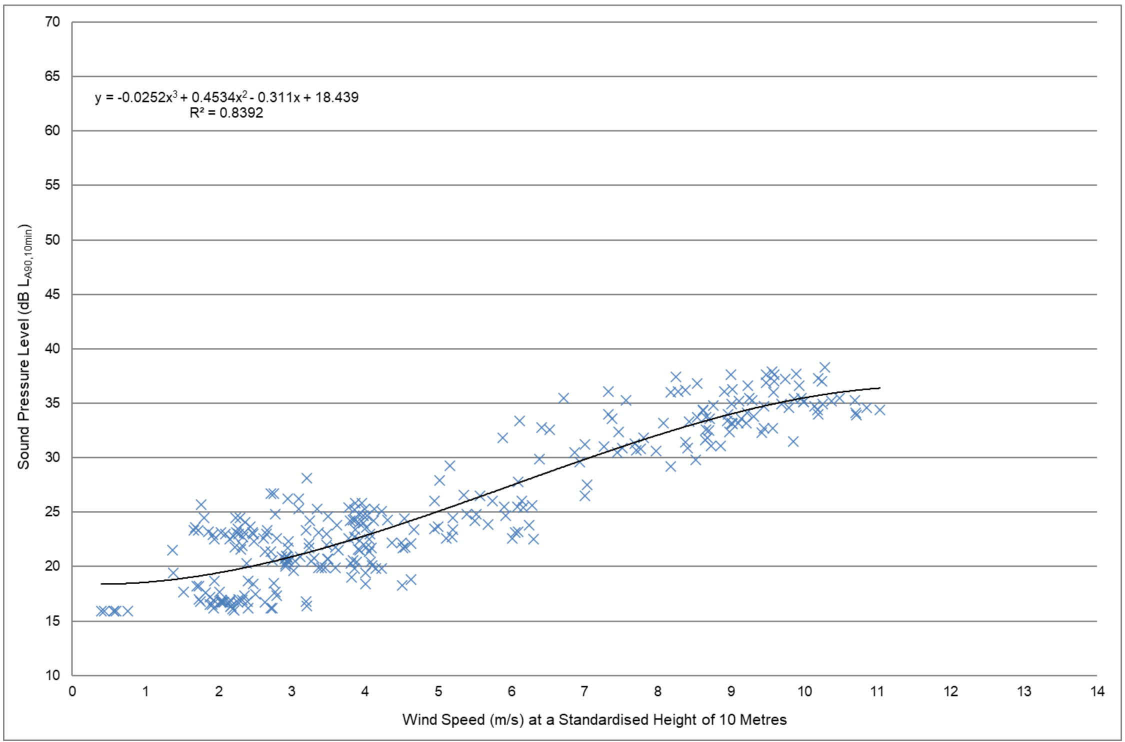


Figure 11-12 Location D - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night-time wind directions between 0 and 180 Degrees

11.4.1.5 Location E

Location E lies to the northwest of the Proposed Development turbines, considering the distances to the Slievecallan turbines and the surrounding topography the contribution from the Slievecallan turbine is not considered to significant at Location E. Figure 11-13 and Figure 11-14 present the measured background noise levels at Location E. For daytime and night-time periods, the data has been filtered to include only wind directions between 60 and 200 degrees, which represents downwind conditions from the Proposed Development. These wind directions are also representative of downwind conditions from the operational Slievecallan turbines. Therefore, the measured noise levels at Location E, potentially include a slight contribution from the Slievecallan turbines. The predicted levels from Slievecallan at the measurement location are considered worst case due to the prediction methodology used in the assessment i.e. favourable conditions for noise propagation and the allowance for uncertainty in the prediction calculations. The predicted turbine noise levels at R007 from the Slievecallan turbines have been subtracted from the measured noise levels to derive the background noise levels in accordance with the guidance discussed in Section 11.3.6.5. The resulting background noise levels are presented in Table 11-11 in Section 11.4.1.6.

11.4.1.5.1 Daytime Quiet Periods

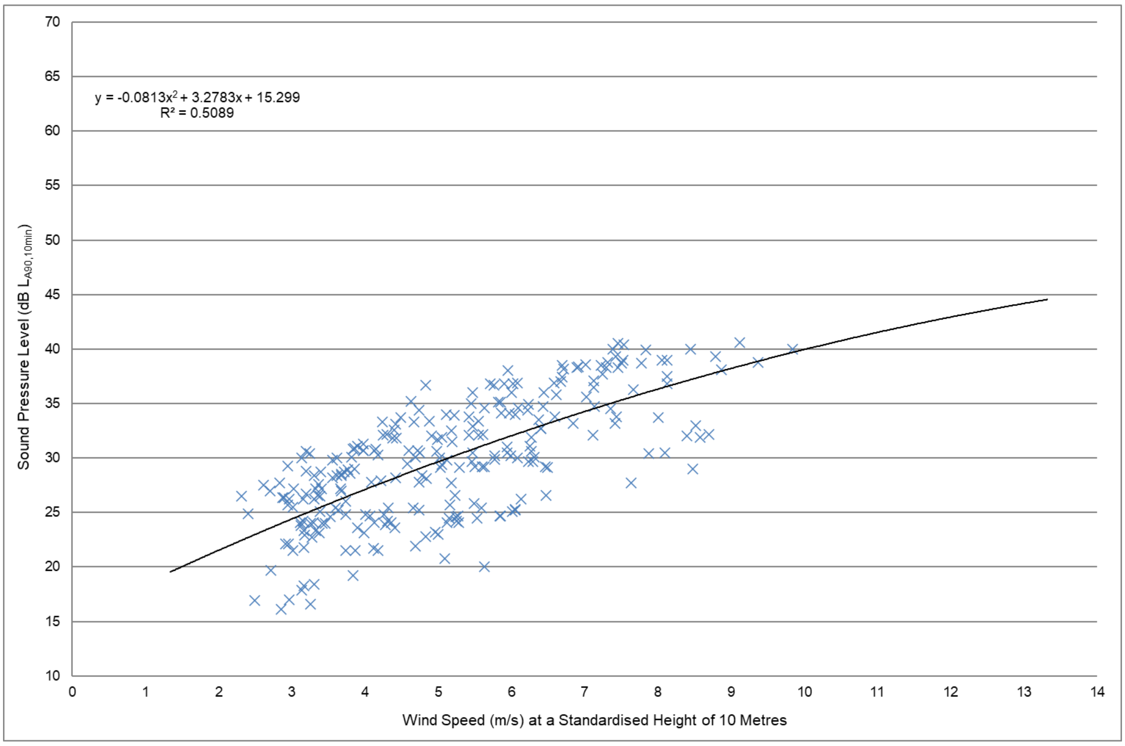


Figure 11-13 Location E - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime wind directions between 60 and 200 Degrees

