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 Derrinlough Wind Farm Development (the 'Proposed Development'). The Proposed Development will encompass 21 No. wind turbines up to a tip height of 185 metres above the top of the foundation. 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 to the nearest noise sensitive location (NSL's). To inform this assessment, background noise levels have been measured at several representative NSL's in the vicinity of the proposed development site.

Existing operational, permitted and proposed wind farm developments with the potential for cumulative impacts were identified and assessed as part of this assessment namely the Meenwaun (existing and proposed) and Cloghan (permitted and proposed) wind farms. 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.

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.

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.

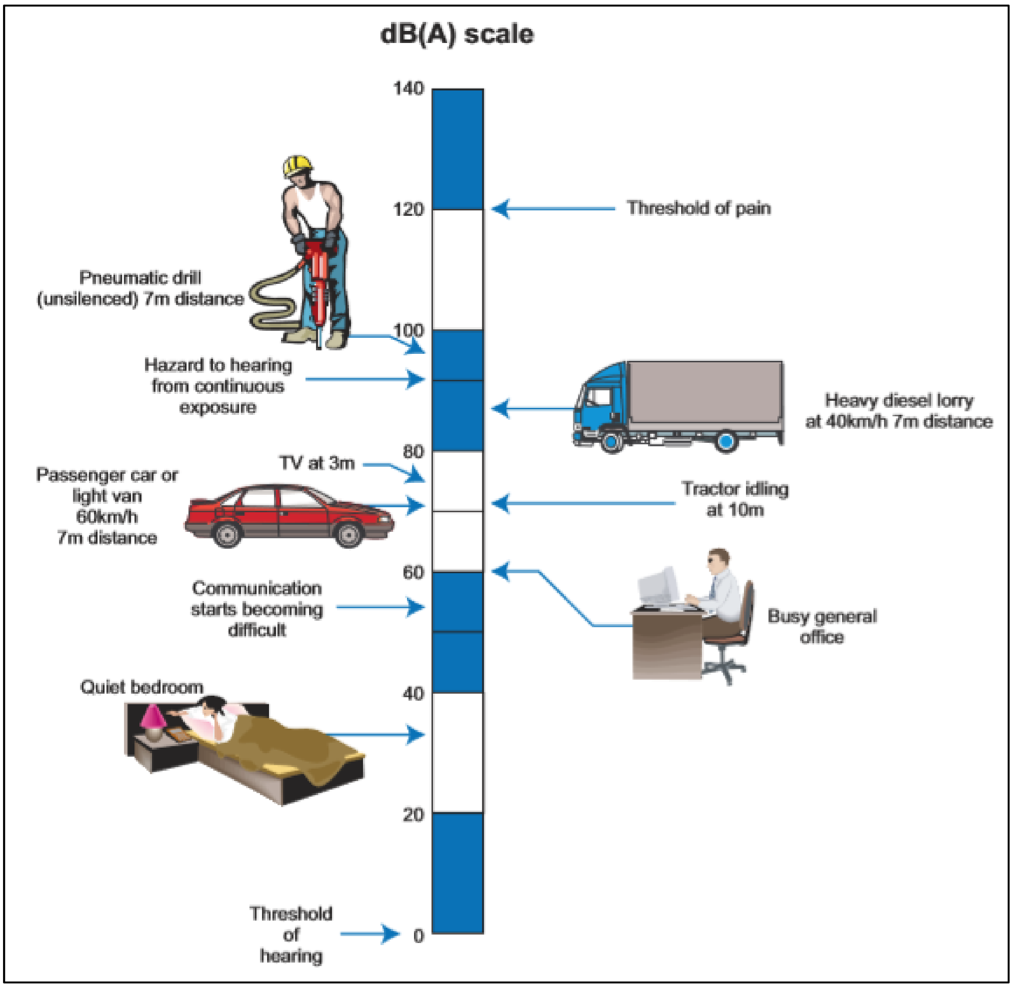

Figure 11.1The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)

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 have 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 1.1.8 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 and operational 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 phase of the proposed development at NSL's;
- Undertake predictive calculations to assess the potential impacts associated with the operational 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 1.1 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 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 façade 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, LAeq,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 $L_{Aeq,1hr}$. 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 as a result of 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, 2011)

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 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 of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater 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.

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.

This set of criteria has been chosen as it is in line with the intent of the relevant Irish guidance. The proposed operational noise criteria curves for wind turbine noise at various noise sensitive locations are presented in Section 11.4.2.

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 guidance contained within the institute of Acoustics (IoA) document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (2013) (IOA GPG) and 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 in order 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 taking into account.

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*
>
> *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.*

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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

5.1.5 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

Proposed changes to the assessment of noise impacts associated with on-shore wind energy developments are outlined in the *Draft Revised Wind Energy Development Guidelines* December 2019 prepared by the Department of Housing, Planning and Local Government. These Guidelines are currently in draft format and subject to public and stakeholder consultation. In line with best practice, the assessment presented in the EIAR is based on the current guidance outlined in Section 5.6 of the Wind Energy Development Guidelines for Planning Authorities, 2006.

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. 45dB 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. 45dB L_{den}) may be a poor characterization 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.

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

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."*

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.

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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*

'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. In the absence of published guidance to date, it is considered best practice to adopt the penalty rating and assessment scheme contained in an article published in the Institute of Acoustics publication *Acoustics Bulletin* (Vol. 42 No. 2 March/April 2017) titled, *Perception and Control of Amplitude Modulation in Wind Turbines Noise*.

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 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."*

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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*

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 (>750m), 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 Noise Conditions for Other Wind Farm Developments

The following Planning Permission relating to the other wind farm developments are discussed in the following sections. As previously stated, it is a requirement that turbine noise emissions from all existing, permitted and proposed wind energy developments are included in the noise impacts assessment.

11.3.6.1 Cloghan Wind Farm

The permissible noise limits for the Cloghan development are contained in Condition No. 11 of An Bord Pleanála Reference PL19.244053

The permitted development provides, by way of condition of consent, that noise levels at all dwellings shall not exceed the greater of 43dB(A) or 5dB(A) above background.

For the assessment presented in this report we have assumed that the absolute noise limit of 43dB $L_{A90\ 10min}$ on turbine noise from the Cloghan wind farm will apply to all NSL's unless a property is listed as a landowner with financial involvement in the project. In these instances, a limit of 45dB L_{A90} has been applied in line with best practice guidance.

11.3.6.2 Meenwaun Wind Farm

The grant of planning for the Meenwaun development does not stipulate noise conditions; however, it does refer to the noise limits outlined in the EIS chapter. The methodology adopted in the Meenwaun EIS is in line with the assessment of Derrinlough presented in this Chapter i.e. the noise level limits presented in the Meenwaun EIS are in line with the current best practice.

In the absence of specific noise limits in the grant of planning, and for the purpose of undertaking a robust assessment, the cumulative turbine limits derived by AWN for the proposed development outlined in Section **Error! Reference source not found.** shall be applied to NSL's in the vicinity of the Meenwaun development. This approach is line with best practice.

11.3.7 Background Noise Assessment

An environmental 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 7 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.

11.3.7.1 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.).

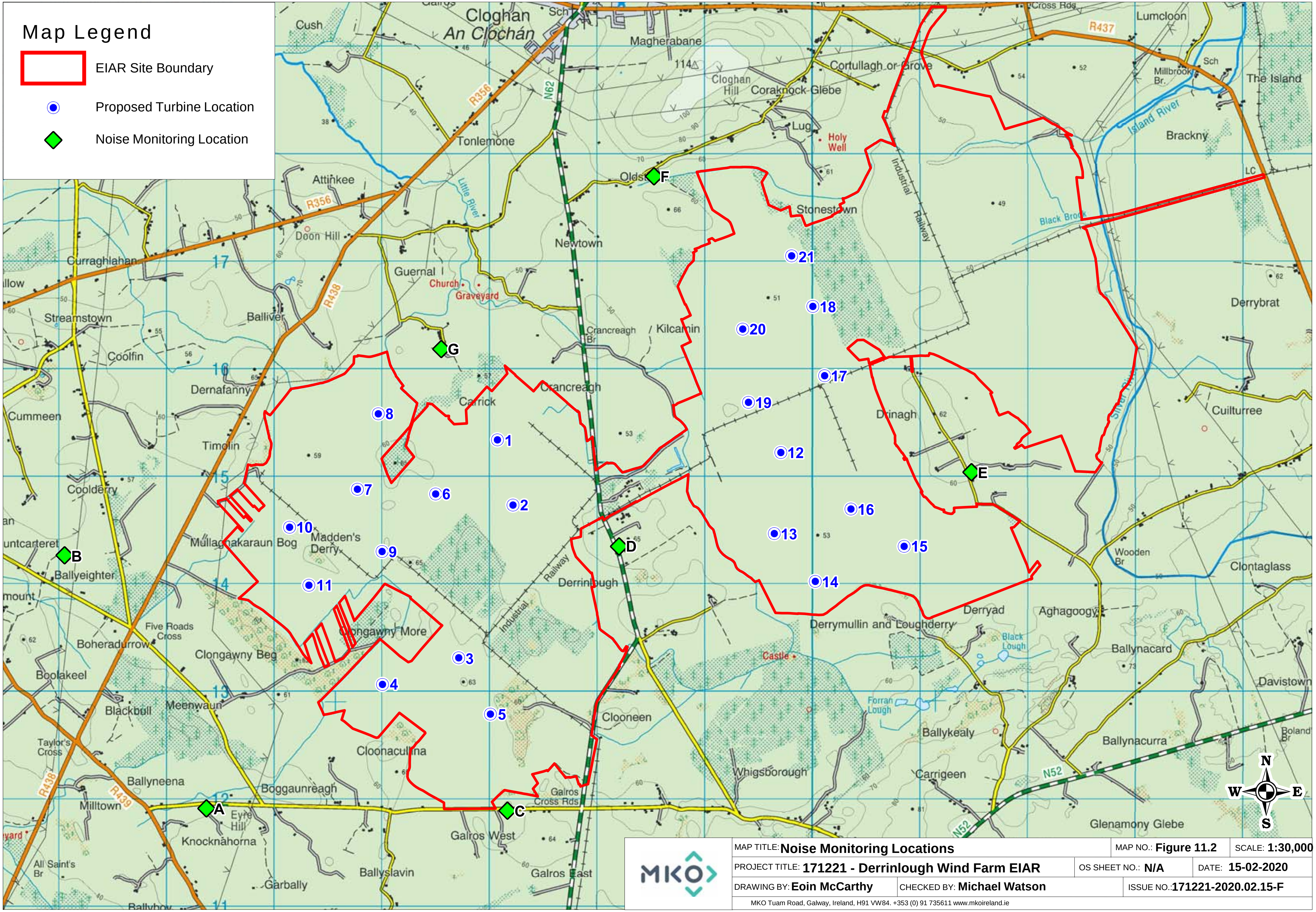
The locations selected for the noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in Table 11.4 and illustrated in Figure 11.2.

Table 11.4 Measurement Location Coordinates

Location	(ID Ref)	Coordinates – Irish Grid (IG)	
		Easting	Northing
A	R186	204,371	211,915
B	n/a	203,052	214,270
C	R156	207,170	211,894
D	R071	208,208	214,353
E	R131	211,485	215,043
F	R062	208,533	217,795
G	R051	206,553	216,175
Met Mast Anemometer	n/a	205673	214805

The NSL's are spread over a relatively large area and the noise monitoring locations were selected to obtain background noise levels representative of the noise environments at noise sensitive locations surrounding the site. Consideration was also given to the potential for noise from existing turbines effecting the survey when selecting the locations.

The background noise away from any significant sources were typically noted to be 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


Map Legend
EIAR Site Boundary
Proposed Turbine Location
Noise Monitoring Location
Cloghan
An Clochán
Cush
Magherabane
Cortullagh or Grove
Clogahn Hill
Coraknock Glebe
Lug
Holy Well
Lumcloon
The Island
Millbrook Br.
Island River
Brackny
Tonlemone
Attinkee
Little River
Oldstown
Stonestown
Industrial Railway
Black Brook
Doon Hill
Newtown
Curraghlahan
Guernal
Church
Graveyard
Streamstown
Balliver
Crancreagh Br
Kilcamin
Derrybrat
Coolfin
Dernafanny
Carrick
Crancreagh
Cummeen
Drinagh
Cuilturree
Timolin
Silver River
Coolderry
Mullaghakaraun Bog
Madden's Derry
Derrinlough
Wooden Br
Clontaglass
Ballyeighter
Derryad
Aghagoogy
Derrymullin and Loughderry
Five Roads Cross
Boheradurrow
Clongawny More
Clongawny Beg
Black Lough
Castle
Ballynacard
Boolakeel
Davistown
Blackbull
Meenwaun
Clooneen
Forran Lough
Ballykealy
Taylor's Cross
Cloonacullina
Ballynacurra
Whigsborough
Carrigeen
Boland Br
Ballyneena
Boggaunreagh
Galros Cross Rds
Milltown
Eyre Hill
Glenamony Glebe
Knocknahorna
Galros West
All Saint's Br
Ballyslavin
Galros East
Garbally
R356
R437
R438
R439
N62
N52
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MAP TITLE: Noise Monitoring Locations
MAP NO.: Figure 11.2
SCALE: 1:30,000
PROJECT TITLE: 171221 - Derrinlough Wind Farm EIAR
OS SHEET NO.: N/A
DATE: 15-02-2020
DRAWING BY: Eoin McCarthy
CHECKED BY: Michael Watson
ISSUE NO.: 171221-2020.02.15-F
MKO Tuam Road, Galway, Ireland, H91 VW84. +353 (0) 91 735611 www.mkoireland.ie

noise environments from observations made on site during installation, interim visits and collection are presented below for each monitoring location where relevant.

