# 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 impact from the proposed Meenbog wind farm development (the 'Proposed Development') on local residential amenity. The Proposed Development comprises up to 19 no. wind turbines with a maximum overall ground level to blade tip height of up to 156.5 metres. There are 14 houses located within 2.5 kilometres of the proposed turbine locations, four of which are derelict. The closest noise sensitive location (NSL) is located approximately 750m to the nearest proposed turbine location i.e. Location H257 from proposed turbine T17. Note, Location H257 is involved in the development. The nearest third party NSL is H253, situated some 1,620mfrom the nearest turbine (T19). A full description of the Proposed Development is provided in Chapter 4 of this EIAR.

Baseline noise levels have been measured at locations representative of the nearest noise sensitive properties. Noise predictions have been prepared for construction and wind turbine operation activities in relation to the nearest properties to the Proposed Development.

### 11.1.2 Statement of Authority

This chapter of the EIAR has been prepared by AWN Consulting.

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Dermot Blunnie (Senior Acoustic Consultant) holds a BEng(Hons) in Sound Engineering and an MSc in Applied Acoustics. He has nine years working in the field of acoustics. He is a corporate member of the the Institute of Acoustics and has completed the IOA Diploma in Acoustics and Noise Control. He has prepared numerous environmental impact assessment chapters for various developments such as major infrastructural developments, mixed use developments and specialises in wind energy development projects.

**Damian Kelly**
Damian Kelly (Technical Director) holds a B.Sc. from DCU and a M.Sc. from QUB. He some 20 years' experience as an acoustic consultant and is a Member of the Institute of Acoustics. He has extensive knowledge in the field of noise modelling and prediction, having developed many of the largest and most complex examples of proprietary noise models prepared in Ireland to date. He has extensive modelling experience in relation to wind farm, industrial and road infrastructure projects. He is a sitting member of the committee of the Irish Branch of the Institute of Acoustics.

## 11.2 Methodology

The methodology adopted for this noise impact assessment is as follows:

- Review of appropriate guidance and specification of suitable construction and operational noise / vibration criteria;
- Characterisation of the receiving noise and vibration environment;

- Characterisation of the Proposed Development;
- Prediction of the noise and vibration impact and cumulative associated with the Proposed Development, and;
- Evaluation of noise and vibration impacts and effects.

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

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

An indication of the level of some common sounds on the dB(A) scale is presented in Plate 11.1, which shows a quiet bedroom at around 35 dB(A), a nearby noisy HGV at 90 dB(A) and a pneumatic drill at about 100 dB(A).

In general, there are two quite distinct types of noise source within a wind turbine. The mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise produced by the passage of the blades through the air. Since the early 1990s there has been a significant reduction in the mechanical noise generated by wind turbines. It is now, usually less than, or of a similar level to the aerodynamic noise. Aerodynamic noise from wind turbines is generally broad-band in nature and in this respect, is similar to, for example, the noise of wind in trees.

Well-designed wind farms should be located so that increases in ambient noise levels around noise-sensitive developments are kept to acceptable levels with relation to existing background noise. This will normally be achieved through good design of the turbines and through allowing sufficient distance between the turbines and any existing noise-sensitive development so that noise from the turbines will not normally be significant.