11.4.1.5.2 Night-time Quiet Periods

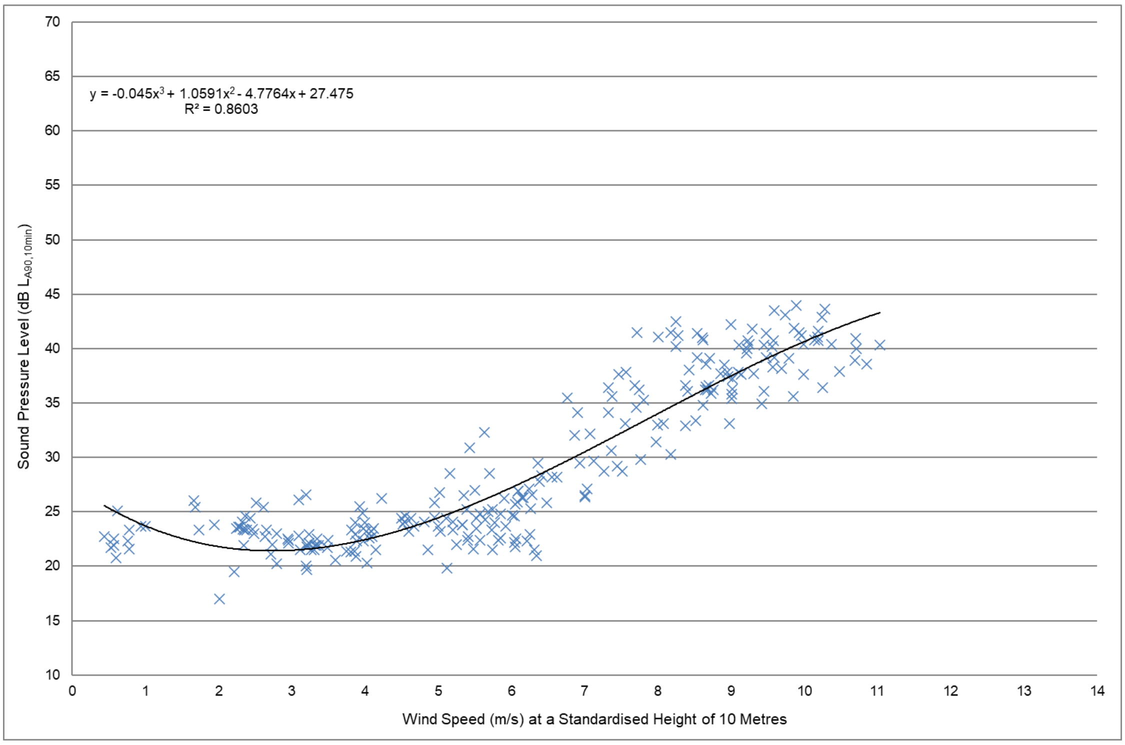


Figure 11-14 Location E - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night -time wind directions between 60 and 200 Degrees

11.4.1.6 Summary of Background Noise Levels

Table 11-11 presents the derived $L_{A90,10min}$ noise levels for each of the monitoring locations for daytime quiet periods and night-time periods with directional filtering applied and logarithmic subtraction applied as described in the previous sections. These levels have been derived using regression analysis carried out on the data sets in line with guidance contained the IoA GPG and the *Supplementary Guidance Note (SGN) No. 2 Data Processing & Derivation of ETSU-R-97 Background Curves.*

Table 11-11 Derived Background Noise Levels

Location	Period	Derived $L_{A90, 10 min}$ Levels (dB) at various Standardised 10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A	Day	26.3	26.6	27.3	28.2	30.0	32.1	33.6	36.2
	Night	17.1	18.3	20.1	22.2	24.5	26.6	28.5	30.0
B	Day	29.0	30.6	32.0	33.2	35.9	38.5	40.0	40.0
	Night	26.3	27.7	28.1	29.4	30.6	34.0	37.0	39.7
C	Day	27.2	28.6	30.0	31.6	34.0	36.5	39.1	41.7
	Night	23.2	25.0	26.6	28.0	30.7	33.3	35.9	38.5
D	Day	23.8	25.5	28.3	31.3	34.0	35.0	35.0	35.0
	Night	19.5	20.2	21.0	22.2	26.7	30.3	32.9	34.7
E	Day	24.1	26.7	29.1	31.4	33.8	36.0	38.0	39.8
	Night	20.8	21.0	22.2	24.8	29.2	33.4	37.2	40.5

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, As the noise criteria are based on the background noise levels, the effect of baseline noise level being lower than normal leads to 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.

11.4.2 Wind Turbine Noise Criteria

In accordance with the noise criteria set out in the Wind Energy Development Guidelines outlined in section 11.3.2.2.2 A lower daytime fixed limit of 40 dB $L_{A90,10-min}$ has been adopted for low-noise environments i.e., where the background noise is less than 30 dB(A). The criterion adopted is robust and is an acceptable noise limit in areas of low background noise, this follows a review of the prevailing background noise levels and is deemed appropriate in respect of the following:

- The EPA document *'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)'* (EPA, 2016) proposes a daytime noise criterion of 45 dB(A) in 'areas of low background noise'. The proposed lower threshold here is 5 dB more stringent than this level.
- The neighbouring Slievecallan Development has been conditioned by An Bord Pleanála (ABP) under planning reference PL03.237524 (Clare County Council planning Ref: P10/09) with a lower threshold of 43 dB L_{Aeq} which equates to an L_{A90}

level of 41 dB L_{A90}. This is 1 dB higher than the proposed lower threshold of 40 dB L_{A90} for the Proposed Development.
- The Coor Shanavogh Wind Farm was conditioned by ABP (planning Ref. PL 03.239378) with a lower threshold of 43 dB L_{A90}. This is 3 dB higher than the proposed lower threshold for the Proposed Development.
- A lower threshold of 40 or 43 dB is commonly adopted in planning conditions for similar developments that have been granted planning permission by ABP and local planning authorities in recent years for example, Derryadd Wind Farm (ABP Ref: PL14.303592), Coole Wind Farm (ABP Ref: PL25M.300686) Cloncreen (ABP Ref: PA0047) and Meenbog (ABP Ref: PL05E.300460).
- The 2006 *Wind Energy Development Guidelines* states that "*An appropriate balance must be achieved between power generation and noise impact.*" Adopting a lower fixed limit is likely have a significant impact on the potential energy yield of the Proposed Development.