Site visits were carried out during the morning and afternoon time; therefore, no observations were made during night-time periods. There was no perceptible source of vibration noted at any of the survey locations.

Plate 11-1 to Plate 11-14 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.

11.3.7.1.1 Location A

The noise meter at Location A was positioned at the side of the house which provided screening to the two nearest turbines at Meenwaun wind farm and the boiler flue on the façade of the garage. Farm machinery was audible in the distance and occasional local traffic was also noted. The nearest turbine at Meenwaun is approximately 1.35km to the northeast and the turbines were not audible during site visits.

Plate 11-1 Location A - Picture 1

Plate 11-2 Location A – Picture 2

11.3.7.1.2 Location B

The noise meter at Location B was positioned at the eastern side of the house. There was a line of sight to the Meenwaun turbines, the nearest turbine being located approximately 1.8km to the southeast. It was noted that these turbines were operating but not audible during site visits. Distant road traffic and birdsong were noted to be the main noise sources at this location.

Plate 11-3 Location B – Picture 1

Plate 11-4 Location B – Picture 2

11.3.7.1.3 Location C

The noise meter at Location C was positioned in the garden on the western side of the house. The nearest turbine at Meenwaun is approximately 1.7km to the northwest. Distance plant machinery noise, road traffic noise and birdsong were noted at this location.

Plate 11-5 Location C – Picture 1

Plate 11-6 Location C – Picture 2

11.3.7.1.4 Location D

Location D was positioned approximately 35m from the edge of the N62 road to the rear of the property. Road traffic noise dominated the noise environment. The Briquette Factory is located approximately 200m to the north and steady broadband noise from this facility was noted to be dominating the background noise during lulls in road traffic.

Plate 11-7 Location D – Picture 1

Plate 11-8 Location D – Picture 2

11.3.7.1.5 Location E

Location E was noted to be a quiet location, distant from any significant environmental noise sources. Road traffic noise from the N62 was audible in the background. The location of the meter at the rear of the house provided screening from the local road (L7005) and distant road traffic noise.

Plate 11-9 Location E – Picture 1

Plate 11-10 Location E – Picture 2

11.3.7.1.6 Location F

The only noise source noted at Location F was distant road traffic from the N62. Local traffic was also noted along the adjacent road (L7009). The meter was positioned at the rear of the house to provide screening from the local road.

Plate 11-11 Location F – Picture 1

Plate 11-12 Location F – Picture 2

11.3.7.1.7 Location G

Location G was noted to be a quiet location, isolated from any significant environmental noise sources. Distant road traffic noise from the N62 was slightly audible but it was noted to be upwind conditions at the time. There was some noise associated with work activity in the stables at the rear of the house but was not considered significant.

Plate 11-13 Location G – Picture 1

Plate 11-14 Location G – Picture 2

11.3.7.2 Measurement Periods

Noise measurements were conducted at each of the monitoring locations over the period outlined in Table 11.5.

Table 11.5 Measurement Periods

Location	Start Date	End Date
All	17 January 2019	20 February 2019

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.

11.3.7.3 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	3702	0.1 dB
B	RION – NL-52	12154	0.2 dB
C	RION – NL-52	3392	0.2 dB
D	RION – NL-52	3432	0.1 dB

Location	Equipment	Serial Number	Maximum Calibration Drift Noted between Checks
E	RION – NL-52	3789	-0.1 dB
F	RION – NL-52	4569	0.1 dB
G	RION – NL-52	13789	0.0 dB

Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator where appropriate. Instruments were calibrated on each interim visit and any drift noted. All calibration drifts were less than ±0.5 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 a Texas Instruments TR-525 console and a data logger that was installed at Location D 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 at met mast anemometers located within the site of the proposed development and was supplied to AWN for the data analysis.

11.3.7.4 Procedure

Measurements were conducted at seven 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.

11.3.7.5 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 form 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 Meenwaun turbines for the measured noise data. For guidance, reference has been made to Section 5.2.3 of the IOA GPG which states:

> *"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)."*

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

Upwind filtering has been applied at the relevant locations (i.e. Locations A, B, C and D)

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

- Daytime Amenity hours are:
  - all evenings from 18:00 to 23:00hrs;
  - Saturday afternoons from 13:00 to 18:00hrs, and;
  - all day Sunday from 07:00 to 18:00hrs.
- Night-time hours are 23:00 to 07:00hrs.

The background noise levels are derived for each location with reference to the standardised 10m height wind speed relative to the assessment hub height of 110m.

11.3.7.5.1 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 at 84m and 100m heights have been corrected to a height of 110m (the hub height adopted for the noise assessment) in accordance with Method B of Section 2.6 of the IOA GPG. The calculated hub height 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:

Shear Exponent Profile: $U = U_{ref} \times [(H \div H_{ref})]^m$

Where:

U	Calculated wind speed
U_{ref}	Measured HH wind speed.
H	Height at which the wind speed will be calculated.
H_{ref}	Height at which the wind speed was measured.
m	shear exponent = $\log(U/U_{ref})/\log(H/H_{ref})$

The Calculated hub height wind speeds have been standardised to 10 m height using the following equation:

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

Where:

H_1	The height of the wind speed to be calculated (10m)
H_2	The height of the measured 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.

11.3.8 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 permitted and proposed developments. This section discusses the methodology for the noise modelling process.

11.3.8.1 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).

11.3.8.2 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 11.3

11.3.8.2.1 *Turbine Details*

Table 11.7 details the co-ordinates of the 21 no. proposed turbines that are being considered in this assessment.

Table 11.7 Proposed Derrinlough Turbine Co-ordinates

Turbine Ref.	Coordinates – Irish Grid (IG)	
	Easting	Northing
T01	207,077	215,344
T02	207,257	214,738
T03	206,717	213,317
T04	206,008	213,069
T05	207,012	212,792
T06	206,503	214,841
T07	205,775	214,884
T08	205,969	215,587
T09	206,005	214,306
T10	205,144	214,531
T11	205,324	213,991
T12	209,713	215,226
T13	209,652	214,472
T14	210,033	214,027
T15	210,859	214,353
T16	210,364	214,701
T17	210,119	215,941
T18	210,010	216,585
T19	209,411	215,693
T20	209,358	216,375
T21	209,813	217,056

For the purposes of this assessment, the turbine type assumed for the development site is the Vestas V136 4.2/4.0MW. The turbine is a pitch regulated upwind turbine with a three-blade rotor and is considered to be representative to the type of turbine that would be installed or available on the market.

For the purposes of this assessment predictions have assumed the source of noise at a hub height of 110m.

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 be the subject of a competitive tender process and could include turbines not amongst the turbine models currently available. The turbine eventually selected for installation on site will not give rise to noise levels of greater significance than that used for the purposes of this assessment, to ensure the findings of this assessment remain valid. Any references to the Vestas V136 turbines in this assessment must be considered in the context of the above and should not be construed as meaning it is the only make or model of wind turbine that could be used for the proposed development.

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 Derrinlough turbines.

For the purposes of all predictions presented in this report to account for various uncertainties in the measurement of turbine source levels, a +2dB 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.

Table 11.8 L_{wa} Spectra Used for Prediction Model – Derrinlough Turbine Noise Emissions for Hub Height at 110m.

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	75.9	83.9	88.7	90.6	89.4	85.2	78.0	67.7	95.4
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

Table 11.9 details the noise emission values used for noise modelling of the Meenwaun turbines. The noise emission data has been taken from information presented in the relevant EIS chapter[9] for the Meenwaun development and where necessary supplemented with information from AWN's database using data for a similar turbine type.

Table 11.9 L_{wa} Spectra Used for Prediction Model - Meenwaun Turbine Noise Emissions for Hub Height at 109m.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB LWA
	63	125	250	500	1000	2000	4000	8000	
3	81.1	86.7	89.3	91.3	92.0	88.9	79.3	63.5	97.2
4	83.5	89.4	92.2	93.9	94.3	91.1	81.7	65.9	99.7
5	85.5	92.4	97.0	99.8	100.2	96.4	86.3	69.5	105.0

[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.

[9] Environmental Impact Statement for The Proposed Meenwaun Wind Farm, Co. Offaly. Volume 2 – Main EIS. Chapter 10 – Noise and Vibration. February 2015.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB LWA
	63	125	250	500	1000	2000	4000	8000	
≥6	88.5	94.8	98.4	100.4	100.6	97.5	89.1	72.0	106.0

Table 11.10 details the noise emission values used for noise modelling of the Cloghan turbines. The noise emission data in has been taken from information presented in the relevant EIAR chapter submitted to Offaly County Council in 2019 as part of the planning application for proposed amendments to the consented Cloghan Wind Farm[10] development.

Table 11.10 L_{wa} Spectra Used for Prediction Model – Cloghan Turbine Noise Emissions for Hub Height at 100.5m.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
3	72.9	78.7	82.5	85.5	88.2	88.1	79.8	65.3	93.1
4	77.3	83.1	86.9	89.9	92.6	92.5	84.2	69.7	97.4
5	82.3	88.1	91.9	94.9	97.6	97.5	89.2	74.7	102.4
6	85.7	91.5	95.3	98.3	101.0	100.9	92.6	78.1	105.9
≥7	86.8	92.6	96.4	99.4	102.1	102.0	93.7	79.2	107.0

An uncertainty factor of +1.1 dB is included, in line with the uncertainty factor used in the proposed Cloghan wind farm development. The predicted turbine noise levels from the proposed Cloghan development are greater than the turbine noise levels presented in the EIS for the permitted development therefore the turbine noise emissions for the proposed Cloghan development have been used in this assessment.

As outlined, appropriate guidance is couched in terms of a L_{A90} criterion. The provided turbine noise 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 2dB reduction has been applied to the predicted results 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, 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 11.3 presents additional details relation to the turbine noise model inputs and the turbine location coordinates for other turbines.

[10] *Cloghan Wind Farm – Revised Turbine Dimensions and Site Layout Environmental Impact Assessment Report / Environmental Impact Statement – Volume 1, July 2019*

11.3.8.3 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 optimised 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° ±70°).

Figure 11.2 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°).

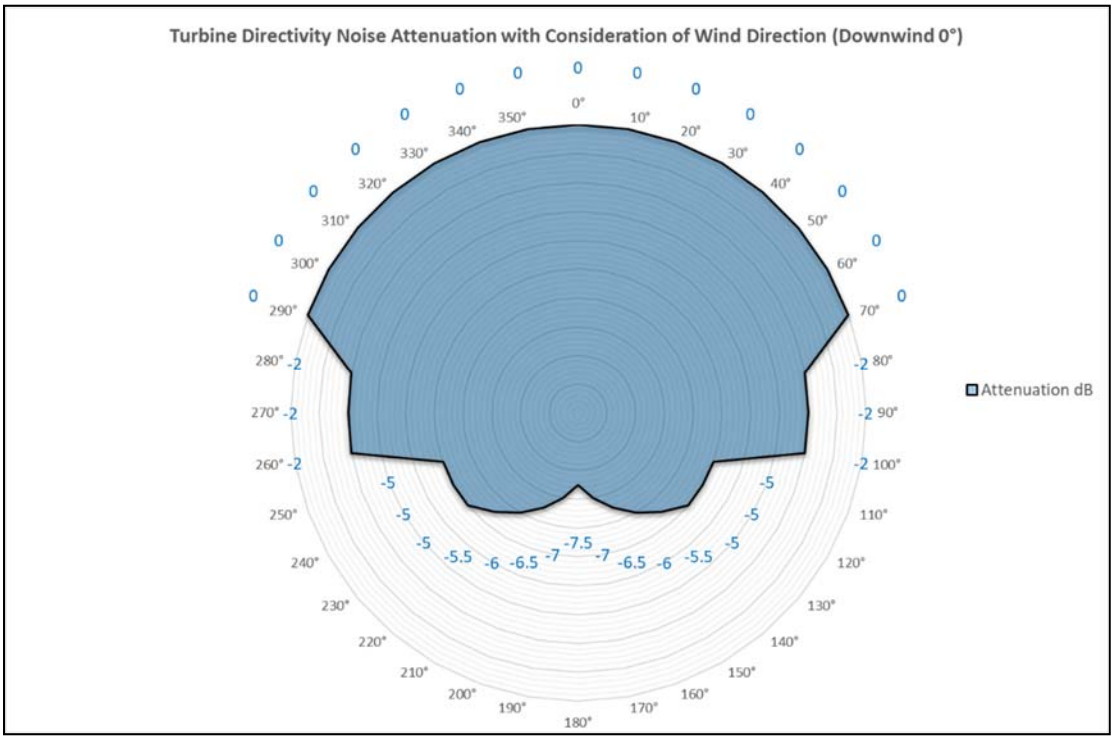


Figure 11.2 Turbine Directivity Attenuation with Consideration of Wind Direction

11.3.8.4 Assessment of Turbine Noise Levels

The predicted cumulative turbine noise level from the proposed development, and all permitted and proposed development in the area will be compared against the derived turbine noise limits and any exceedances of the limits will be identified and assessed. Where necessary, appropriate mitigation measures will be outlined.