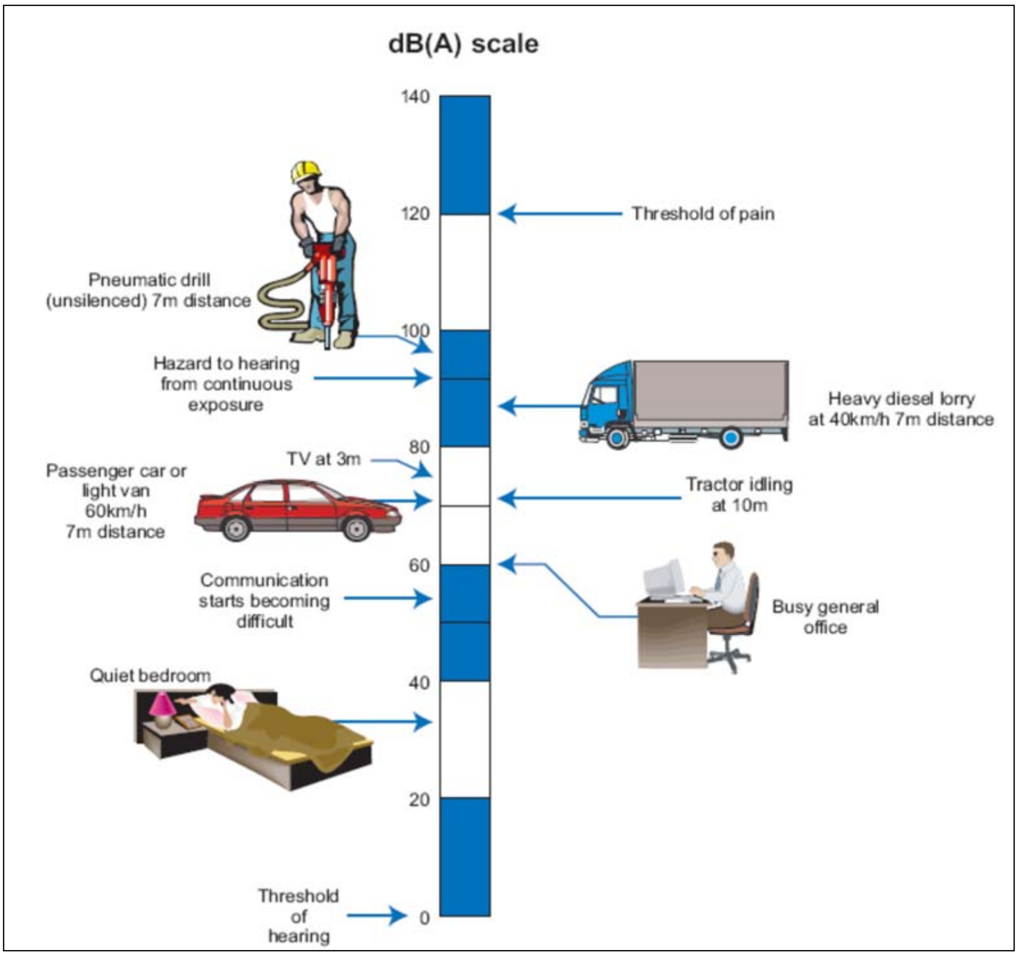


**Plate 11.1 The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)**

For a glossary of terms used in this chapter please refer to Appendix 11.1.

## 11.4 Guidance Documents and Adopted Criteria

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

### 11.4.1 Construction Phase

#### 11.4.1.1 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 *British Standard* BS 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, indicates a significant noise impact is associated with the construction activities.

Table 11.1 sets out the values which, when exceeded, potentially signify a significant effect at the facades of residential receptors 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 ($L_{Aeq,T}$) | Threshold value, in decibels (dB) | | |
|---|---|---|---|
| | Category A Note A | Category B Note B | Category C Note C |
| Night-time (23:00 to 07:00hrs) | 45 | 50 | 55 |
| Evenings and weekends Note D | 55 | 60 | 65 |
| Daytime (07:00 – 19:00hrs) and Saturdays (07:00 – 13:00hrs) | 65 | 70 | 75 |

Note A Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.
Note B Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.
Note C Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.
Note D 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

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

For the appropriate period (e.g. daytime) the ambient noise level is determined and rounded to the nearest 5dB. In this instance, with the rural nature of the site, all properties in the vicinity of the development have ambient noise levels in the range of 40 to 50 dB $L_{Aeq}$. Therefore, all properties will be afforded a Category A designation.

See Section 11.6.2 for the detailed assessment in relation to this site. If the specific construction noise level exceeds the appropriate category value (e.g. 65dB $L_{Aeq,1hr}$ during daytime periods) then a significant effect is deemed to occur.

#### 11.4.1.2 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" (1993)*; and
- *BS 5228 – "Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration" (2009).*

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. These guidelines relate to relatively modern buildings and should be reduced to 50% or less for more critical buildings.

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 such that resonances are excited within structures the limits discussed above may need to be reduced by 50%.

The NRA document *Guidelines for the Treatment of Noise and Vibration in National Road Schemes* also contains information on the permissible construction vibration levels during the construction phase as shown in Table 11.2.

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of:

**Table 11.2 Allowable 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 |

## 11.4.2 Operational Phase

### 11.4.2.1 Noise

The noise assessment summarised in the following sections has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document "*Wind Energy Development Guidelines*" 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 & 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.

**"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) outlines the appropriate noise criteria in relation wind farm developments.

The following extracts from this document should be considered:

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

While this comment is noted it should be stated that the *Wind Energy Development Guidelines* gives no specific advice in relation to what constitutes an '*appropriate balance*'. In the absence of this, guidance will be taken from alternative and appropriate publications.

> *"In the case of wind energy development, a noise sensitive location includes any occupied house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational importance. Noise limits should apply only to those areas frequently used for relaxation of*

*activities for which a quiet environment is highly desirable. Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."*

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

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

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

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

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

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

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

A level of 40dB(A) has been adopted in relation to low noise areas. This is considered appropriate in light of the following:

- The EPA document '*Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)*' proposes a daytime noise criterion of 45dB(A) in '*areas of low background noise*'. The proposed lower threshold here is 5dB more stringent than this level.
- It should be reiterated that the 2006 '*Wind Energy Development Guidelines*' calls for "*An appropriate balance must be achieved between power generation and noise impact.*" Based on a review of other national guidance in relation to acceptable noise levels in areas of low background noise it is considered that the criteria adopted as part of this assessment are robust.

In summary, the proposed operational limits in $L_{A90,10min}$ for the Proposed Development are:

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

In relation to noise sensitive properties where the owner has an interest in the development, the IOA GPG allows for the fixed limits to be increase to 45dB $L_{A90,10min}$ or 5dB(A) above background noise (whichever is higher) for both day and night time periods.

With regards to noise sensitive locations in Northern Ireland, the ETSU-R-97 Guidelines are pertinent as the "*Wind Energy Development Guidelines*" published by the Department of the Environment, Heritage and Local Government (2006) are not applicable in this jurisdiction.

Based on the baseline noise monitoring carried out and reviewed in this assessment, day and night time noise criteria curves have been derived for the development. Again, it should be noted that the lowest baseline noise levels monitored at the various monitoring locations have been used in this process in order to adopt a worst-case approach in the derivation of the noise criteria curves. Given the exceptionally low number of dwellings in the immediate vicinity of the proposed turbines, two baseline noise monitoring locations were considered robust for this assessment.