Following comparison of the previously presented guidance the proposed operational limits in $L_{A90,10min}$ for the Proposed Development are:

- 40 dB $L_{A90,10min}$ for quiet daytime environments with background noise less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments with background noise not less than 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher), and;
- 43 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) for night time periods.

With respect to the methodology in relevant guidance documents outlined in Section 11.3.2.2 the noise criteria curves in Table 11-12 have been derived for the NSL's surrounding the Proposed Development. These limit values are determined through applying the criteria to the derived background noise levels in Table 11-11

Table 11.12 Noise Criteria Curves

Location	Period	Derived $L_{A90, 10 min}$ Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
B	Day	40.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.7
C	Day	40.0	40.0	45.0	45.0	45.0	45.0	45.0	46.7
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.5
D	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Location	Period	Derived $L_{A90,\ 10\ min}$ Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
E	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.5

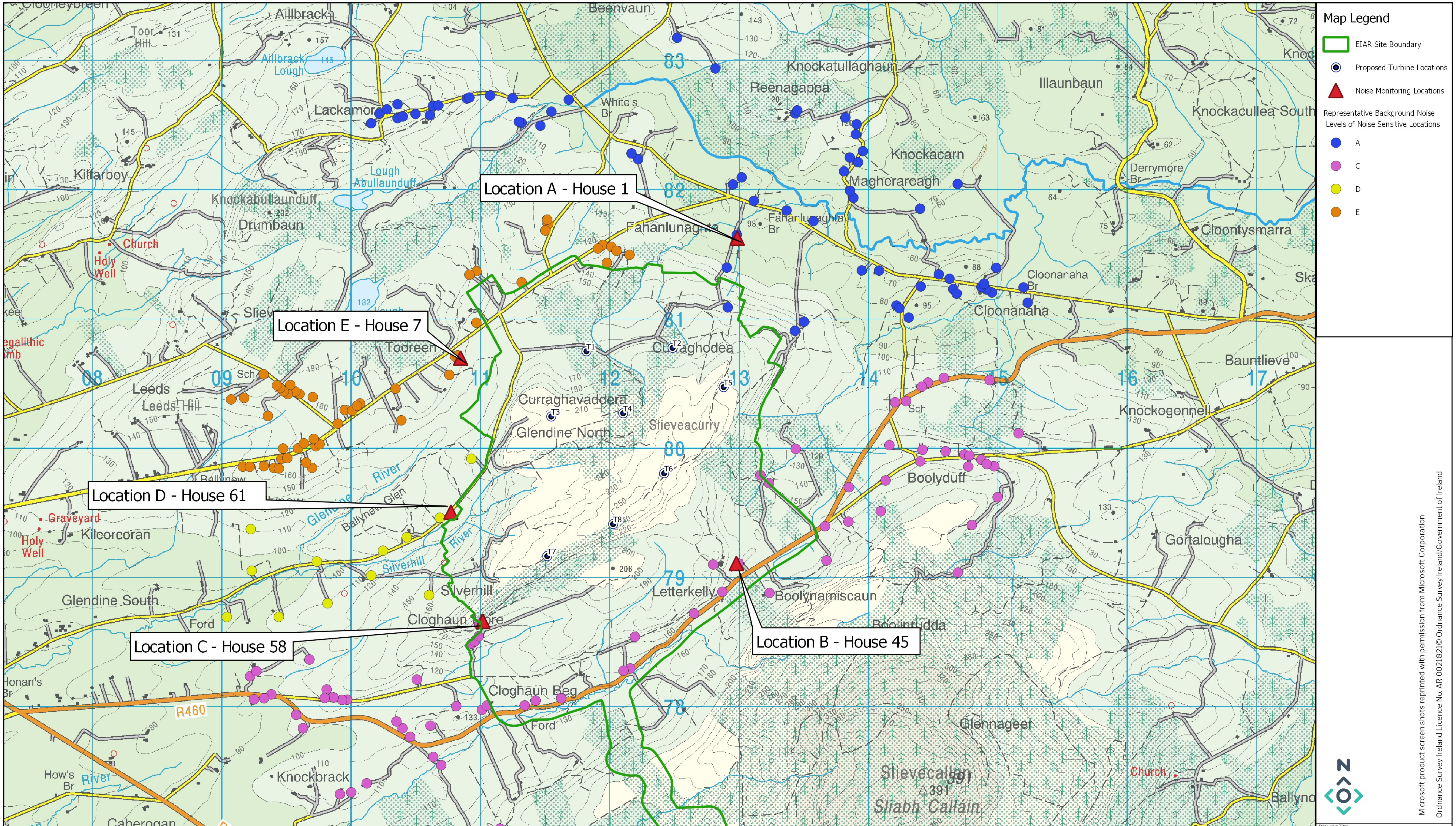
11.4.2.1 Assigning Turbine Noise Limits

The derived background noise levels have been assigned to other NSL's which are deemed to be representative of the measurement locations. Where background noise measurements have been conducted in the vicinity and/or are judged to be typical/indicative of the background noise levels of the area at the measurement location, the background noise levels can be used for deriving turbine noise thresholds at other locations.

Table 11-13 confirms where representative background noise levels have been assigned to each of the relevant NSL's for the purpose of setting noise limits for the assessment of turbine noise. They level have been assigned based on professional judgement in line with best practice guidance of representative background noise levels measured as part of the survey. The representative locations are illustrated in Figure 11-15.

Table 11-13 Assignment of Representative Background Noise Levels

Representative Background Noise Levels	Noise Sensitive Location (NSL)
A	R001, R009, R017, R022, R023, R024, R025, R029, R033, R064, R066, R067, R068, R069, R070, R071, R072, R073, R074, R075, R120, R121, R125, R126, R127, R128, R129, R130, R135, R138, R139, R164 to R194 & R198
C	R028, R030 to R058, R060, R076 to R093, R096, R097, R098, R099, R122, R131, R132, R133, R134, R136, R137, R147, R148, R149, R150, R151, R153, R154, R157, R158, R159, R195, R196 & R197
D	R021, R059, R061, R062, R063, R065, R094, R095, R100, R123, R124 & R152
E	R002, R003, R004, R005, R006, R007, R008, R010, R011, R012, R013, R014, R015, R016, R018, R019, R020, R026, R027, R102 to R120, R141 to R146, R155, R156, R160, R161, R162 & R163



Microsoft product screen shots reprinted with permission from Microsoft Corporation
Ordnance Survey Ireland Licence No. AR 0021821© Ordnance Survey Ireland/Government of Ireland

Drawing Title	
Representative Background Noise Levels	
Project Title: Slieveacurry Renewable Energy Development, Co. Clare	
Drawn By: Ellen Costello	Checked By: Michael Watson
Project No.: 170224c	Drawing No.: Figure 11-15
Scale: 1:27500	Date: 29.10.2021

MKO
Planning and Environmental Consultants
Tuam Road, Galway
Ireland, H91 VW84
+353 (0) 91 735611
email:info@mkoireland.ie
Website: www.mkoireland.ie

11.5 Likely Significant Effects and Associated Mitigation Measures

11.5.1 Do-Nothing Scenario

If development were not to proceed then the existing noise environment will remain largely unchanged. In areas where traffic noise is a significant source in the environment, increases in traffic volumes on the local road network would be expected to result in slight increases in overall ambient and background noise in the area over time.