The following presents a breakdown of the various steps involved in the assessment of operational turbine noise level:

- Screen the cumulative turbine noise predictions against the lowest potential (worst-case) criteria outlined in Table 11.11 to identify any locations with a potential exceedance.
- Undertake directional noise prediction calculations to refine the noise prediction results as described in Section 11.3.8.3.
- Identify locations with potential cumulative exceedances that occur as result of the proposed development only (i.e. Derrinlough turbines).
- Calculate the level of attenuation required from the Derrinlough turbines to achieve the adopted turbine noise criteria or the attenuation required to Derrinlough such that the predicted contribution of the Derrinlough turbines is 10 dB below the cumulative turbine limit value in accordance with best practice guidance.

11.3.9 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 11.3.7 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 11.3.7.2. Figure 11.3 illustrates the distributions of wind speed and wind direction standardised to 10 metre height over the baseline noise survey period detailed in Table 11.15.

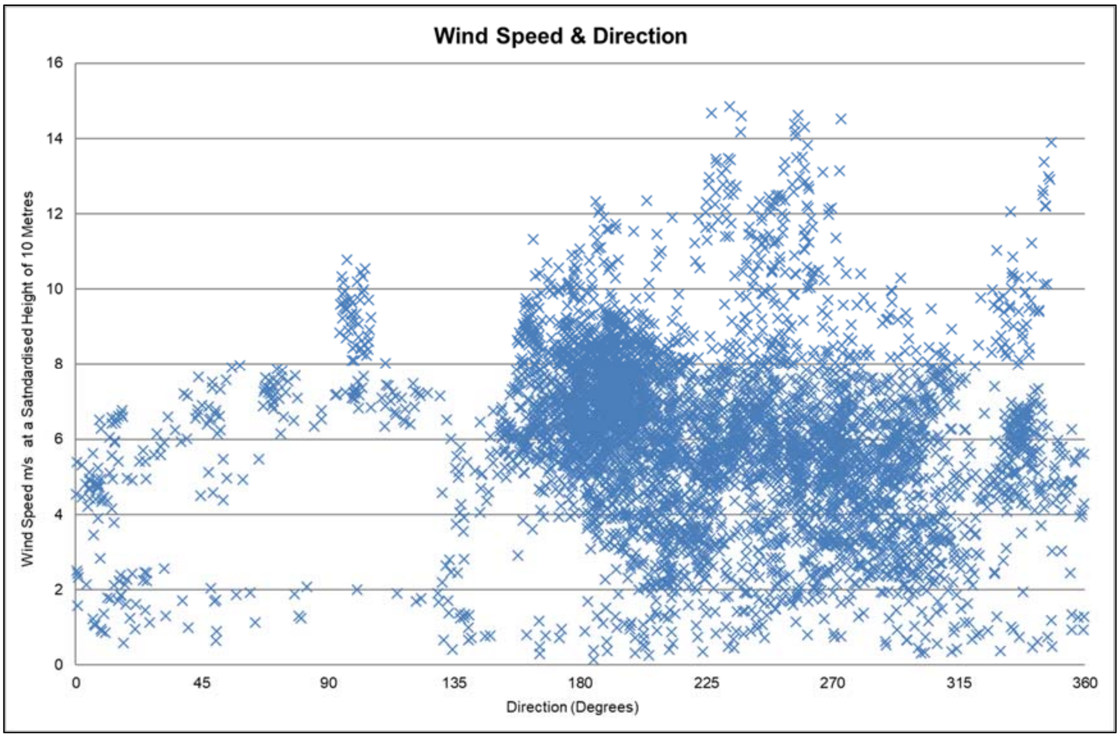


Figure 11.3 Distributions of Wind Speeds and Directions Over the Survey Period

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 11.3.7 and 11.3.7.5. 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

11.4.1.1.1 *Daytime Quiet Periods*

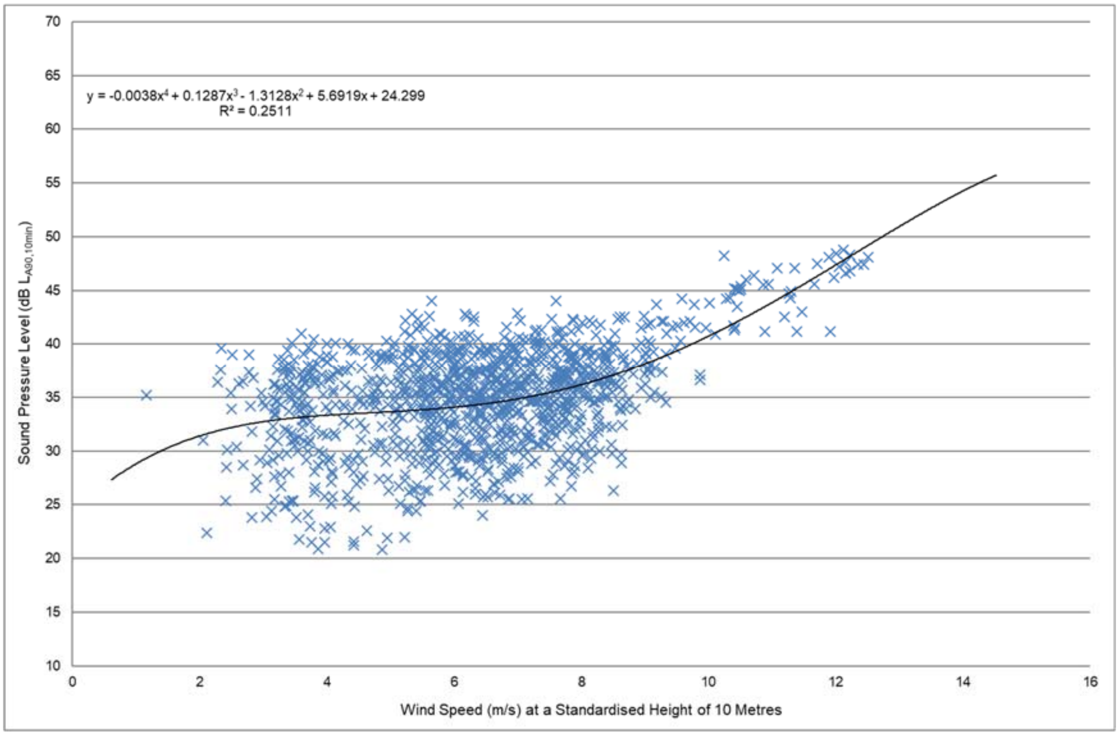


Figure 11.4 Location A - Background Noise Levels dB $L_{A90,\ 10\ min}$ – Daytime

11.4.1.1.2 *Night-time Quiet Periods*

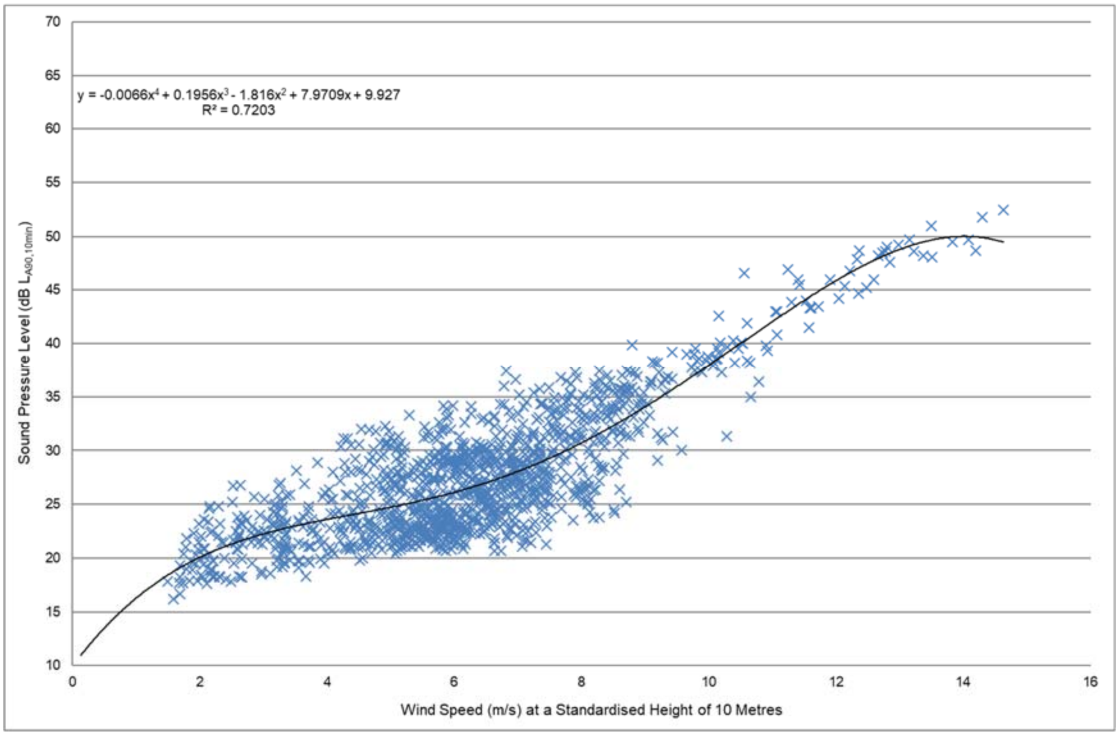


Figure 11.5 Location A - Background Noise Levels dB $L_{A90,\ 10\ min}$–Night -time