**Future Potential Guidance Changes**

Proposed changes to the assessment of noise impacts associated with on-shore wind energy developments are outlined in the Department of Environment, Community & Local Government (DECLG) document Review of the Wind Energy Guidelines 2006 "Preferred Draft Approach". It is acknowledged that his document is the subject of detailed consultation with interested parties and stakeholders. At the time of writing the document is still in draft format, therefore, in line with best practice, the core of the assessment presented in the body of this chapter is based on the guidance currently outlined in Section 5.6 of the "*Wind Energy Development Guidelines*".

**"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*" guidance document is based on the ETSU publication "*The Assessment and Rating of Noise from Wind Farms*".

Current best practice calls for the control of wind turbine noise by the application of noise limits at the nearest noise sensitive properties. It is considered that absolute noise levels applied at all wind speeds are not suited to wind turbine developments and therefore best practice is to adopt noise limits relative to background noise levels in the vicinity of the noise sensitive locations. Therefore, one critical aspect of the noise assessment of wind energy proposals relates to the identification of baseline noise levels through on site noise surveys.

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 carried out in light of guidance contained within IoA document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* and related to wind speed measurements that are collated at the site of the wind turbine development itself. Regression analysis is then applied to this data set to derive background noise levels at various wind speeds, and from this, the appropriate day and night time noise criterion curves can be established.

The 'study area' for background noise surveys and noise assessment should, as a minimum, be the area within which noise levels from the proposed, consented and existing wind turbines may exceed 35 dB $L_{A90}$ at up to 10 m/s wind speed. (Note: unless stated, in this document the wind speed reference for noise data is the 10 metre standardised wind speed, derived from the wind speed at turbine hub height.

Noise emissions associated with the wind turbine units themselves are predicted in accordance with *ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation* (1996) and again considering guidance contained within IoA document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*. 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 guidance contained within Section 5.6 of the "*Wind Energy Development Guidelines*". Where noise predictions indicate that reductions in noise emissions are required in order to satisfy any adopted criteria consideration can be given to site lay out, detailed downwind analysis and various modes of 'low noise' operation that are typically offered by modern wind turbine units.

#### 11.4.2.2 Special Characteristics

**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 *'EPA document Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)'* 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"* 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. On the subject of infrasound, the article notes:

*"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"* and it is concluded 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".*

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

If low frequency noise issues are identified, appropriate mitigation measures, including site curtailment under conditions (i.e. wind direction/speed) that give rise to the issue can be implemented where required through the turbine control system associated with the development.

**Amplitude Modulation**
In the context of this assessment, AM is defined as:

> *"Periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency (BPF) of the turbine rotor(s)."*

In this first instance it is appropriate to define AM. It is now generally accepted that there are two mechanisms which can cause amplitude modulation:

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

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

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

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

The RenewableUK AM project (RenewableUK 2013) has coined the term 'normal' AM (NAM) for this inherent characteristic of wind turbine noise, which has long been recognized 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 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.

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) '*A Method for Rating Amplitude Modulation in Wind Turbine Noise*' (August 2016). 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.

The AMWG does not 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 AM. 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.

**Comment on Sleep Disturbance/ Human Health Impacts**

<u>The National Health & Medical Research Council</u>

The relevant Australian authority on health issues, the National Health and Medical Research Council (NHMRC), conducted a review into wind farms and potential health issues in 2009, and is currently undertaking a more detailed review of the evidence[1]. A 2010 NHMRC report concluded:

> *"This review of the available evidence, including journal articles, surveys, literature reviews and government reports, supports the statement that: There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines."*

The NHMRC also released a draft information paper on wind farms and human health[2] for public consultation in early 2014. The paper summarised the evidence on whether wind farms cause health effects in humans, and provided an overview of the process by which the evidence was identified, critically appraised and interpreted by the reference group.

That information paper also found that:

> *"There is no reliable or consistent evidence that wind farms directly cause adverse health effects in humans."*

*<u>Health Canada</u>*

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014[3]. The study was initiated

1 National Health and Medical Research Council, 2014, Wind Farms and human health. Available at https://www.nhmrc.gov.au/your-health/wind-farms-and-human-health.

2 National Health and Medical Research Council, 2014, NHMRC Draft Information Paper: Evidence on Wind Farms and Human Health Available https://consultations.nhmrc.gov.au/public_consultations/wind_farms

3 Health Canada 2014, Wind Turbine Noise and Health Study: Summary of Results. Available at http://www.hc-sc.gc.ca/ewh-semt/noisebruit/turbine-eoliennes/summary-resume-eng.php

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 being annoyed.

New South Wales Health Department

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

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

Victorian Department of Health

The Victorian Department of Health released two booklets on wind farms, sound and health in May 2013[4]. One focused on technical information about the nature of sound and the other contained community information.

The community information booklet concluded that:

> *"The evidence indicates that sound can only affect health at sound levels that are loud enough to be easily audible. This means that if you cannot hear a sound, there is no known way that it can affect health. This is true regardless of the frequency of the sound."*

South Australian EPA Infrasound Study

A report released in January 2013 by the South Australian Environment Protection Authority (EPA)[5] found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

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

4 Department of Health, Victoria, 2013, http://www.health.vic.gov.au/environment/windfarms.htm

5 EPA South Australia, 2013, Wind farms http://www.epa.sa.gov.au/environmental_info/noise/wind_farms

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."*

The Australian Medical Association

The Australian Medical Association put out a position statement on Wind Farms and Health in 2014[6]. 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."*

Massachusetts Institute of Technology (MIT)

MIT released a critical review of the scientific literature in December 2014[7]. The review took into consideration health effects such as stress, annoyance and sleep disturbance, as well as other effects that have been raised in association with living close to wind turbines. The study found that:

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

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

## 11.5 Receiving Environment

This stage of the assessment was to determine typical background noise levels in the vicinity of the noise sensitive locations in closest proximity to the development site. This was done through installing unattended sound level meters at two representative locations in the surrounding area for approximately a two-week period. The survey was carried out over two phases i.e. approximately two-weeks monitoring at each location.