11.5.2 Construction Phase Potential Impacts

A variety of items of plant will be in use for the purposes of site preparation, construction of turbines, roads, substation extension, grid connection, and other site works. There will be vehicular movements to and from the site that will make use of existing roads. Due to the nature of these activities, there is potential for generation of significant levels of noise, however, considering the distances between most construction activities and sensitive locations, the risk of significant impacts is considered low. An assessment of the potential construction noise and vibration impacts is presented in the following Sections.

Due to the nature of the construction activities it is difficult to accurately calculate the magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels at the nearest sensitive receptors using guidance set out in *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.*

The predicted noise levels referred to in this section are indicative only and are intended to demonstrate that the contractor can comply with current best practice guidance to minimise any significant noise and vibration impacts. It should also be noted that 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 are expected to be lower than these levels for most of the time at most properties in the vicinity of the Proposed Development.

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

- Turbines and hardstand areas;
- Substation extension and underground cabling connection;
- Operation of borrow pits;
- Site access roads; and
- Internal roads.

Detailed information is included in Chapter 4: Description of the Proposed Development.

In general, the distances between the construction activities associated with the Proposed Development and the nearest NSL's are such that there will be no significant noise and vibration impacts at NSL's. The only exception to this is where grid connection cabling works occur along public roads. 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 element are considered not to have significant noise and vibration impacts at NSL's.

11.5.2.1 Turbines, Hardstands, Substation, Underground cabling and Access Roads

11.5.2.1.1 Noise

Several indicative sources that would be expected on a site of this nature have been identified and predictions of the potential noise emissions calculated at the third party NSL's. The assessment is considered worst-case, construction noise levels will be lower at properties located further from the works.

Construction noise levels at various set-back distances from areas of construction works have been calculated to assess the impact at NSL's situated at greater distances from the works.

Table 11-14 outlines the noise levels associated with the typical construction noise sources assessed in this instance along with typical sound pressure levels and spectra from BS 5228 – 1: 2009. Calculations have assumed an on-time of 66% for each item of plant i.e. 8-hours over a 12-hour assessment period.

Table 11-14 Typical Noise Emission Levels for Typical Construction Activities

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$)[10]	Predicted Noise Level at 250m (dB $L_{Aeq,T}$)	Predicted Noise Level at 500m (dB $L_{Aeq,T}$)	Predicted Noise Level at 700m (dB $L_{Aeq,T}$)
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79	43	36	32
Excavator mounted rock breaker (C.1.9)	Rock breaking	90	54	47	43
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	41	34	30
Piling Operations (C.12.14)	Standard pile driving.	88	52	45	41
General Construction (Various)	All general activities plus deliveries of materials and plant.	84	45	38	34
Dewatering Pumps (D.7.70)	If required.	80	44	37	33
JCB (D.8.13)	For services, drainage, and landscaping.	82	46	39	35

[10] *All plant noise levels are derived from BS 5228: Part 1*

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) 10	Predicted Noise Level at 250m (dB $L_{Aeq,T}$)	Predicted Noise Level at 500m (dB $L_{Aeq,T}$)	Predicted Noise Level at 700m (dB $L_{Aeq,T}$)
Crane (C.4.38)	Erecting Turbines	78	42	35	31
Vibrating Rollers (D.8.29)	Road surfacing.	77	41	34	30
Total Construction Noise (cumulative for all activities)			**58**	**50**	**47**

Turbine and Hardstands

The nearest NSL to any of the proposed turbine is R033, which is situated approximately 528m from proposed Turbine 2. Location R033 is a property owner involved in the Proposed Development, the nearest 3rd party NSL is R021 which is located approximately 700m from Turbine 3.

A rock breaker is included in the plant items in Table 11-14 as depending on the ground conditions it may be necessary to extract rock at turbine bases or at other locations within the Proposed Development.

At the nearest 3rd party NSL (700m), the predicted noise levels from turbine construction activities are in the range of 30 to 43 dB $L_{Aeq,T}$ with a total worst-case construction level of the order of 47 dB $L_{Aeq,T}$. The predicted noise levels at all NSL's (both involved and 3rd party) are below the criteria outlined in Section 11.3.2.1(Category A - 65 dB $L_{Aeq,T}$ during daytime periods).

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 Section 11.3.2.1 and this assessment took into account all items of plant operating simultaneously.

It is concluded that there will be no significant noise impacts associated with the construction of the turbine and hardstands and therefore no specific mitigation measures will be required.

Substation

Based on the same typical construction activities as outlined in Table 11-14 it is predicted that the likely worst-case potential noise level due to construction activities associated with the substation will be in the order of 58 dB $L_{Aeq,T}$ at a distance of 250m which is well below the significance threshold of 65 dB $L_{Aeq,T}$. outlined in Section 11.4.1 and there are no NSL's located within this distance range from the substation.

It is concluded that there will be no significant noise impacts associated with the construction of the Substation and therefore no specific mitigation measures will be required.

Underground Cable Route

The proposed underground grid connection cable route will commence from the Proposed Development and connection to the Slievecallan substation. The cable route measures approximately 7.1 km in total and is mainly located on existing or proposed tracks/roads and within the public road corridor.

The associated construction works will occur for short durations at varying distances from Noise Sensitive Locations (NSL's), at various locations along the route. Table 11-15 presents outline noise calculations, considering the typical anticipated methods of construction, at varying distances from the construction works. The calculations assume that there is no acoustic screening (i.e. barriers) in place between the site works and the NSL.

Table 11-15 Indicative noise calculations for construction – Underground Cable Route

Plant Item (BS 5228 Ref.)	Calculated Construction Noise Level dB $L_{Aeq,T}$ at distance from works (m)			
	25m	50m	100m	150m
Tracked Excavator (C.2.7)	55	48	40	36
Vibratory Plate (C.2.41)	61	54	46	42
Dump Truck (C.2.32)	59	52	44	40
Wheeled Loader (C.2.8)	53	46	38	34
HGV (C.6.19)	58	51	43	39
Combined L_{Aeq} from all works	**65**	**58**	**50**	46

Calculations indicate that the impact noise criteria may be exceeded in the unlikely event where the majority construction activity occurs within approximately 20m of an NSL. However, as the works will progress along the route the worst-case predicted impacts will be reduced. There are only 2 no. NSL's located within 20m of the underground cable route (R044 and R049) It is envisioned that they will be at the closest position to the nearest NSL's for no more than 2 to 3 days and therefore the impact will not be significant. In both these instances the contractor shall adopt practical mitigation measures in line with best practice guidance to minimise potential impacts at the NSL's, refer to Section 11.5.5 for details. As outlined in table 11-15, at a distance of 50m and greater, the noise level is estimated to be 58 dB $L_{Aeq,T}$, therefore properties outside this range were not considered further.