11.4.1.2 Location B

11.4.1.2.1 *Daytime Quiet Periods*

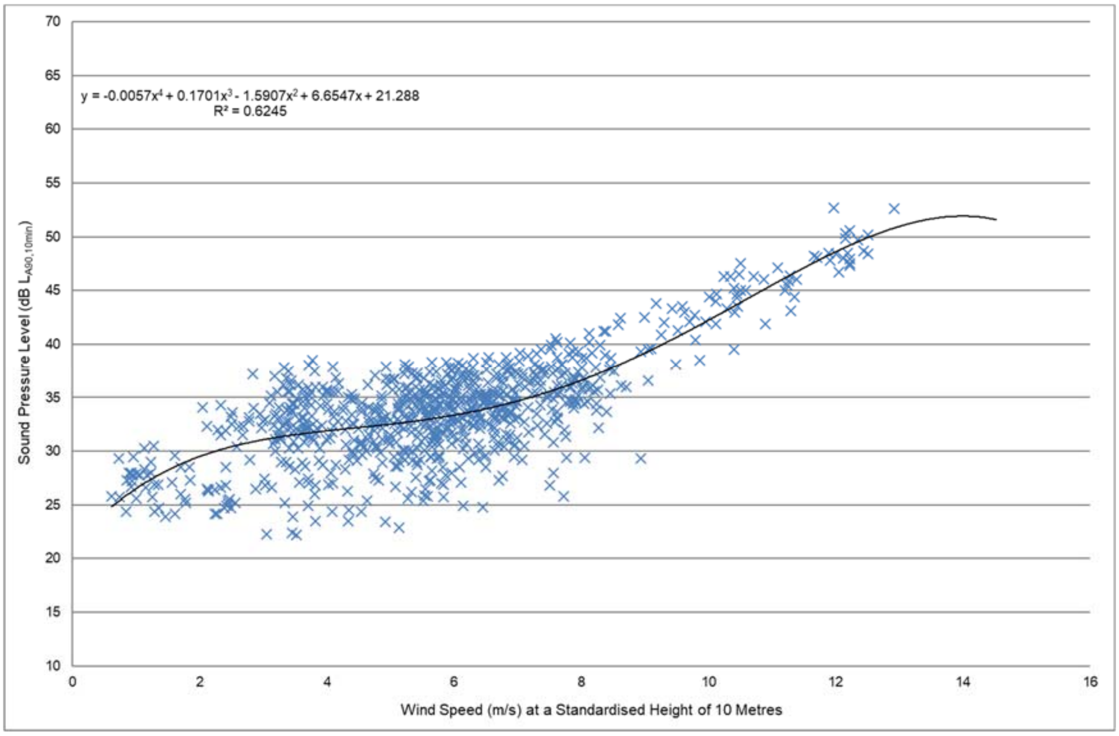


Figure 11.6 Location B - Background Noise Levels dB $L_{A90,\ 10\ min}$–Daytime

11.4.1.2.2 Night-time Quiet Periods

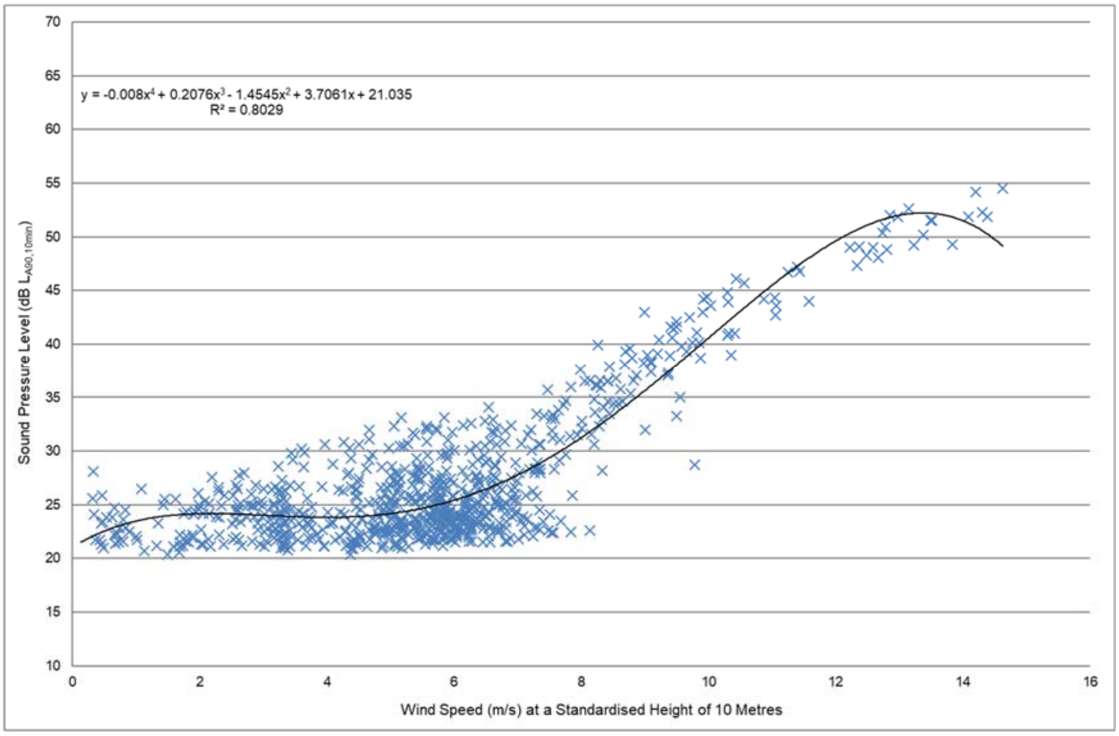


Figure 11.7 Location B - Background Noise Levels dB $L_{A90,\ 10\ min}$–Night -time

11.4.1.3 Location C

11.4.1.3.1 Daytime Quiet Periods

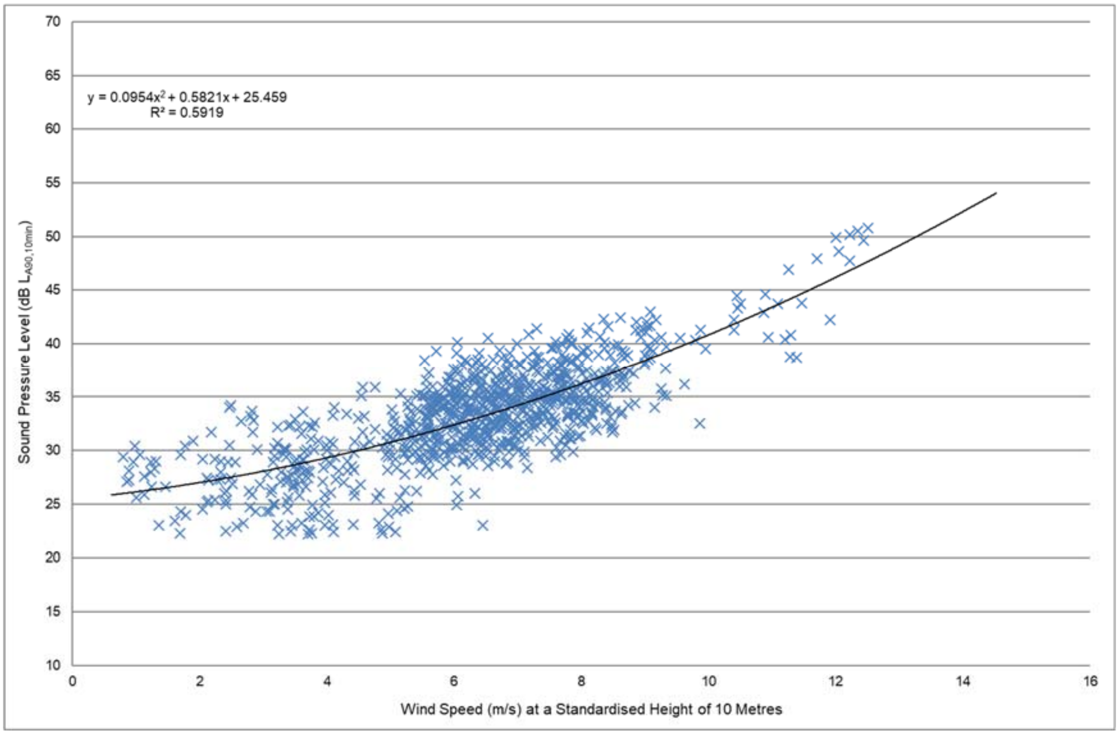


Figure 11.8 Location C - Background Noise Levels dB $L_{A90,\ 10\ min}$–Daytime

11.4.1.3.2 *Night-time Quiet Periods*

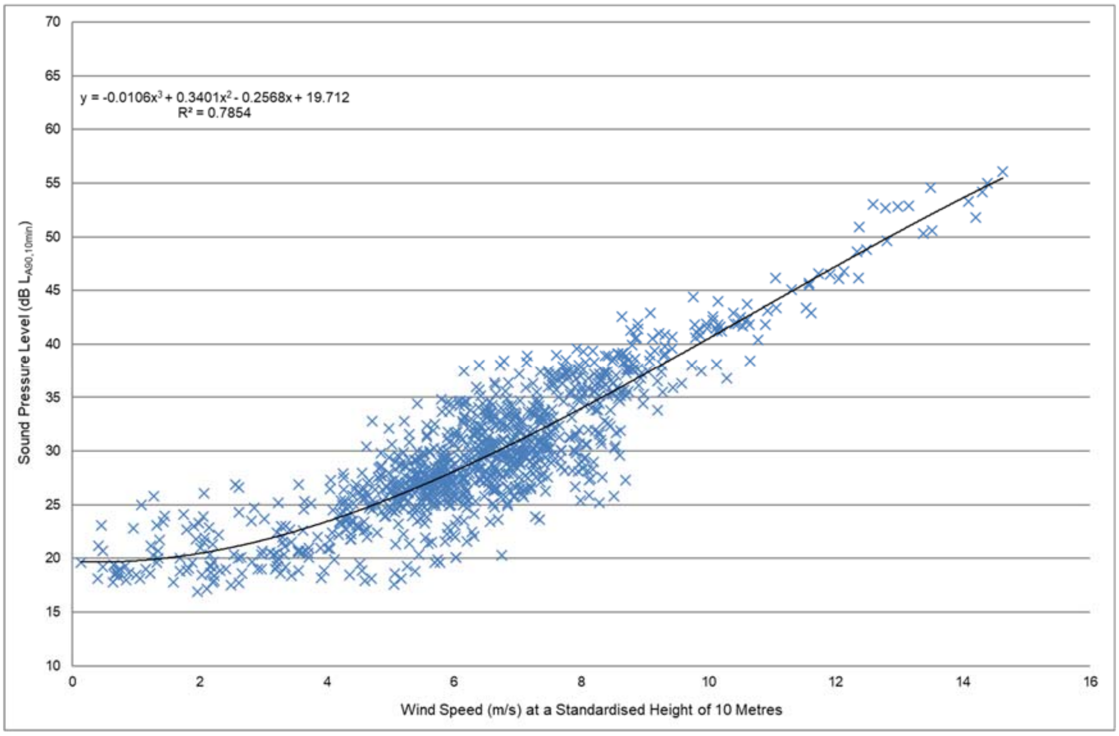


Figure 11.9Location C - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night -time

11.4.1.4 Location D

11.4.1.4.1 *Daytime Quiet Periods*

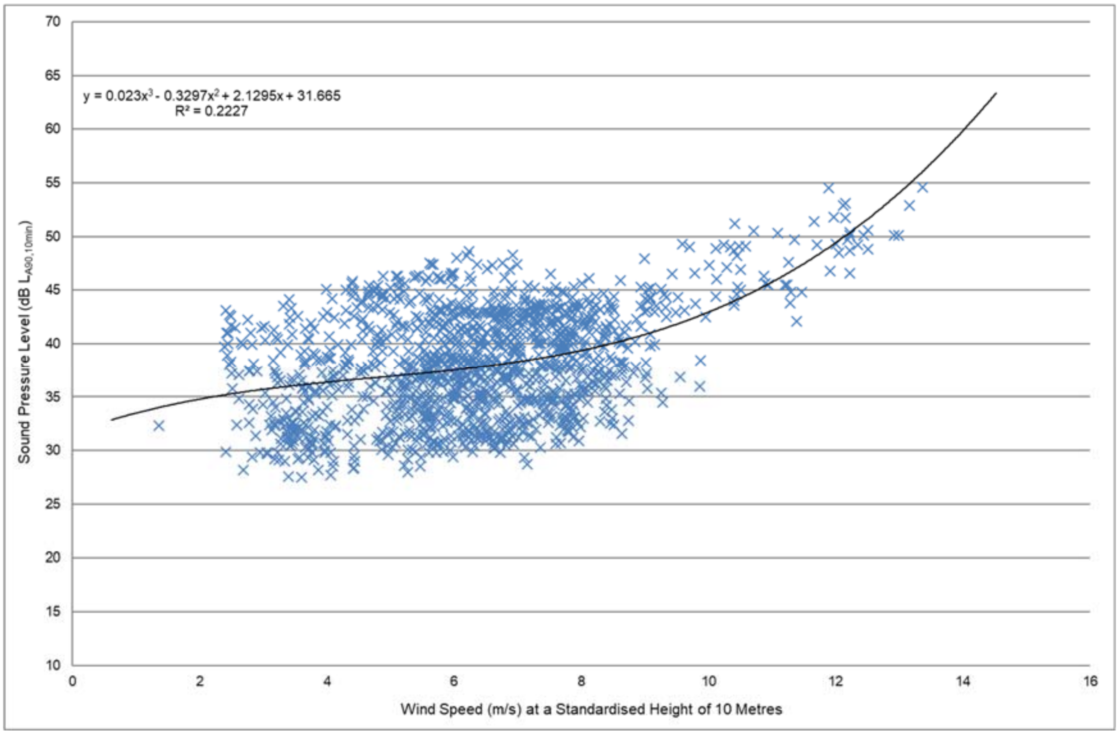


Figure 11.10 Location D - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime

11.4.1.4.2 *Night-time Quiet Periods*

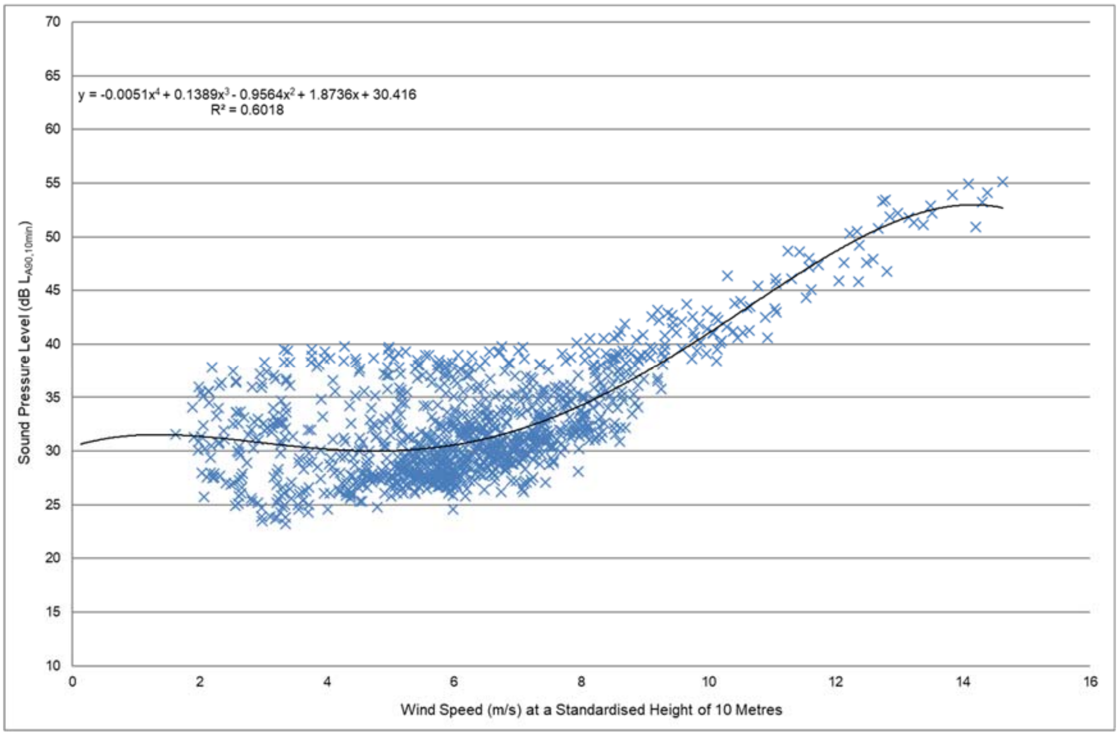


Figure 11.11 Location D - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night -time