### 11.5.1 Choice of Measurement Locations

The noise monitoring locations were identified by preparing a preliminary noise contour at an early stage of the assessment. The selection of monitoring locations was supplemented by reviewing aerial images of the study area and other online sources of information (e.g. Google Earth) and verified on the ground.

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

7 Journal of Occupational and Environmental Medicine, 2014, Wind Turbines and Health: A Critical Review of the Scientific Literature.

The IoA GPG recommends that the study area for the background noise surveys and noise assessment should, as a minimum, be the area within which noise levels from the proposed, consented and existing wind turbines may exceed 35 dB $L_{A90}$.

The selected locations for the noise monitoring are outlined in the following sections and are identified in Figure 11.1. Figure 11.2 and Figure 11.3 provide specific details of the noise monitoring installations. Coordinates for the noise monitoring locations and met mast location are detailed in Table 11.3.

**Table 11.3 Measurement Location Coordinates**

| Location | Coordinates - Irish Grid (IG) | |
|---|---|---|
| | Easting | Northing |
| A (R256) | 209,738 | 387,814 |
| B (R255) | 209,897 | 387,720 |
| Met Mast (ID 6071) | 206,857 | 385,326 |

**Figure 11.2 Location A (R256) Installation**

**Figure 11.3 Location B (R255) Installation**

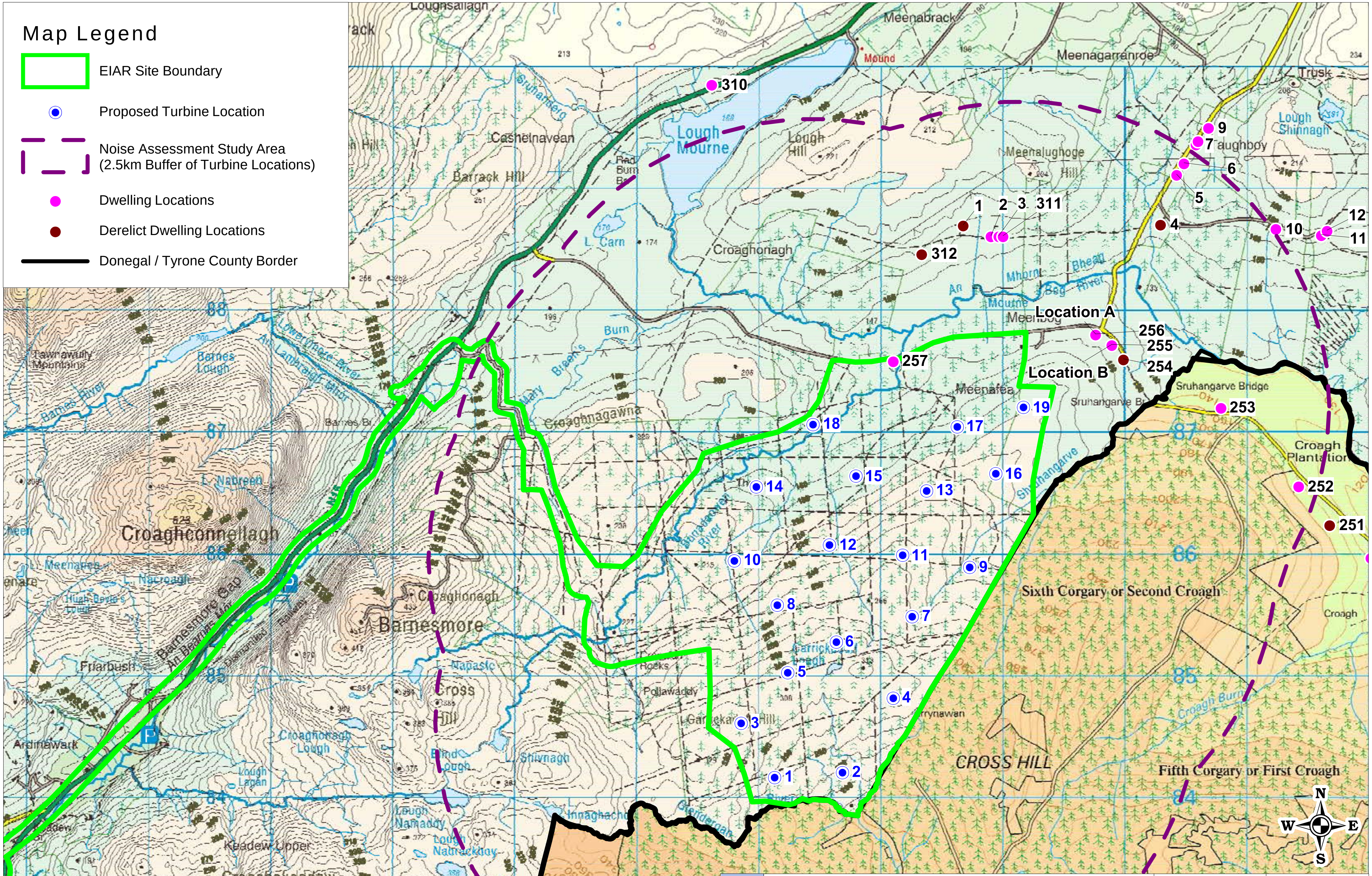
Noise sources were noted to be local road traffic distant farm machinery and activity, distant road traffic noise and noise in local foliage was not contributing much to the background noise. Wind turbine noise from existing developments was not audible at any of the locations during periods when engineers were on site. It is considered that the background noise monitoring location give a robust picture of background noise levels experienced at typical residential noise sensitive locations in the vicinity of the site.