Internal Roads

It is proposed to construct new and upgrade existing internal roads to access the proposed turbines and associated infrastructure as part of the Proposed Development. Review of the internal road layout has identified that the nearest NSL is R033 which is located 200m from the proposed road at the nearest point. All other locations are at greater distances with the majority at significantly greater distances. The full description of the proposed internal roads is outlined in Chapter 4 of the EIAR.

Table 11-16 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.

Table 11-16 Typical Construction Noise Emission Levels for Roads

Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [11]	Highest Predicted Noise Level at Stated Distance from Edge of Works (dB $L_{Aeq,T}$)
		200m
HGV Movement (C.2.30)	79	43
Excavator with Rock Breaker (C9.12)	85	47
Vibrating Rollers (D.8.29)	77	41
Total Construction Noise (cumulative for all activities)		49

At the nearest noise sensitive location, the predicted noise levels from construction activities associated with internal roads are of the order of 49 dB $L_{Aeq,T}$, which is well below the significance threshold of 65 dB $L_{Aeq,T}$. outlined in Table 11-1. The calculated noise levels presented are considered to present a worst-case scenario as they are assessed at the closest point along all roads.

It is concluded that there will be no significant noise impacts associated with the construction of internal roads and therefore no specific mitigation measures will be required.

Junction Upgrade Works

As detailed in Chapter 4, Section 4.4, the junction accommodation works along the proposed turbine delivery route will encompass hardsurfacing at the junction on the L1074 at Fahanlunaghta More Road and at the Fahanlunaghta More Road / forestry access road junction.

The proposed works will require placement of temporary hardcore surfacing and creation of visibility splays so the areas can be used during the delivery of large turbine components and will be reinstated to their original condition or as required in consultation with Clare County Council.

The nearest NSL to the road widening works are R008, at approximately 130m.

Typical construction plant items and their associated noise levels at various distances are presented in Table 11-17.

Table 11-17 Typical Construction Noise Levels for the Junction Accommodation and Road Widening works.

Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [12]	Highest Predicted Noise Level at Stated Distance from Edge of Works (dB $L_{Aeq,T}$)		
		100	130	200
HGV Movement (C.2.30)	79	56	53	49
Tracked Excavator (C.4.63)	77	54	51	47
Vibrating Rollers (D.8.29)	77	54	51	47
Total Construction Noise		59	55	52

[11] *All plant noise levels are derived from BS 5228: Part 1*
[12] *All plant noise levels are derived from BS 5228: Part 1*

At a distance of 130m, the predicted noise levels from construction activities are of the order of 55 dB $L_{Aeq,T}$, which is below the significance threshold of 65dB $L_{Aeq,1hr}$. The contractor shall adopt practical mitigation measures referred to in Section 11.5.5 in line with best practice guidance to minimise potential impacts at the NSLs. With respect to the EPA's guidance for description of effects, the potential worst-case associated effect at the nearest NSL associated with the road widening works are expected to be Negative, Slight and Temporary.

11.5.2.1.2 Vibration

There are no vibration impacts anticipated at sensitive locations during the Construction Phase due to the nature of the construction activities associated with the Proposed Development and the distances from construction works to NSLs. To provide context for this discussion, AWN Consulting have previously conducted vibration measurements under controlled conditions, during trial construction works, on a sample site where concrete slab breaking was carried out. The trial construction works consisted of the use of the following plant and equipment when measured at various distances:

- 3 tonne hydraulic breaker on small CAT tracked excavator; and
- 6 tonne hydraulic breaker on large Liebherr tracked excavator.

Vibration measurements were conducted during various staged activities and at various distances. Peak vibration levels during staged activities using the 3 Tonne Breaker ranged from 0.48 to 0.25 PPV (mm/s) at distances of 10 to 50m respectively from the breaking activities. Using a 6 Tonne Breaker, measured vibration levels ranged between 1.49 to 0.24 PPV (mm/s) at distances of 10 to 50m, respectively. The measured PPV from rock breaking activities, was significantly below the proposed vibration limits set out in Table 11-3. Vibration levels associated with the activities for the Proposed Development is expected to be of a lower magnitude to the rock breaking activity discussed above. Therefore, due to the distance of the proposed works from sensitive locations, it is concluded that there will be no significant vibration impacts associated with the construction phase of the Proposed Development and therefore no specific mitigation measures will be required.

Notwithstanding the above, any construction activities undertaken on the site will be required to operate below the recommended vibration criteria set out in Table 11-3.

11.5.2.1.3 Description of Effects

With respect to the EPA criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive locations associated with the construction of Turbines, Hardstands, Substation, Underground Cabling, and Internal Roads of the Proposed Development are described below.

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

It is not expected that there will be any significant cumulative impacts at NSL's should the various elements of the construction phase be undertaken simultaneously.

11.5.2.2 Construction Traffic

This section has been prepared to review potential noise impacts associated with construction traffic on the local road network. The information presented in Chapter 14 (Section 14.1 Traffic and Transport) has been used to inform the assessment here.

The following situations are commented upon here:

- Stage 1a – Site Preparation and Ground Works
- Stage 1b – Concrete Pouring
- Stage 2a – Extended Artic Deliveries (large turbine components)
- Stage 2b – Other Deliveries (small turbine components)

Changes in the traffic noise levels associated with the additional traffic for each of the construction stages listed above have been calculated for several routes. Table 11-18 presents a summary of the data used for the calculations in this assessment. The figures in Table 11-18 have been derived from the traffic data in Chapter 14 with corrections applied for the passenger car unit (PCU) factors.