11.4.1.5 Location E

11.4.1.5.1 *Daytime Quiet Periods*

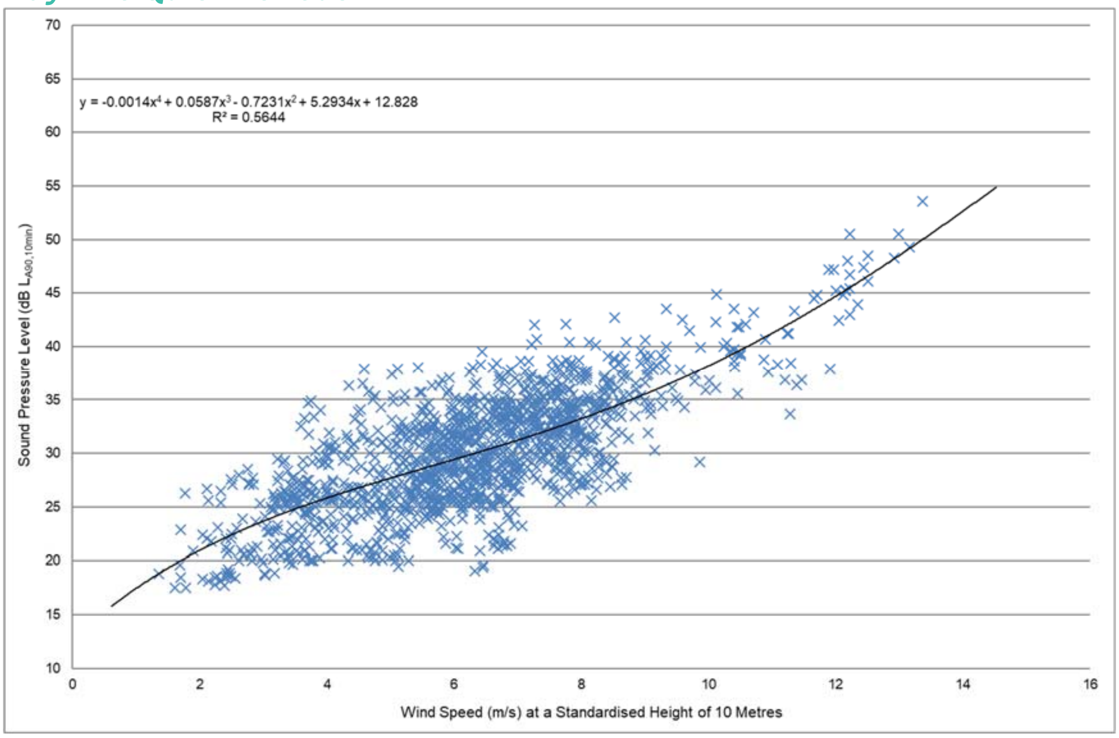


Figure 11.12 Location E - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime

11.4.1.5.2 *Night-time Quiet Periods*

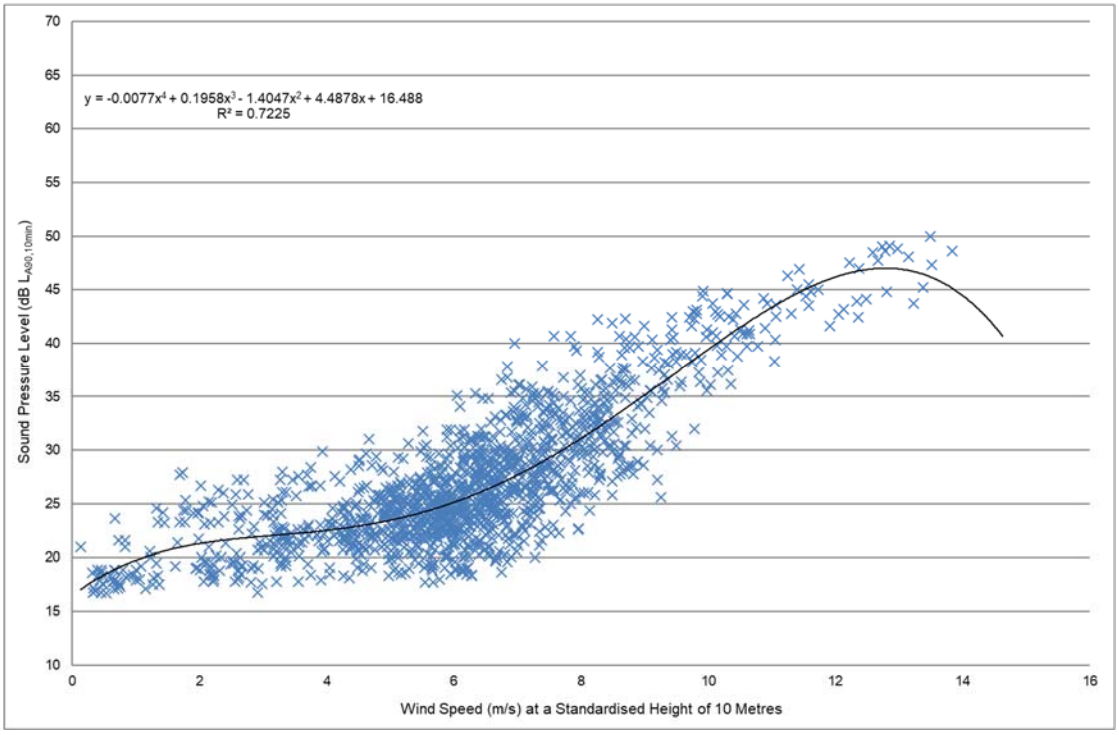


Figure 11.13 Location E - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night -time

11.4.1.6 Location F

11.4.1.6.1 *Daytime Quiet Periods*

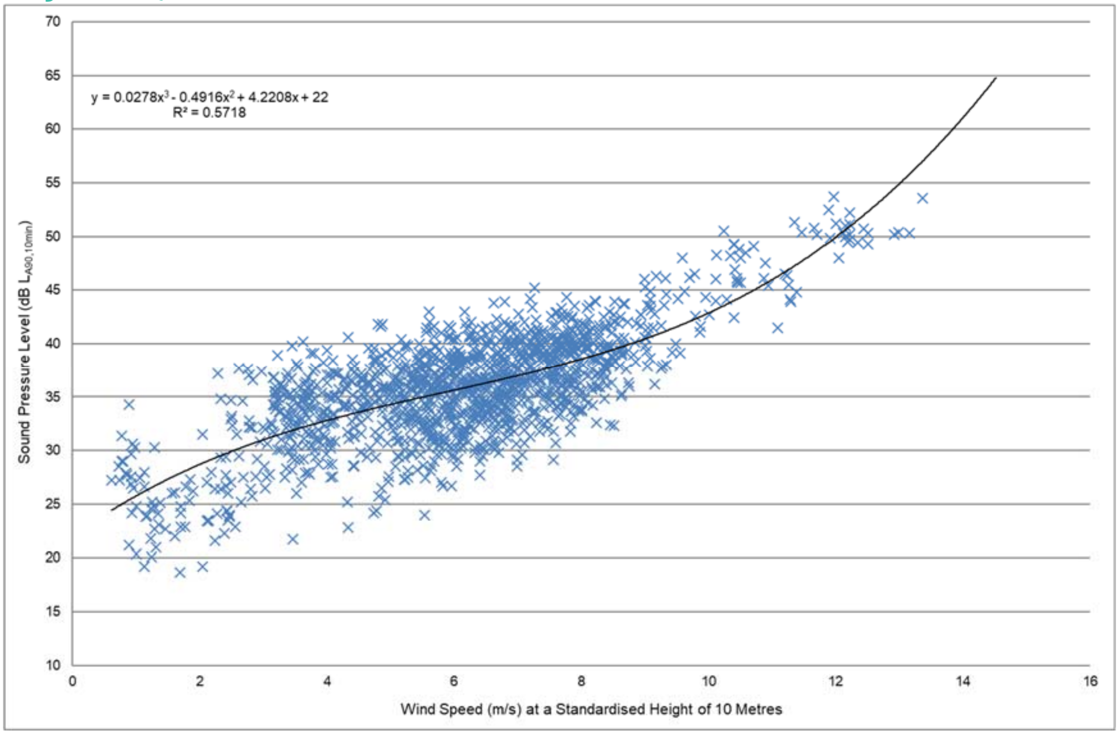


Figure 11.14 Location F - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime

11.4.1.6.2 *Night-time Quiet Periods*

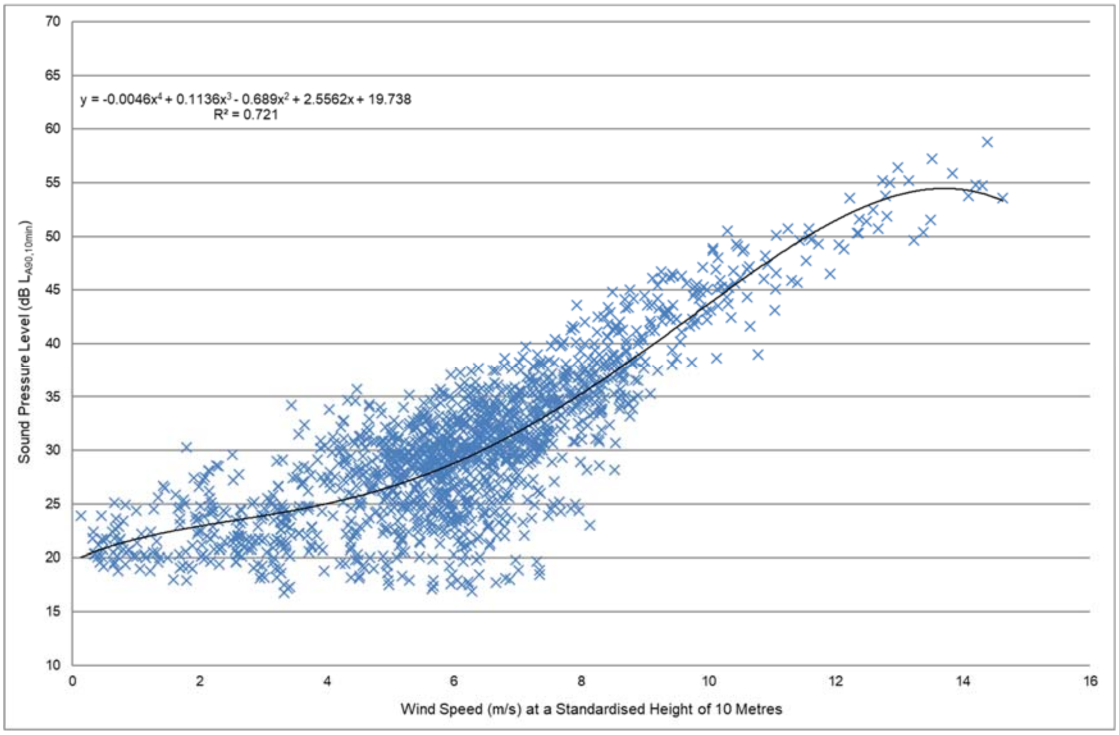


Figure 11.15 Location F - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night -time