### 11.5.2 Measurement Periods

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

**Table 11.4 Noise Measurement Periods**

| Location | Start Date | End Date |
|---|---|---|
| A (R256) | 13:50hrs 15th October 2014 | 16:10hrs 31st October 2014 |
| B (R255) | 16:50hrs 31st October 2014 | 13:50hrs 18th November 2014 |




MAP TITLE: Noise Monitoring Locations and Study Area | MAP NO.: Figure 11.1 | SCALE: 1:40,000

PROJECT TITLE: 160502 - Meenbog Wind Farm, Co. Donegal | DATE: 20-11-2017

DRAWING BY: Eoin McCarthy | CHECKED BY: Michael Watson | ISSUE NO.: 160502-2017.11.20-F

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A sufficient variety of wind speed and weather conditions were encountered over the survey periods in question. Figure 11.4 and Figure 11.5 illustrations the distributions of wind speed and wind direction over each of the monitoring phases detailed in Table 11.4.

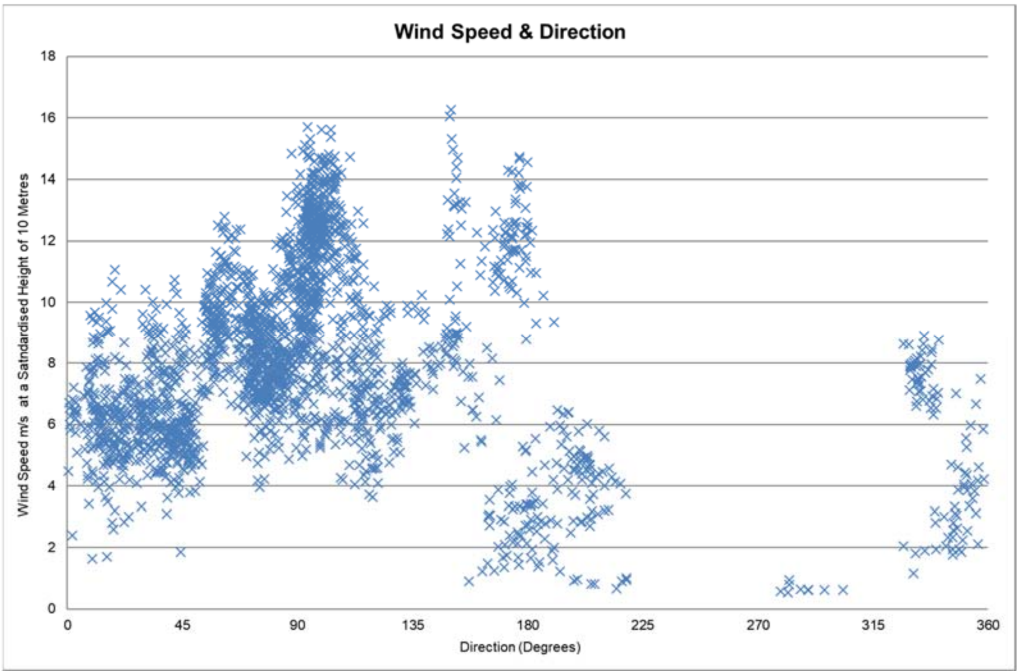



**Figure 11.4** **Distributions of Wind Speeds & Direction during Monitoring Phase 1**

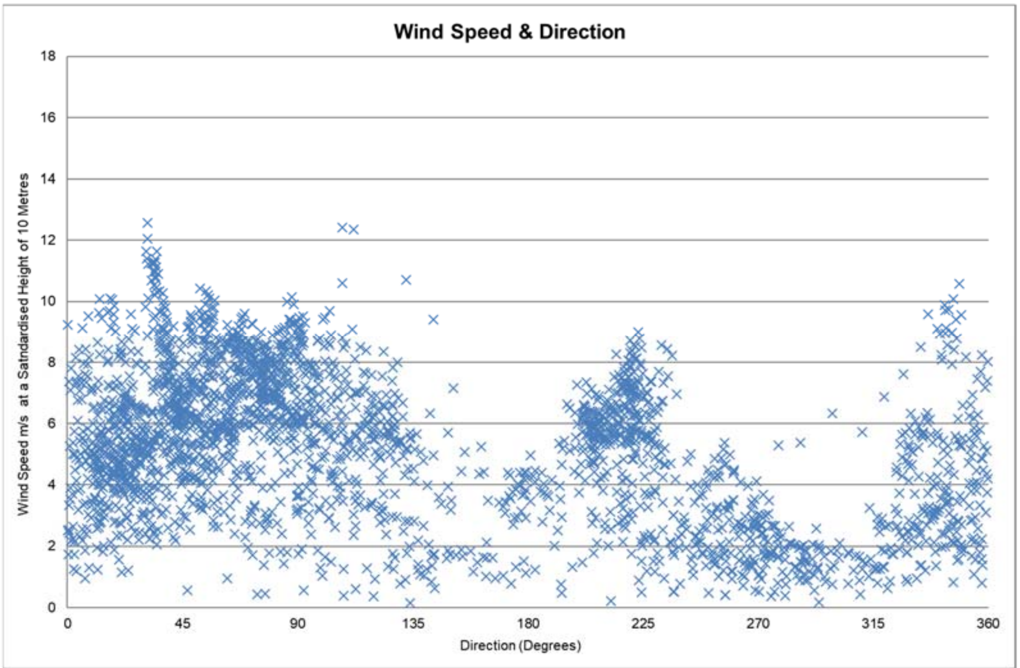



**Figure 11.5** **Distributions of Wind Speeds & Direction during Monitoring Phase 2**

### 11.5.3 Personnel and Instrumentation

AWN Consulting installed and removed the noise monitors at all locations. The following instrumentation was used at the various locations:

**Table 11.5 Instrumentation**

| Location | Equipment | Serial Number |
|---|---|---|
| A (R256) | Brüel & Kjær Type 2238 | 2246196 |
| B (R255) | Brüel & Kjær Type 2238 | 2246196 |

Before and after each phase of the monitoring survey noise measurement equipment was check calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator. A copy of the relevant calibration certification for the instrument is presented in Appendix 11.2.

Rain fall was monitored and logged using a Texas Electronics Rainfall Sensor, Model TR 525. This allows for the identification of periods of rain fall to allow for the removal sample periods affect by rainfall from the noise monitoring data sets in line with best practice when calculating the prevailing background noise levels. The rain fall monitor was located in the vicinity of the site for the duration of the survey.

Wind speed and directional data was obtained from the existing met mast, located in the townland of Meenbog, for the survey periods (Met Mast ID 6071). The Meenbog met mast consist of various anemometers at 80m, 65m 50m 35m and 10m heights.

### 11.5.4 Procedure

Measurements were conducted at the two locations over the survey periods. Sample periods for the noise measurements were 10-minutes during both the daytime and night-time periods. The results were saved to the instrument memory for later analysis. Survey personnel noted potential primary noise sources contributing to noise build-up during the installation and removal of the sound level meters from site (e.g. identified significant noise sources in the area such as local traffic or farm yard activities). $L_{Aeq,10min}$ and $L_{A90,10min}$ parameters were measured in this instance.

### 11.5.5 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 following relevant guidance as outlined in the IoA document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine.*

As the highest anemometer on the Meenbog met mast was 80m, 'Method B' as outlined in the IoA GPG was used to calculate a hub height (98m) wind speed based on the exponent profile or wind shear profile calculated between the measured wind speeds at 80m and 65m. The IoA states the following in relation to this:

> "*A meaningful extrapolation should be undertaken, and this would be achieved with the upper anemometer being at a height not less than 60% of the hub height of the proposed turbine and the lower anemometer at least 15 metres below it. Within those requirements, the two measurement heights closest to the hub height should be used.*"

This has been done using the following equation:

*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 IoA GPG presents the following equations in relation to the derivation of a standardised wind speed at 10m above ground level from hub height (HH):

*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.

### 11.5.6 Results

The results of the background noise monitoring programme are extensive in nature. The raw data sets are not included in this document but are kept on file, along with the measured and derived[8] wind speeds for the survey period.

Note that for the data tables presented in the following sections all noise data obtained during the survey has been reviewed however, for the statistical analysis on which the noise criteria are based, reference is made to noise data collated during '*quiet periods*' of the day and night as defined in the *ETSU*[9] document. This definition is as follows:

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

---

8 Derived to a height of 10m above ground based on guidance contained within Institute of Acoustics Acoustic Bulletin Technical Contribution "*Prediction and Assessment of Wind Turbine Noise – Agreement about Relevant Factors for Noise Assessment for Wind Energy Projects*" (dated March/April 2009)

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

The ETSU document outlines the rationale as to why the use of the $L_{A90}$ parameter for the assessment of wind turbine sites is preferred over the $L_{Aeq}$ parameter. These should be noted in the view of the $L_{Aeq}$ data sets presented and commented upon in this report. It states the following:

> *"experience in the field when performing such measurements indicates that short, transitory noise events can significantly change the $L_{Aeq}$. These events are not related to the noise emitted by the wind farm. These transitory noise events can be sources such as low flying aircraft, bird song, animal noises, cars, wind effects on microphone, etc.*
>
> *Measurements performed in rural areas indicate that the ambient $L_{Aeq}$ noise levels may be 5 – 25dB(A) above the $L_{90}$ background levels due to these transitory events. Therefore, when performing noise measurements for the assessment of compliance with planning conditions or obligations, confusion can occur due to the $L_{Aeq}$ being significantly higher than the $L_{90}$ background noise level due to noise sources not associated with the wind farm.*
>
> *The Noise Working Group is agreed that the $L_{A90(10\ minutes)}$ descriptor should be used for both the background noise and the wind farm noise and that when setting limits, it should be borne in mind that the $L_{A90(10\ minutes)}$ from the wind farm is likely to be 1.5 – 2.5dB(A) less than the $L_{Aeq}$ measured over the same period".*