Table 11-18 Construction Traffic Data for Assessment

Route	Stage	Traffic Units	%HGV
1. N85 south of Claureen Roundabout	Existing	11,736	3.8
	1a	11,819	3.9
	1b	11,946	4.9
	2a	11,787	3.8
	2b	11,789	3.8
2. N85 west of Claureen Roundabout	Existing	21,364	3.2
	1a	21,447	3.2
	1b	21,574	3.8
	2a	21,415	3.2
	2b	21,417	3.2
3. N85 south of Inagh	Existing	6,578	2.6
	1a	6,661	2.8
	1b	6,788	4.6
	2a	6,629	2.7
	2b	6,631	2.7
4. R460 west of Inagh	Existing	6,711	2.6
	1a	6,794	2.8
	1b	6,921	4.5
	2a	6,762	2.7
	2b	6,764	2.7
5. L1074	Existing	1,080	2.6

Route	Stage	Traffic Units	%HGV
	1a	1,163	3.5
	1b	1,290	13.0
	2a	1,131	3.0
	2b	1,133	3.2

Based on the traffic data presented in Table 11-18 the changes in noise level relative to the expected traffic noise from the baseline year has been calculated and are outlined in Table 11-19.

Table 11-19 Calculated Changes in Traffic Noise Levels

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
1a – Site Preparation and Ground Works	1	0.1	247
	2	0.0	
	3	0.2	
	4	0.2	
	5	1.0	
1b – Concrete Pouring	1	0.7	8
	2	0.4	
	3	1.4	
	4	1.4	
	5	5.2	
2a – Extended Artic Deliveries (large turbine components)	1	0.0	22
	2	0.0	
	3	0.1	
	4	0.1	
	5	0.5	
2b – Other Deliveries (small turbine components)	1	0.1	8
	2	0.0	
	3	0.1	
	4	0.1	

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
	5	0.6	

Except for Stage 1b on Route 5, the predicted increases in traffic noise levels during each of the construction stages of the Proposed Development are less than 1.3 dB along all routes. With reference to the criteria set out in Section 11.3.2.1.2 the potential impacts are negligible to minor. With reference to the DMRB criteria, the increase calculated for Stage 1a on Route 5 is potentially moderate however, the estimated duration of the corresponding phase is only 8 days and is therefore does not constitute a significant effect. No additional mitigation measures are proposed.

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

11.5.2.2.1 Description of Effects

With respect to the EPA criteria for description of effects, the potential worst-case effects at the nearest noise sensitive associated with the additional traffic generated during the construction phase of the Proposed Development are described below.

Quality	*Significance*	*Duration*
Negative	Not significant	Temporary

11.5.2.3 Borrow Pits and Rock Extraction Methods

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 in the vicinity of the potential borrow pits location indicated in Table 11-20.
- Table 11-21 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 11-20 Proposed Borrow Pit Location

Co-ordinates (ITM)		
Borrow Pit	Easting	Northing
1	512,658	680,167

Co-ordinates (ITM)		
Borrow Pit	Easting	Northing
2	511,192	678,955

Table 11-21 Plant Noise Emission Levels

Item	BS 5228 Ref:	dB L_w Levels per Octave Band (Hz)								dB(A)
		63	125	250	500	1k	2k	4k	8k	
Crusher	Table C1.14	121	114	107	109	103	99	94	87	110
Rock Breaker	Table C9.11	119	117	113	117	115	115	112	108	121

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 predicted levels at the 10 no. NSL's, with the highest predicted noise levels is presented in Table 11-22.

Table 11-22 Prediction Noise Levels from Borrow Pit Activity at Nearest NSL's

Scenario A		Scenario B	
Location Ref	$L_{Aeq,T}$	Location Ref	$L_{Aeq,T}$
R057	38	R057	49
R058	37	R058	49
R056	37	R056	47
R034	37	R034	47
R039	32	R053	40
R040	31	R054	40
R053	31	R040	39
R051	31	R039	39
R054	31	R032	39
R032	31	R055	39

Review of the results contained in Table 11-22 confirms the following:

- Predicted construction noise levels for both Scenario A and B at the borrow pit 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. 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.

11.5.2.3.1 *Description of Effects*

With respect to the EPA criteria for description of effects, the potential worst-case effects at the nearest noise sensitive locations associated with the Borrow Pits during the construction phase of the Proposed Development are described below.

Quality	*Significance*	*Duration*
Negative	Not significant	Temporary

11.5.3 Operational Phase Potential Impacts

11.5.3.1 Turbine Noise Assessment

The predicted noise levels for the Proposed Development, in combination with Slievecallan and Coor Shanavogh wind farms, has been calculated for all noise sensitive locations identified within the study area. The predicted noise levels for all noise sensitive locations with the potential for any significant cumulative turbine noise impacts has also been calculated.

A worst-case omni-directional assessment has been completed assuming all noise sensitive locations are downwind of all turbines at the same time (which will never be the case) and noise predictions have been made using the ISO 9613-2 standard relate to worst-case conditions favorable to noise propagation (typically downwind propagation from source to receiver and/or downward refraction under temperature inversions).

The result of the noise prediction models have been compared against the turbine noise limits that have been assigned to each of the NSL's in accordance with the criteria set out in Section 11.3.2.2 and the background noise levels at NSL's discussed in Section 11.4.1.

At all NSL's the worst omni-directional cumulative turbine noise levels are below the criterion curves. The results of this exercise for all NSL's are presented in Appendix 11-5. Appendix 11-6 presents the predicted omni-directional results at all NSL's from the operation of the Proposed Development in isolation.

A noise contour for the omni-directional cumulative rated power wind speed (i.e. highest noise emission) for the cumulative scenario and the Proposed Development in isolation is presented in Appendix 11-7.

11.5.3.2 Internal Roads

Considering that there is no significant traffic expected on internal roads during the operational phase and the significant distances from any internal road to the nearest NSL; there are no noise and vibration impacts anticipated from internal roads during the operational phase. Occasionally over the operational life of the proposed development, internal roads may be used by specialist equipment including cranes to access the turbines for maintenance, but this would be infrequent and would not result in any significant impact.

11.5.3.2.1 *Description of Effects*

With respect to the EPA criteria for description of effects, the potential worst-case effects at the nearest noise sensitive location associated with the operation of internal roads are described below.

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

11.5.3.3 Substation

As previously stated, the location of the proposed extension to the existing substation is shown in the site layout drawings in Appendix 4-1 of this EIAR. The substation will 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.

The following extract from the *EirGrid Evidence Based Environmental Studies Study 8: Noise – Literature review and evidence-based field study on the noise effects of high voltage transmission development* (May 2016) states the following in relation to noise impacts associated with 110KvA substation installations:

> *"The survey on the 110kV substation at Dunfirth indicated that measured noise levels (L_{Aeq}) were less than 40 dB(A) at 5m from each of the boundaries of the substation. This is below the WHO night-time free-field threshold limit of 42 dB for preventing effects on sleep and well below the WHO daytime threshold limits for serious and moderate annoyance in outdoor living areas (i.e. 55 dB and 50 dB respectively). Spectral analysis of the data recorded at this site demonstrated that there were no distinct tonal elements to the recorded noise level. To avoid any noise impacts from 110kV substations at sensitive receptors, it is recommended that a minimum distance of 5m is maintained between 110kV substations and the land boundary of any noise sensitive property."*

The substation installation will have comparable noise emissions to the 110kV unit discussed above. Considering an indicative distance between a similar substation and a noise-sensitive location of 250m, the noise from the operation of the proposed substation will not be significant. There is no noise-sensitive location within 250m of the substation and any noise emissions from the substation will therefore be inaudible at all NSL's.