11.4.1.7 Location G

11.4.1.7.1 *Daytime Quiet Periods*

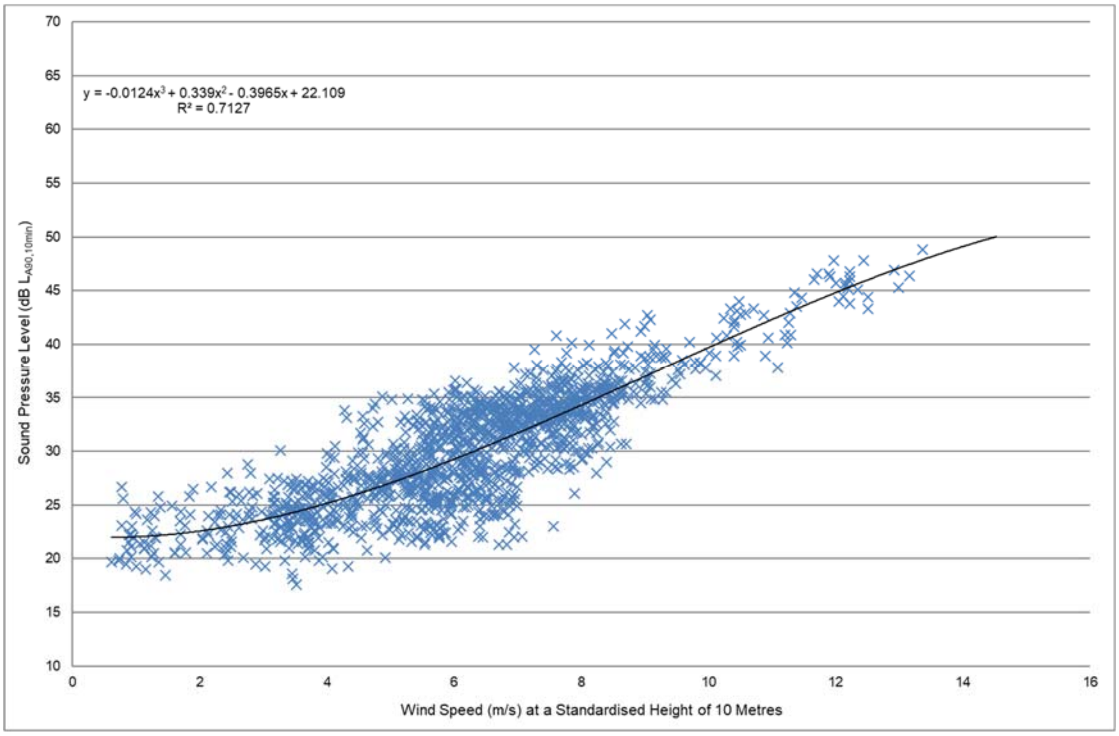


Figure 11.16 Location G - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime

11.4.1.7.2 Night-time Quiet Periods

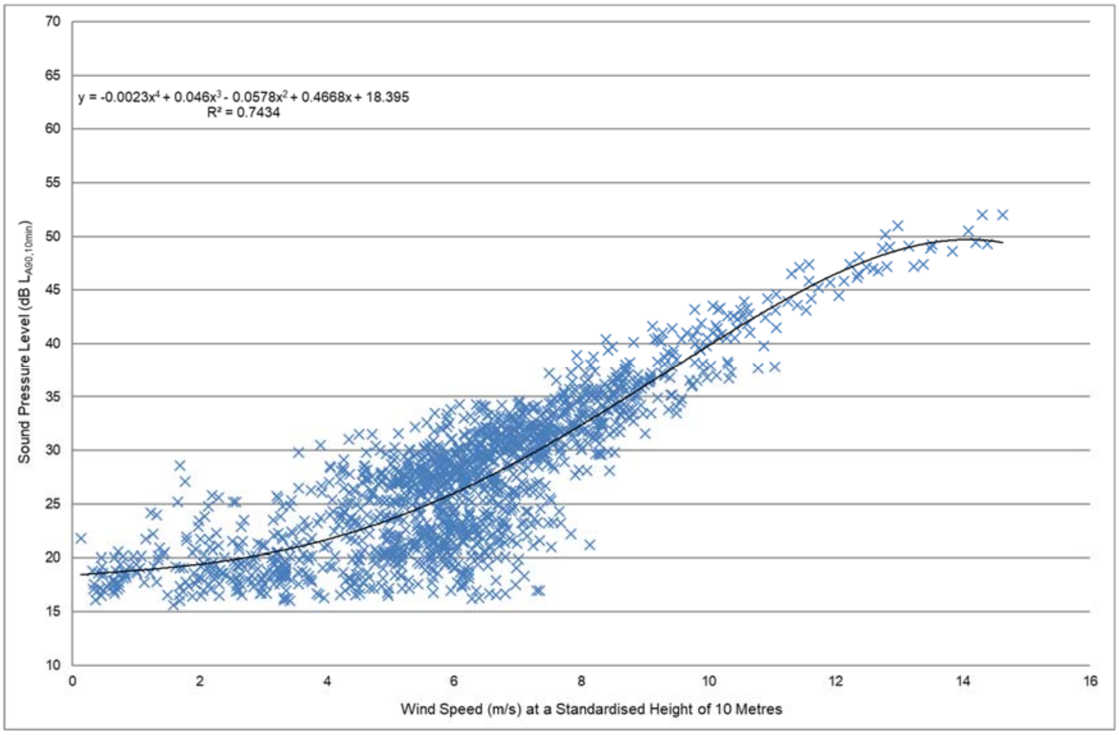


Figure 11.17 Location G - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night -time

11.4.1.8 Summary of Background Noise Levels

Table 11.11 presents the various derived LA90,10min noise levels for each of the monitoring locations for daytime quiet periods and night-time periods. These levels have been derived using regression analysis carried out on the data sets in line with 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	32.7	33.3	33.7	34.1	34.8	36.1	38.1	40.6
	Night	22.2	23.6	24.7	26.1	28.0	30.6	33.9	37.6
B	Day	31.1	31.9	32.5	33.3	34.6	36.5	38.9	41.9
	Night	23.8	23.8	24.2	25.4	27.7	31.1	35.4	40.2
C	Day	28.1	29.3	30.8	32.4	34.2	36.2	38.4	40.8
	Night	21.7	23.4	25.6	28.1	30.9	34.0	37.2	40.6
D	Day	35.7	36.4	36.9	37.5	38.3	39.4	40.9	43.0
	Night	30.0	30.0	30.0	30.6	32.1	34.4	37.6	41.4
E	Day	23.7	25.8	27.7	29.4	31.2	33.2	35.5	38.2
	Night	22.0	22.5	23.5	25.2	27.7	31.2	35.3	39.7

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
F	Day	31.0	32.8	34.3	35.6	37.0	38.5	40.4	42.8
	Night	23.9	25.0	26.6	28.8	31.8	35.4	39.6	44.0
G	Day	23.6	25.2	27.1	29.3	31.7	34.3	37.0	39.6
	Night	20.3	21.7	23.6	26.1	29.1	32.6	36.4	40.3
Envelope	Day	23.6	25.2	27.1	29.3	31.2	33.2	35.5	38.2
	Night	20.3	21.7	23.5	25.2	27.7	30.6	33.9	37.6

A worst-case envelope based on the lowest average levels at the various wind speeds for both day and night time is presented in Table 11.11. It is proposed to adopt this envelope limit to derive turbine noise thresholds for the initial screening phase of the assessment. In a situation where measurements have been conducted near another receiver or the location is deemed to be representative of the measured background noise levels at other locations, these can be used for establishing appropriate noise limits at other locations.

The background noise data shall be used to derive appropriate noise limits for each of the noise sensitive locations.

11.4.2 Wind Turbine Noise Criteria

A lower daytime threshold of 40 dB $L_{A90,10\text{-}min}$ has been adopted for low noise environments where the background noise is less than 30 dB(A). This follows a review of the prevailing background noise levels and is deemed appropriate considering 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 nearby Cloghan wind farm has permitted noise limits are as per Condition No. 11 of An Bord Pleanála Reference PL19.244053 with a lower threshold for turbine noise of 43 dB $L_{A90,10\text{-}min.}$
- The grant of planning for the Meenwaun development refer to the noise limits outlined in the EIS chapter which proposed a lower threshold for turbine noise of 40 dB $L_{A90,10\text{-}min}$.
- It is reiterated that the 2006 *Wind Energy Development Guidelines* states that "*An appropriate balance must be achieved between power generation and noise impact.*"

Based on other national guidance (EPA, 2016) in relation to acceptable noise levels in areas of low background noise and grant of planning conditions for other permitted wind turbine development in the area it is considered that the criteria adopted as part of this assessment are robust.

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 of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater 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	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.6
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
B	Day	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.9
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.2
C	Day	40.0	40.0	45.0	45.0	45.0	45.0	45.0	45.8
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
D	Day	45.0	45.0	45.0	45.0	45.0	45.0	45.9	48.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.4
E	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	44.7
F	Day	45.0	45.0	45.0	45.0	45.0	45.0	45.4	47.8
	Night	43.0	43.0	43.0	43.0	43.0	43.0	44.6	49.0
G	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	45.3
Envelope	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

11.5 Likely Significant Effects and Associated Mitigation Measures

11.5.1 Do-Nothing Scenario

If the proposed development were not to proceed, the site would continue to be managed under the requirements of the relevant IPC licence, and existing commercial forestry, telecommunications and wind measurement would continue. The rail lines that supply peat to Derrinlough Briquette Factory would continue to be used until the manufacture of peat briquettes ceases.

When peat extraction activity ceases, a Rehabilitation Plan will be implemented in accordance with the IPC licence requirements, to environmentally stabilise the site through encouragement of re-vegetation of bare peat areas, with targeted active management being used to enhance re-vegetation and the creation of small wetland areas (if required).

If development were not to proceed then the existing noise environment will remain largely unchanged notwithstanding other proposed and permitted wind turbine developments in the area. 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 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. These are discussed in the following Sections.

Due to the nature of the construction activities it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels at the nearest sensitive receptor 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. 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 will 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 Hardstands;
- Substation and Grid connection;
- Site entrances;
- Internal roads;
- Met Masts;
- Underpasses;
- Internal amenity pathways;
- Additional amenity links; and
- Amenity Carpark.

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 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, Grid Connection and Internal Roads

11.5.2.1.1 *Noise*

Turbine and Hardstands

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 nearest sensitive receptor. The assessment is considered to be a worst-case, construction noise levels will be lower at properties located further from the works. The nearest sensitive location (NSL) (R130) is situated approximately 762m from proposed Turbine 15.

Table 11.13 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 11.13 Typical Construction Noise Emission Levels for Turbine Construction

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [11]	Predicted Noise Level at 750m (dB $L_{Aeq,T}$)
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79	31
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	29
Piling Operations (C.12.14)	Standard pile driving.	88	40
General Construction (Various)	All general activities plus deliveries of materials and plant.	84	33
Dewatering Pumps (D.7.70)	If required.	80	32
JCB (D.8.13)	For services, drainage and landscaping.	82	34
Grid Connection Works	Breaking, excavation, loaders and road roller	82	34
Vibrating Rollers (D.8.29)	Road surfacing.	77	29

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

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [11]	Predicted Noise Level at 750m (dB $L_{Aeq,T}$)
Total Construction Noise (cumulative for all activities)			44

At the nearest noise sensitive location, the predicted noise levels from construction activities are in the range of 29 to 40 dB $L_{Aeq,T}$ with a total worst-case construction level of the order of 44 dB $L_{Aeq,T}$. In all instances the predicted noise levels at the nearest NSL's are below the appropriate criteria outlined in Section 11.4.1 (Category A - 65 dB $L_{Aeq,T}$ during daytime periods).

This assessment is considered representative of worst-case and construction noise levels will be lower at properties located further than 750 m from the works.

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 11.4.1 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 and Grid Connection Works

The proposed substation is located in north-east Drinagh (refer to site layout drawings in Appendix 4.4 of the EIAR). The noise impact at the nearest NSL has been assessed to identify the potential greatest impact associated with the construction of the Substation at the nearest NSL.

The nearest NSL to the substation site is at approximately 330m with grid connection works expected to take place at a closer distance of 270m to the same NSL at the closest point of the works. Based on the same construction activities as outlined in Table 11.13 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 53 dB $L_{Aeq,T}$ at the nearest NSL which is well below the significance threshold of 65dB $L_{Aeq,1hr.}$ outlined in Section 11.4.1.

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

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 R184 which is located 200m from the proposed works. 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 11.14 outlines the typical construction noise levels associated with the proposed works for this element of the construction. Calculations have assumed an on-time of 66% for each item of plant.

Table 11.14 Typical Construction Noise Emission Levels for Roads

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 $L_{Aeq,T}$)
		200m
HGV Movement (C.2.30)	79	43
Mini Tracked Excavator with Rock Breaker (C5.2)	83	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 are of the order of 49 dB $L_{Aeq,T}$, which is well below the significance threshold of 65dB $L_{Aeq,1hr.}$ outlined in **Error! Reference source not found.**. 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.

11.5.2.1.2 Vibration

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

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.

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, Grid Connection 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 in order 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.

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

The following situations are commented upon here:

- Stage 1a – Site Preparation – Concrete Pouring
- Stage 1b – Site Preparation and Ground Works
- 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 11.15 presents a summary of the data used for the calculations in this assessment. The figures in Table 11.15 have been derived from the traffic data in Chapter 14 with corrections applied for the passenger car unit (PCU) factors.