#### 11.5.6.1 Location A (256)

##### *11.5.6.1.1 Daytime Period*

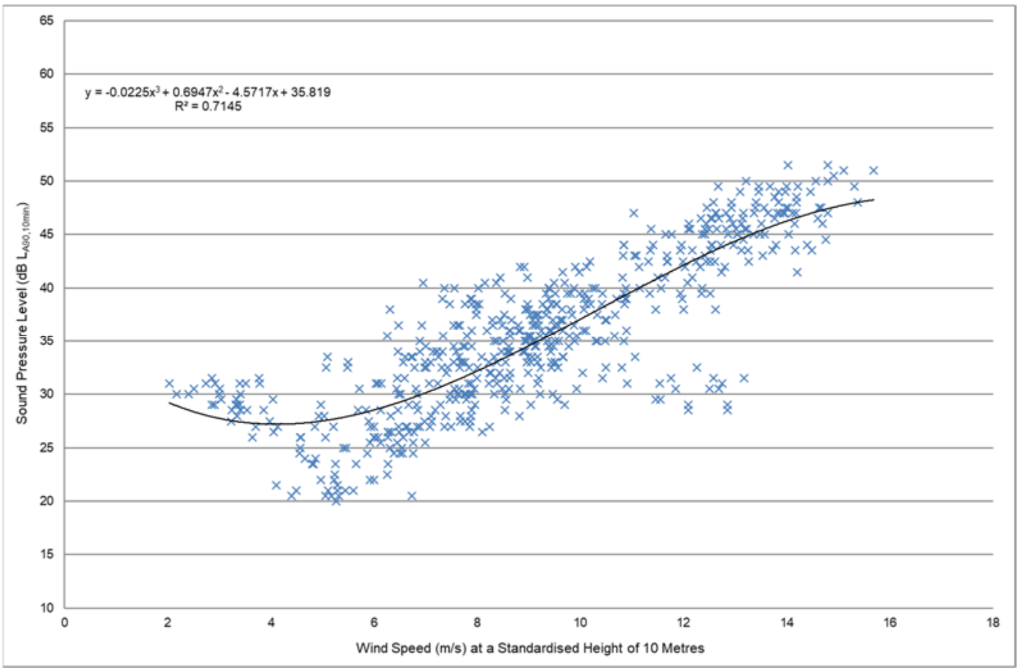



**Figure 11.6 Baseline Noise Levels $L_{A90,\ 10\ min}$ dB – Location A – Daytime Period**

#### *11.5.6.1.2 Night Time*

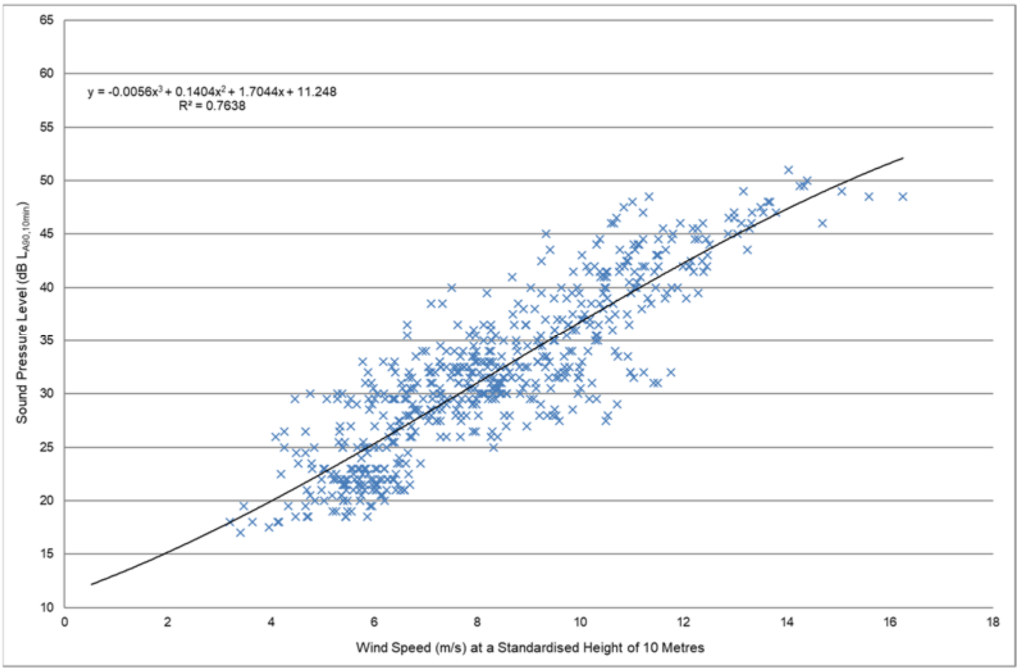



**Figure 11.7 Baseline Noise Levels $L_{A90,\ 10\ min}$ dB – Location A – Night Time**

### 11.5.6.2 Location B (255)

#### *11.5.6.2.1 Daytime Period*

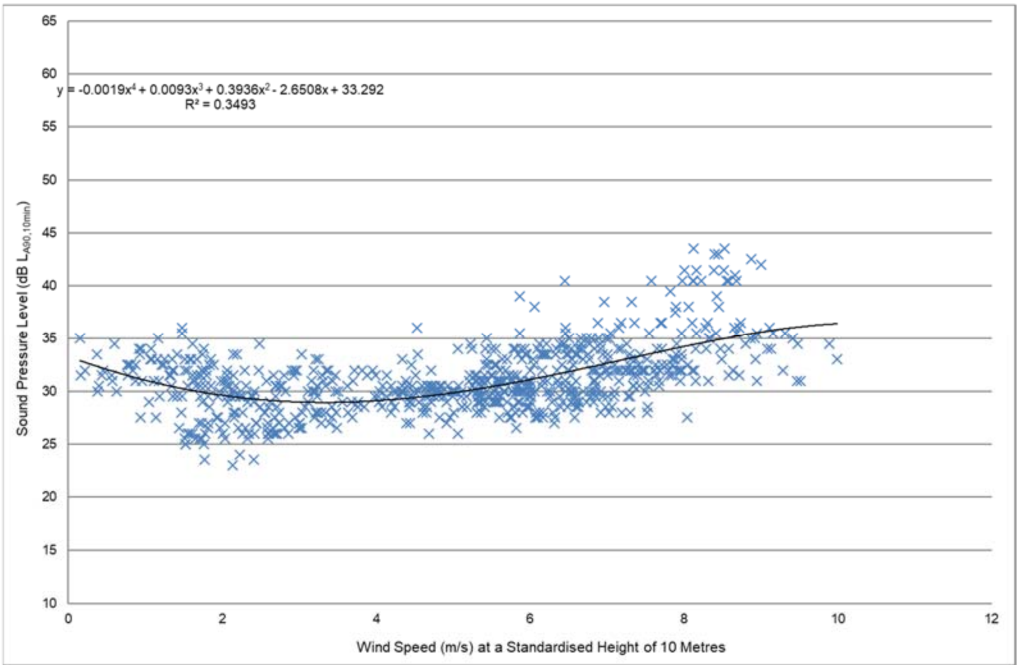



**Figure 11.8 Baseline Noise Levels $L_{A90,\ 10\ min}$ dB – Location B – Daytime Period**

##### *11.5.6.2.2 Night Time*

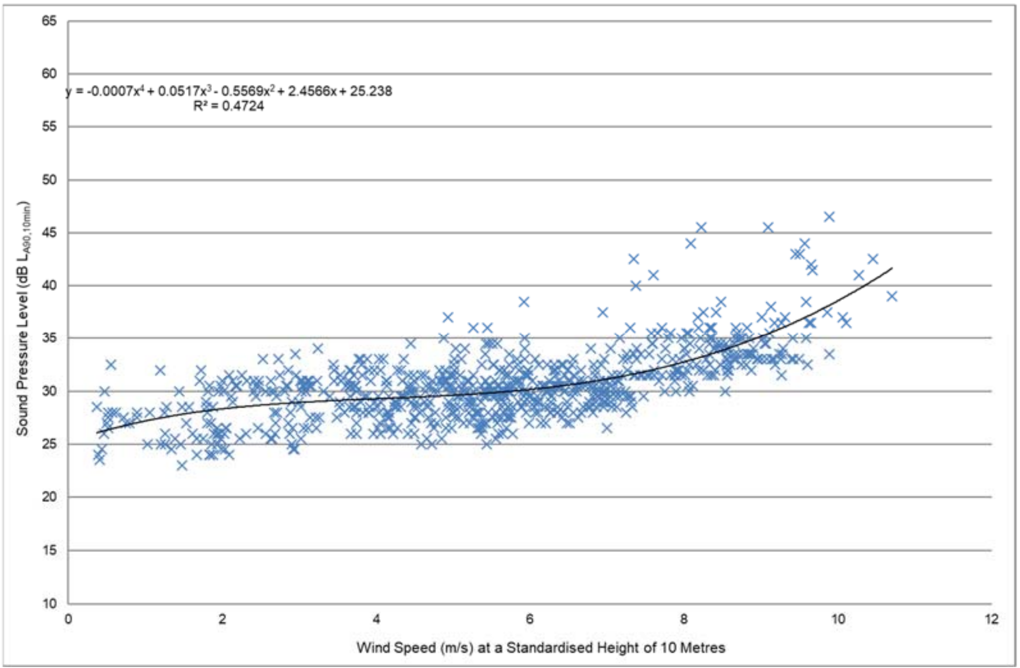



**Figure 11.9 Baseline Noise Levels $L_{A90,\ 10\ min}$ dB – Location B – Night Time**

#### 11.5.6.3 Summary

Table 11.6 presents the various derived $L_{A90,10min}$ noise levels for each of the monitoring locations for daytime quiet periods and night time periods. These levels have been derived using regression analysis carried out on the data sets in line with best practice guidance.