It is therefore concluded that noise emissions from the operation of the substation will be negligible, the noise from the substation will be inaudible at all NSL's and will have no impact on the operation noise emissions from the Proposed Development.

11.5.3.3.1 *Description of Effects*

With respect to the EPA criteria for description of effects, the potential worst-case effects at the nearest noise sensitive location associated with the operation of the Substation are described below.

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

11.5.4 Decommissioning Phase Potential Impacts

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 likely be used.

The wind turbines proposed as part of the Proposed Development are expected to have a lifespan of approximately 30 years. Following the end of their useful life, the wind turbines may be replaced with a new set of turbines, subject to planning permission being obtained, or the Proposed Development may be decommissioned fully. The onsite substation will remain in place as it will be under the control of EirGrid. A full description of the decommissioning phase is presented in Chapter 4.

Criteria for decommissioning noise are the same those presented in Section 11.3.2.1 The noise and vibration impacts associated with any decommissioning of the site are considered to be less than those outlined in relation to the construction of the Project (as per Section 11.5.2) and there is no items of plant or activity expected to give rise to noise levels that would be considered out of the ordinary or in exceedance of the levels outlined in Section 11.3.2.1.

11.5.4.1 Description of Effects

With respect to the EPA criteria for description of effects, the anticipated associated effects at the nearest noise sensitive locations associated with the decommissioning phase are described below.

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

It is not expected that there will be any significant impacts at NSL's should the various elements of the decommissioning phase be undertaken simultaneously.

11.5.5 Construction Phase Mitigation

The assessment of potential impacts has demonstrated that the Proposed Development is predicted to comply with the identified criteria for the construction phase. However, to minimise potential noise and vibration impacts, a schedule of mitigation measures has been developed and is set out in the following sections.

Regarding construction activities, 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* have been taken into account.

11.5.5.1 Construction Phase Mitigation Measures – Noise

While it was concluded in Section 11.5.2 that there will be no significant noise impacts associated with the construction of the Proposed Development and that no specific mitigation measures were required, the following best practice mitigation measures from BS5528-1 standard will be implemented for the duration of the construction phase:

- 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/developer, 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 locations;
- keeping site access roads even to mitigate the potential for vibration from lorries.

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

- selection of plant with low inherent potential for generation of noise and/ or vibration;
- placing of noise generating / vibratory plant as far away from sensitive properties as possible within the site constraints, and;
- regular maintenance and servicing of plant items.

The contract documents will clearly specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures and comply with the recommendations of British Standard 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 implemented on site, 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 close to NSL's outside of general construction hours will be surrounded by an acoustic enclosure or portable screen.
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Section 11.3.2.1 using methods outlined in British Standard 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 19:00hrs Monday to Saturday. However, to ensure that optimal use is made of good weather periods or at critical periods within the programme (i.e. concrete pours, rotor/tower deliveries) it will be necessary on occasion to work outside of these hours.

Where rock breaking is employed, the following are examples of measures that will be considered, 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, it would be advisable to postpone blasting during unfavourable weather conditions if possible. 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 used to minimise effects may consist of some or all the following:

- Restriction of hours within which blasting can be conducted.
- A publicity campaign undertaken before any work and blasting starts (e.g. 48 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.

11.5.5.2 Construction Phase Mitigation Measures – Vibration

While it was concluded in Section 11.5.2.1.2 that there will be no significant vibration impacts associated with the construction of the Proposed Development and that no specific mitigation measures were required, it is recommended that vibration from construction activities will be limited to the values set out in Section 11.3.2.1.

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 to sensitive buildings these limits may need to be reduced.

Considering the distances between locations where works with the potential to generate significant vibration will take place and the nearest NSL's, no significant impact will be experienced. Therefore, no mitigation measures are proposed.

With respect to blasting, the following mitigation measures shall 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.

11.5.6 Operational Phase Mitigation Measures

A cumulative assessment of the operational noise levels has been undertaken in accordance with best practice guidelines and procedures as outlined in Section 11.3.2.2 of this Chapter.

The findings of the assessment confirmed that the predicted operational noise levels from the Proposed Development in combination with existing and proposed wind farms will be within the relevant best practice noise criteria. Therefore, no specific mitigation measures are required.

If alternative turbine technologies are considered for the Proposed Development, the actual turbine to be installed on the site will fall within the turbine range detailed in Section 4.1 of Chapter 4 Description of the Proposed Development and the drawings included in Appendix 4-1, and an updated noise assessment will be prepared to confirm that the noise emissions will comply with the noise criteria as per best practice guidance outlined in Section 0 and/or the relevant operational criteria associated with the grant of planning. If necessary, suitable curtailment strategies will be designed and implemented for alternative technologies to ensure compliance with the relevant noise criteria, should detailed assessment conclude that this is necessary.

Based on review of relevant guidance and best practice as set out in Section 11.3.2.2 it is considered that the following are appropriate noise criteria in relation to the operation of the wind turbines in relation to the Proposed Development:

- 40 dB $L_{A90,10min}$ for quiet daytime environments of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater than or equal 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) and at NSL's involved with wind energy development, and;
- 43 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) for night time periods.

All wind speeds should be stated with reference to the standardised 10 metre height wind speed.

11.5.6.1 Curtailment

As stated above the assessment confirms that the cumulative noise levels are within the relevant best practice noise criteria, and therefore no mitigation measures are required in respect of noise. Notwithstanding the above, this section discusses the principle of noise curtailment to demonstrate that all modern wind turbines have the capability of operating in reduced noise modes, should it be necessary to reduce the noise contribution from any installed turbine.

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 is a proven effective mitigation to ensure noise limits are complied with.

As an example of this turbine control capability, the following table shows the sound power levels for the Vestas V136 turbine at the hub height of 120m for Normal Operation and should be read as augmenting Table 11-8, along with the sound power levels for the various operational modes that can be applied to this turbine. As can be seen at mid to higher wind speeds a reduction in the noise level of up to 5dB can be achieved dependent on the operational mode set on the specific turbines.