Table 11.15 Construction Traffic Data for Assessment

Route	Stage	Traffic Units	%HGV
1. N52 – Tullamore	Baseline year (2022)	5,383	7.2
	1a	5,653	9.5
	1b	5,674	9.9
	2a	5,473	7.3
	2b	5,469	7.2
2. N52 – Birr	Baseline year (2022)	8,221	7.2
	1a	8,491	8.7
	1b	8,513	9.0
	2a	–	–
	2b	–	–
3a. N62 - North of access	Baseline year (2022)	2,967	11.0
	1a	3,237	14.7
	1b	3,259	15.3
	2a	–	–
	2b	–	–
3b. N62 – South of access	Baseline year (2022)	2,967	11.0
	1a	3,237	14.7
	1b	3,259	15.3
	2a	3,057	11.0
	2b	3,054	10.9

Route	Stage	Traffic Units	%HGV
4. R357	Baseline year (2022)	2,346	7.2
	1a	–	–
	1b	2,637	12.9
	2a	–	–
	2b	–	–

Based on the traffic data presented in Table 11.15 the changes in noise level relative to the expected traffic noise from the baseline year (2022) have been calculated and are outlined in Table 11.16.

Table 11.16 Calculated Changes in Traffic Noise Levels

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
1a – Site Preparation – Concrete Pouring	1. N52 – Tullamore	1.1	6
	2. N52 – Birr	0.7	4
	3a. N62 - North of access	1.4	11
	3b. N62 – South of access	1.4	10
	4. R357	–	–
1b – Site Preparation and Ground Works	1. N52 – Tullamore	1.2	147
	2. N52 – Birr	0.8	98
	3a. N62 - North of access	1.5	245
	3b. N62 – South of access	1.5	245
	4. R357	2.4	7
2a – Extended Artic Deliveries (large turbine components)	1. N52 – Tullamore	0.1	38
	2. N52 – Birr	–	–
	3a. N62 - North of access	–	–
	3b. N62 – South of access	0.1	38
	4. R357	–	–
2b – Other Deliveries (small turbine components)	1. N52 – Tullamore	0.1	21
	2. N52 – Birr	–	–
	3a. N62 - North of access	–	–

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
	3b. N62 – South of access	0.1	21
	4. R357	–	–

The predicted increases in traffic noise levels during each of the construction stages of the proposed development are less than 3 dB along all routes. With reference to the criteria set out in Section 11.3.2.1.2 the potential impacts are minor are worst case and 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	Slight	Short-term

11.5.3 Operational Phase Potential Impacts

11.5.3.1 Turbine Noise Assessment

The predicted noise levels for the proposed development has been calculated for all noise sensitive locations identified within a minimum radius of 2 km of the proposed turbines.

A worst-case omni-directional assessment has been completed assuming all noise locations are downwind of all turbines at the same time (an impossible scenario) 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).

Due to the number of NSL's included in the assessment, an initial screening of the cumulative omni-directional noise levels has been undertaken by comparing the worst-case predicted turbine noise levels against the worst-case criteria curves based on the lowest background noise level envelope for day and night. This screening exercise identified a total of 19 no. NSL with potential exceedance of the worst-case noise criteria curve envelope. The 19 NSL's are listed in Table 11.17. At all other NSL's the cumulative turbine noise levels are predicted to be below the criteria curves. Figure 11.19 overleaf presents a map of the proposed development showing all NSL's

Table 11.17 List of Location with Potential Exceedances

NSL Ref.	Coordinates – Irish Grid (IG)	
	Easting	Northing
R007	204,416	212,866

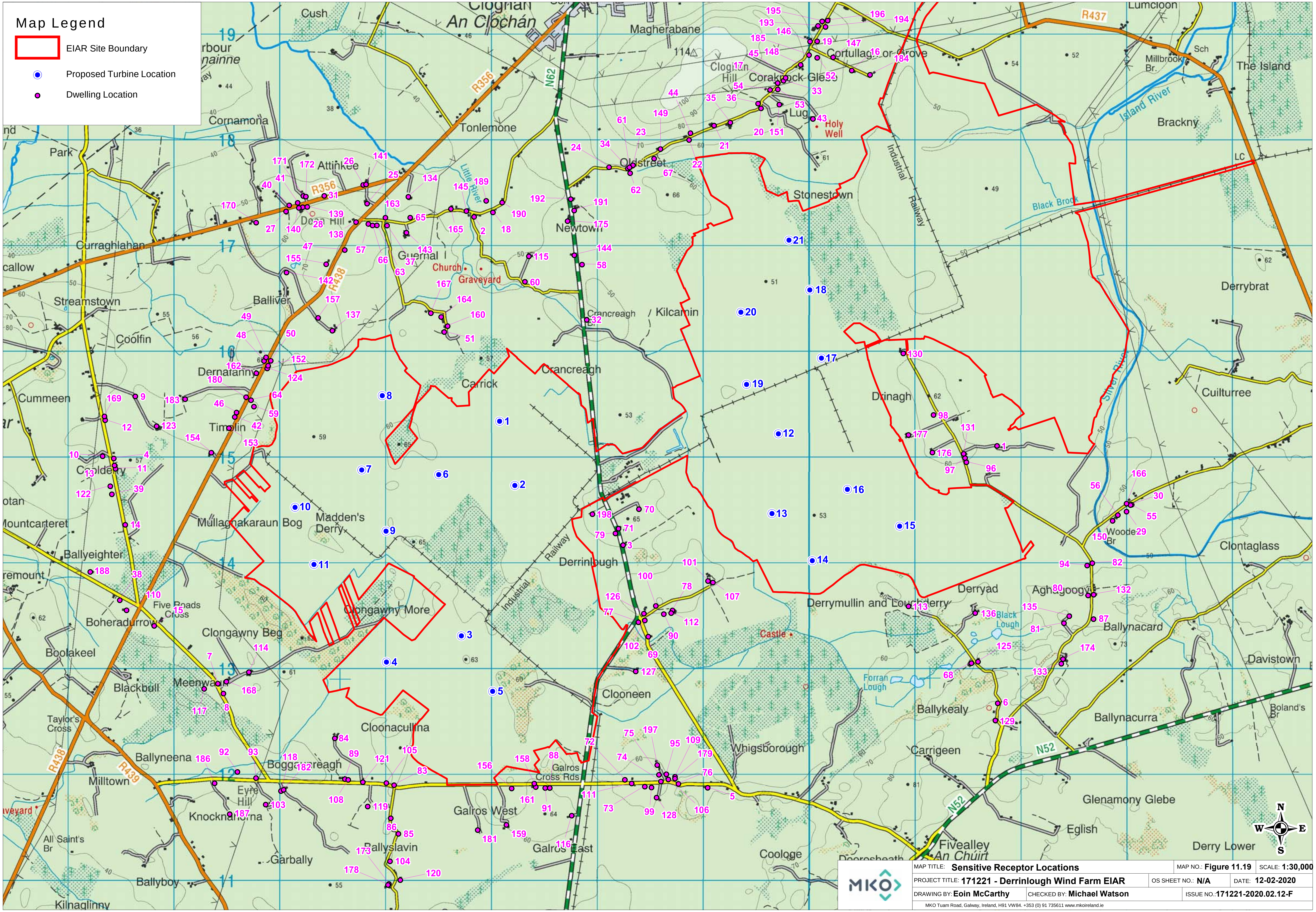
NSL Ref.	Coordinates – Irish Grid (IG)	
	Easting	Northing
R008	204,468	212,772
R032	207,901	216,303
R058	207,857	216,826
R070	208,395	214,514
R083	206,081	211,906
R084 [Note 1]	205,521	212,349
R089	205,616	211,963
R093	204,776	211,973
R105	206,008	211,926
R108	205,648	211,956
R114	204,709	212,974
R117	204,286	212,816
R118	205,012	211,850
R121	205,786	211,934
R144	207,784	216,914
R168	204,495	212,884
R182	205,037	211,862
R198	207,955	214,466

Note 1: In relation to NSL R084, the EIS (Noise Chapter) for Meenwaun stated that if the windfarm was permitted that this property would no longer be used as a dwelling by any person and therefore it was not assessed as a receptor in that EIS and is not be considered a NSL in this assessment.

The omni-directional cumulative turbine noise predictions and the predictions from the proposed Derrinlough turbines in isolation are presented in Appendix 11.4.

The turbine noise emissions from the proposed Derrinlough turbines are all below the worst-case criteria curves based on the lowest background noise level envelope for day and night at all locations. However, the noise contribution from the Derrinlough turbines increases the overall cumulative turbine noise levels which result in potential exceedances of the criteria at certain NSL's. These NSLs will be addressed in the following sections. It should also be noted that some of the potential exceedances can be attributed to the contribution of the worst case predicted turbine levels from other developments i.e. the predicted turbine noise levels would be the same if the contribution from the Derrinlough turbines were omitted.

The turbine noise level contribution of each wind farm development at NSL's with potential exceedances must be analysed to determine if mitigation is required to the proposed Derrinlough turbines. The various stages of this assessment are set out in the following Sections. As previously stated, the initial screening for this assessment applied the worst-case criteria curves based on the lowest background noise level envelope. Following a review of the 19 no. locations identified from the initial screening and listed in Table 11.12, appropriate noise limits have been assigned to each of the relevant NSL's based on professional judgement in line with best practice guidance of representative background noise levels measured as part of the survey. The noise criteria curves for Location C are deemed to be appropriate for all locations where the predicted omni-direction cumulative noise emissions have indicated a potential exceedance.


Map Legend
EIAR Site Boundary
Proposed Turbine Location
Dwelling Location
MAP TITLE: Sensitive Receptor Locations
MAP NO.: Figure 11.19
SCALE: 1:30,000
PROJECT TITLE: 171221 - Derrinlough Wind Farm EIAR
OS SHEET NO.: N/A
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Two of the seven locations included in the background noise survey attract lower noise criteria curves than Location C, namely Location E and G. As described in Section 11.3.7.1, both these locations were isolated from any significant environmental noise source which is not deemed to be representative of the list of NSL's in Table 11.12. All other locations in the background noise survey attract a higher noise criteria curve. Therefore, adopting the background noise from Location C is robust and appropriate for this assessment

The predicted omni-directional cumulative noise levels at the 18 no. locations have been compared against the adopted noise criteria curves and are presented in Table 11.18.

Table 11.18 Review of Cumulative Predicted Turbine Noise Levels against Relevant Criteria at Screened NSL's

House ID	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)				
		3	4	5	6	≥7
R007	Dwelling	33.8	36.5	41.7	42.8	42.9
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	1.7	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R008	Dwelling	33.8	36.5	41.7	42.9	42.9
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	1.7	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R032	Dwelling	31.8	36.1	41.1	44.4	45.4
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance Daytime Exceedance	–	–	1.1	4.4	0.4
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	1.4	2.4
R058	Dwelling	30	34.3	39.3	42.6	43.6
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	–	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	0.6
R070	Dwelling	28.1	32	37	40.2	40.9
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	–	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R083	Dwelling	30.8	33.6	38.8	40.2	40.3
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	–	–	–
	Night Limits	43	43	43	43	43

House ID	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)				
		3	4	5	6	≥7
	Potential Night time Exceedance	–	–	–	–	–
R089	Dwelling	34	36.7	41.9	43.1	43.1
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	1.9	–	–
	Night Limits	43	43	43	43	43
	Night time Exceedance	–	–	–	0.1	0.1
R093	Dwelling	31.2	33.9	39.1	40.3	40.3
	Daytime Limits	40	40	40	40	45
	Daytime Exceedance	–	–	–	0.3	–
	Night Limits	43	43	43	43	43
	Night time Exceedance	–	–	–	–	–
R105	Dwelling	31.5	34.2	39.4	40.8	40.9
	Daytime Limits	40	40	40	40	
	Potential Daytime Exceedance	–	–	–	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R108	Dwelling	33.8	36.5	41.7	42.9	43
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	1.7	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R114	Dwelling	37.7	40.3	45.5	46.6	46.6
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	0.3	5.5	1.6	1.6
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	2.5	3.6	3.6
R117	Dwelling	32.4	35	40.3	41.4	41.5
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	0.3	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R118	Dwelling	31.3	34	39.2	40.4	40.4
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	–	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R121	Dwelling	32.9	35.6	40.8	42.1	42.1
	Daytime Limits	40	40	40	45	45

House ID	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)				
		3	4	5	6	≥7
	Potential Daytime Exceedance	–	–	0.8	–	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R144	Dwelling	28.9	33.2	38.2	41.5	42.5
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	–	1.5	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–
R168	Dwelling	34.7	37.3	42.6	43.7	43.7
	Daytime Limits	40	40	40	45	45
	Potential Daytime Exceedance	–	–	2.6	–	–
	Night Limits	43	43	43	4343	43
	Night time Exceedance	–	–	–	0.7	0.7
R182	Dwelling	31.5	34.2	39.4	40.6	40.7
	Daytime Limits	40	40	40	40	45
	Daytime Exceedance	–	–	–	0.6	–
	Night Limits	43	43	43	43	43
	Night time Exceedance	–	–	–	–	–
R198	Dwelling	28.5	32.3	37.3	40.4	41
	Daytime Limits	40	40	40	40	45
	Daytime Exceedance	–	–	–	0.4	–
	Night Limits	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–

A noise contour for the omni-directional rated power wind speed (i.e. highest noise emission) for the cumulative scenario and the proposed development in isolation is presented in Appendix 11.5.