Table 11-23 Sound power levels for normal operation and for various modes for the Vestas V136 turbine

Description	Predicted Noise Level dB L_{A90} at Standardised Wind Speed at 10m A.G.L.						
	3	4	5	6	7	8	>9
Mode 0	94.0	96.8	101.5	103.9	103.9	103.9	103.9
Mode SO1	91.7	95.2	99.9	101.8	101.8	102.0	102.0
Mode SO2	91.7	95.2	99.1	99.4	99.5	99.5	99.5

All modern turbines have the ability to control their power and noise levels in a similar manner, and the suitability of any turbine for the site will be dependent on whether it can operate in an efficient manner while also remaining within any noise limits that may be conditioned in the event of favourable consideration.

11.5.6.2 Low Frequency Noise

In the unlikely event that an issue with low frequency noise is associated with the Proposed Development, it is recommended that an appropriate detailed investigation be undertaken. Due consideration should be given to guidance on conducting such an investigation which is outlined in Appendix VI of the EPA document entitled *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (NG4) (EPA, 2016). This guidance is based on the threshold values outlined in the Salford University document entitled *Procedure for the assessment of low frequency noise complaints*, Revision 1, December 2011.

11.5.6.3 Amplitude Modulation

In the unlikely event that a complaint is received which indicates potential amplitude modulation (AM) associated with turbine operation, the operator shall 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 an accepted 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.

11.5.6.4 Monitoring

Commissioning noise surveys will be undertaken to ensure compliance with any noise conditions applied to the development. 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.

11.5.7 Decommissioning Phase Mitigation Measures

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 the development, i.e. as per Section 11.5.2.

11.5.8 Description of Residual Effects

11.5.8.1 Construction and Decommissioning Phase

During the construction and decommissioning phase of the project there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other construction activities. However, given the distances between the main construction works and nearby noise sensitive properties 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 noise and vibration effects are kept to a minimum. It is reiterated here that the assessment has concluded that the expected noise and vibration phase levels will be well within the criteria outlined in Section 11.3.2.1 and therefore there are no significant effects associated with the construction and decommissioning phases.

With respect to the EPA's criteria for description of effects, in terms of these construction activities, the potential worst-case associated residual effects at the nearest noise sensitive locations associated with the various elements of the construction and decommissioning phases are described below.

11.5.8.2 General Construction – Turbines and Hardstands Substation and Grid Connection

11.5.8.2.1 *Turbines and Hardstands*

The predicted residual noise effect associated with this element of the construction phase is described follows:

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.

11.5.8.2.2 *Substation*

The predicted residual noise effect associated with this element of the construction phase is described follows:

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.

11.5.8.2.3 *Underground Cable Connection*

The predicted residual noise effect associated with this element of the construction phase is described follows:

Quality	*Significance*	*Duration*
Negative	Slight	Temporary to 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.

11.5.8.3 Internal Roads Construction

The predicted residual noise and vibration effect associated with the proposed internal road construction operations at NSL's is summarised as follows:

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 one location with the greatest potential impact.

11.5.8.4 Junction Upgrade Works

The predicted construction noise and vibration effects associated with the junction upgrades and road widening works are summarised as follows:

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

11.5.8.5 Borrow Pits and Rock Extraction Methods

The predicted residual noise and vibration effect associated with the Borrow Pit operations at NSL's is summarised as follows:

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 one location with the greatest potential impact.

11.5.8.6 Construction Traffic

With reference to the criteria set out in Section 11.3.2.1.2. The predicted increases in traffic noise levels due to the construction traffic of the Proposed Development were at worst case minor. The potential worse case residual effect associated with construction traffic with respect to the EPA criteria is described as follows:

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 route and stage with the greatest potential impact.

11.5.8.7 Operational Phase

11.5.8.7.1 *Wind Turbine Noise*

At some NSL's where there is existing wind turbine noise from operational developments, the contribution from the Proposed Development will be inaudible and there will be no significant changes to the noise environment.

At others, i.e. those NSL's situated closer to the Proposed Development, an increase in the cumulative turbine noise level will be noticeable.

The assessment has demonstrated that the turbine noise emissions from the Proposed Development, in combination with all existing and proposed wind energy developments as described in 11.3.7.2.1, will be within best practice noise criteria curves recommended in Irish guidance '*Wind Energy Development Guidelines for Planning Authorities'* published by the Department of the Environment, Heritage and Local Government in 2006. Therefore, it is not considered that a significant effect is associated with the development.

While environmental noise levels at low wind speeds will increase due to the Proposed Development 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 noise sensitive locations to the site:

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

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

For most of the NSL's assessed the effect of the operational turbines can be described as follows:

Quality	*Significance*	*Duration*
Negative	Slight	Long-tern

11.5.8.7.2 *Substation Noise*

The associated residual effect from the operation of the substation is summarised as follows:

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

11.5.8.8 Vibration

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

Quality	*Significance*	*Duration*

Neutral	Imperceptible	Long Term

11.5.9 Cumulative Effects

11.5.9.1 Construction Phase

It is not expected there will be any other construction activities that would give rise to significant cumulative impacts during the construction phase. The predicted noise emissions for the Proposed Development are not of enough magnitude to cause an increase in the cumulative construction noise emissions exceeding the threshold for significant impacts at any NSL.

The predicted noise levels from the construction activity would need to be in excess of 55 dB L_{Aeq} for the potential for a cumulative noise increase with other construction works that would result in an exceedance of the noise threshold. The only element of the construction phase where there may be potential for cumulative construction noise impacts are grid connection works occurring in proximity to an NSL. In such instance, the contractor will adopt appropriate mitigation measures to minimise any impacts in line with best practice as discussed in Section 11.5.5. It is expected that with appropriate mitigation measures in place, cumulative impacts during the construction phase will not be significant.

11.5.9.2 Operational Phase

A review of existing, proposed and permitted wind turbine developments in the wider study has been undertaken in accordance with the guidance contained in the IOA GPG. The operational noise impact assessment has considered the potential cumulative impacts of the Proposed Development in combination with the existing Slievecallan Wind Farm and the proposed Coor Shanavogh Wind Farm, in accordance with best practice guidance discussed in Section 11.3.2.2. The assessment has demonstrated that the turbine noise emissions from the Proposed Development in combination with all existing and proposed wind energy developments will be within best practice noise criteria as set out in Section 0. Therefore, there are no significant cumulative impacts predicted from the Proposed Development.

11.6 Conclusion

When considering a development of this nature, the potential noise and vibration effects on the surroundings must be considered for three stages: the short-term construction and demolition phases 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 the drawings in Appendix 4-1 and manufacturer's turbine noise emission levels, cumulative turbine noise levels have been predicted at NSL's for a range of operational wind speeds, in accordance with applicable guidance. The predicted operational noise levels will be within best practice noise limits; therefore, no significant noise effects are associated with the Proposed Development.

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