Where predicted levels from Meenwaun or Cloghan, at a given NSL, are at or above the assessment criteria limit, then the contribution from the Derrinlough turbines at the same NSL will be limited to 10 dB below the noise limit value to ensure there are no cumulative exceedances of the noise limits as a result of the proposed development, this approach is in line with best practice guidance presented in Section 11.3.2.2.4.

The predicted omni-directional turbine noise levels from the proposed Derrinlough turbines in isolation are below the worst-case criteria curves based on the lowest background noise level envelope for day and night at all NSL's. However, predicted noise levels due to Derrinlough turbines increases the overall cumulative turbine noise levels, which in some cases results in a predicted exceedance of criteria. Some worked examples of the logarithmic calculations at 7m/s wind speed during night-time periods are set out in Table 11.19 to demonstrate how the cumulative noise sources combine on the logarithmic scale and how the reduction required to the Derrinlough turbines has been calculated.

Table 11.19 Example of Logarithmic Addition of Noise Sources in This Assessment

NSL	Representative Background Noise Level, dB	Noise Level Derrinlough Turbine, dB	Noise Level Other Wind Turbines, dB	Cumulative Turbine Level, dB	Cumulative Exceedance Level, dB	Reduction required to Derrinlough Turbine Noise
R089	30.9	34.1	42.5	43.1	0.1	0.7
R114	30.9	35.2	43.0	43.7	0.7	2.2

An overview of this assessment methodology is provided in Section 11.3.7.4 and the relevant guidance for assessment of cumulative impacts in Section 11.3.2.2.

11.5.3.1.1 Consideration of Wind Direction

The preceding section considered omni-directional cumulative noise i.e. assuming all noise locations being downwind of all turbines at the same time. The next step in the assessment is to consider wind directionality and turbine noise propagation in the noise prediction model using the methods outlined in Section 11.3.8.3.

A full suite of directional noise prediction results for all NSL's is presented in Appendix 11.6.

Analysis of the directional noise prediction results has been carried out to determine the level of attenuation (dB) required to the Derrinlough turbines in each wind speed bin, to achieve cumulative turbine noise levels that comply with the assessment criteria. The calculated attenuation requirements are outlined in Table 11.20 and Table 11.21. Section 11.5.6.1 presents outline mitigation measures to demonstrate compliance by achieving the relevant attenuation requirements to address potential cumulative exceedances at 5 no. NSL's.

As previously stated, where levels of existing or proposed turbine noise are predicted to be at or above the noise limit i.e. there is no headroom for additional turbine noise, the Derrinlough turbine noise should be designed to 10dB below this limit to ensure that there is no exceedance of the noise limits. This is in accordance with best practice guidance outlined in Section 11.3.2.2.4.

Table 11.20 Daytime Attenuation Requirements for Derrinlough during Daytime Periods

NSL	Wind Speed	Attenuation (dB) Required to Derrinlough Turbines at Various Wind Speeds and Direction Sector - Daytime							
		N	NE	E	SE	S	SW	W	NW
R114	≥7m/s	–	0.2	0.2	–	–	–	–	–

Table 11.21 Night-time Attenuation Requirements for Derrinlough during Night-time Periods

NSL	Wind Speed	Attenuation (dB) Required to Derrinlough Turbines at Various Wind Speeds and Direction Sector – Night Time							
		N	NE	E	SE	S	SW	W	NW
R032	≥7m/s	–	–	–	1.0	1.8	–	–	–
R058		–	–	–	1.1	–	–	–	–
R089		0.6	–	–	–	–	–	–	–
R114		1.6	2.2	2.1	0.4	–	–	–	0.1
R168		–	0.9	0.9	–	–	–	–	–
R032	6m/s	–	0.3	0.3	1.8	2.3	–	–	–
R089		0.3	–	–	–	–	–	–	–
R114		1.3	1.9	1.8	0.1	–	–	–	–
R168		–	0.6	0.6	–	–	–	–	–

The following should be noted in relation to the attenuation requirement for Derrinlough presented in Table 11.20 and Table 11.21:

- The predicted turbine noise levels from the proposed Derrinlough turbines in isolation are below the noise criteria at all NSL's;
- At all of the NSL's identified in Table 11.20 and Table 11.21 the predicted turbine noise levels are dominated by noise associated with the Meenwaun or Cloghan Wind Farms;
- The predicted turbine noise levels are worst-case in terms of the calculation methods used for noise propagation and include an uncertainty factor of +2dB; and
- The level of turbine noise from the Derrinlough turbines has been attenuation to achieve the adopted turbine noise criteria or attenuation such that the predicted contribution of the Derrinlough turbines is 10 dB below the turbine noise limit values in accordance with best practice guidance.

It is concluded that due to predicted turbine noise levels from other permitted and proposed developments that mitigation in the form of slight attenuation of the Derrinlough turbines may be required under certain wind speeds and directions in order avoid cumulative turbine noise levels exceeding the turbine noise limit values adopted for this assessment at 5 no. NSL's (see Section 11.5.6.1). It should be noted that the assessment has been undertaken in accordance with best practice guidance outlined in the IOA GPG and as previously stated, calculated using the ISO 9613-2 standard and relate to worst-case conditions favourable to noise propagation (typically downwind propagation from source to receiver and/or downward refraction under temperature inversions).

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.

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 proposed substation location is shown in the site layout drawings in Appendix 4.1 of this EIAR. The substation will typically 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 40dB(A) at 5m from each of the boundaries of the substation. This is below the WHO night-time free-field threshold limit of 42dB for preventing effects on sleep and well below the WHO daytime threshold limits for serious and moderate annoyance in outdoor living areas (i.e. 55dB and 50dB 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 and considering the distance between the substation and the nearest noise sensitive location (i.e. 330m) the noise from the proposed substation is not considered to be an issue off-site. The expected noise emissions at location R184 will be less than 23dBA.

It is therefore concluded that there will be no significant noise emissions from the operation of the substation.

Noise from the operation of a substation will not have any significant cumulative impact on the overall noise levels associated with the operation of the proposed development at any noise sensitive location.

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 be used.
The noise and vibration impacts associated with any decommission of the site are considered to be comparable to those outlined in relation to the construction of the Project (as per Section 11.5.2). 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 11.4.1.

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 cumulative 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 expected to comply with the identified criteria for the construction phase. However, 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 noisy / vibratory plant as far away from sensitive properties as permitted by 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 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 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 weekdays and between 7:00hrs and 14:00hrs on Saturdays. 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.

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 11.3.2.111.3.2.1.

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 these limits may need to be reduced by up to 50%.

11.5.6 Operational Phase Mitigation Measures

An 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 internal site roads, amenity facilities and substation will be within the relevant best practice noise criteria. Therefore, no mitigation measures are required for these elements.

Mitigation measures for the management of turbine related noise are outlined in the following section.

11.5.6.1 Turbine Curtailment

The turbine noise assessment has identified that attenuation of the Derrinlough turbine noise emissions will be required under certain wind conditions to ensure that the cumulative turbine noise levels comply with best practice noise criteria at all NSL's. The required attenuation for various wind speeds and directions has been calculated and is presented in Table 11.20 and Table 11.21. It should be noted that in all instances the levels of attenuation calculated for the Derrinlough turbines are based on the contribution of noise from other wind turbine development at the specific locations listed in Table 11.20 and Table 11.21. At all stages of this assessment conservative assumptions have been made on the noise emission for the other windfarm developments to present a typical worst-cast assessment. Therefore, mitigation measures are specific to this assessment and the turbines noise emissions details outlined in Section 11.3.8.2.

Modern wind turbines can be programmed to run in reduced modes of operation (or low noise modes) in order to achieve the calculated attenuation required in the specific wind conditions (i.e. wind speed and direction). Operating the turbines in reduced noise modes is generally referred to as curtailment.

Should predicted exceedances be confirmed at the commissioning stage of the development, it is possible to mitigate for this through curtailment of some turbines in the relevant wind speed and directions. The curtailment strategy would ultimately be developed for the specific turbine technology installed on the site and the associated noise emissions at the various operational wind speeds. If necessary, a detailed curtailment strategy matrix will be developed at the detailed design stage in order to achieve the relevant noise criteria (cumulative) at all NSL's.

If alternative turbine technologies are considered for the site 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 11.3.2.2 and/or the relevant operational criteria associated with the grant of planning for the Proposed Development. If necessary, suitable curtailment strategies will be designed and implemented for alternative technologies to ensure compliance with the relevant noise criteria curves, should detailed assessment conclude that this is necessary.

11.5.6.1.1 *Indicative Curtailment Strategy*

The turbine technology adopted for the assessment of the proposed development is the Vestas V136 4.2/4.0MW as detailed in Section 11.3.8.2. The proposed technology offers several low noise modes of operation. Based on a review of the turbine data available from the manufacturer Table 11.22 outlines the overall dBA sound power (LW) reduction offered by the various modes of operation considered for this assessment.

Table 11.22 Reduced Noise Modes for Indicative Curtailment

Wind Speed	Reduction in Turbine Noise for Various Modes compared to Mode P01 (dB)			
	S01	S02	S011	S012
7 m/s	1.8	4.2	5.9	4.1
6 m/s	2.1	4.4	5.0	4.0

A curtailment matrix has been calculated by applying the overall reduction offered by the reduced noise modes outlined in Table 11.22 to the various turbine noise immissions calculated at each NSL operating in the power optimised mode - Mode PO1 (blades with serrated trailing edge). Table 11.3 presents an indicative curtailment matrix that would achieve the attenuation required at Derrinlough turbines as set out in Table 11.20 and Table 11.21 to ensure that the relevant criteria is complied with at all NSL's.

Table 11.23 Indicative Curtailment Strategy Matrix for Derrinlough to Achieve Criteria

Period	Wind Speed	Turbine Operating Mode in Various Wind Direction Sectors					
		N	NE	E	SE	S	NW
Day	≥7m/s	–	T11 = SO1	T11 = SO1	–	–	–
Night		T04 = SO1 T10 = SO1 T11 = SO2	T04 = SO2 T09 = SO1 T10 = SO1 T11 = SO2	T04 = SO2 T09 = SO1 T10 = SO1 T11 = SO2	T01 = SO1 T02 = SO1 T04 = SO1 T19 = SO1 T20 = SO2	T01 = SO2 T02 = SO2 T19 = SO2 T20 = SO2	T11 = SO1
Day	6m/s	–	–	–	–	–	–
Night		T04 = SO1 T10 = SO1 T11 = SO2	T04 = SO2 T09 = SO1 T10 = SO1 T11 = SO2 T12 = SO1	T04 = SO2 T10 = SO1 T11 = SO2 T20 = SO1	T01 = SO1 T02 = SO2 T04 = SO1 T19 = SO2 T20 = SO2	T01 = SO11 T02 = SO2 T06 = SO1 T08 = SO1 T12 = SO1 T19 = SO2 T20 = SO2	–

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 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.

11.5.6.4 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 farm operations.

For post-commissioning of the proposed turbine units, it is recommended that the noise monitoring detailed in Section 11.3.7 be repeated with consideration of the guidance outlined in the IoA GPG and Supplementary Guidance Note 5.

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 and vibration 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 and Grid Connection*

The predicted residual noise and vibration 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.

11.5.8.3 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 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.

11.5.8.5 Operational Phase

11.5.8.5.1 *Wind Turbine Noise*

At some NSL's were there is existing wind turbine noise from operational development the contribution from Derrinlough will be inaudible and there would be no significant changes to the noise environment while at others NSL's situated closer to the proposed development a slight increase in the cumulative turbine noise level may be noticeable.

The assessment has demonstrated that the turbine noise emissions from the Derrinlough Wind Farm can be mitigated for any potential cumulative exceedances of the overall turbine noise levels and shall 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.

The worst-case predicted omni-directional turbine noise levels from the operation of the proposed Derrinlough turbines in isolation are considered low and well within best practice guidance noise limits albeit a new source of noise will be introduced into the soundscape at some NSL's. Mitigation has been outlined to address potential cumulative exceedances which are predicted to be dominated by noise from other permitted and proposed wind farm developments.

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

11.5.8.5.2 *Substation Noise*

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

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

11.5.8.6 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*
Negative	Imperceptible	Long Term

11.5.9 Cumulative Effects

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. This assessment has considered the potential cumulative impacts of the proposed development in combination with other wind energy developments in the area as required by best practice guidance discussed in Section 11.3.2.2.