**Table 11.6 Derived Levels of $L_{A90,\ 10\ min}$ for Various Wind Speeds**

| Location | Period | Derived $L_{A90,\ 10\ min}$ Levels (dB) at various Standaridsed10m Height Above Ground Wind Speed (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| A (H256) | Day | 27.2 | 27.5 | 28.5 | 30.1 | 32.2 | 34.5 | 37.1 |
| | Night | 20.0 | 22.6 | 25.3 | 28.1 | 31.0 | 33.9 | 36.7 |
| B (H255) | Day | 29.1 | 29.9 | 31.1 | 32.7 | 34.3 | 35.6 | 36.4 |
| | Night | 29.3 | 29.6 | 30.2 | 31.2 | 32.9 | 35.3 | 38.8 |
| Envelope | Day | 27.2 | 27.5 | 28.5 | 30.1 | 32.2 | 34.5 | 36.4 |
| | Night | 20.0 | 22.6 | 25.3 | 28.1 | 31.0 | 33.9 | 36.7 |

A worst-case envelope based on the lowest average levels at the various wind speeds has been presented in Table 11.6. The noise criteria curves for this assessment will be based on this baseline noise envelope. This is considered a worst-case approach to this aspect of the assessment.

## 11.6 Likely Significant Effects and Associated Mitigation Measures

### 11.6.1 Do-Nothing Scenario

If the development is not progressed the existing noise environment in the vicinity of the site and noise sensitive receivers will remain largely unchanged.

## 11.6.2 Construction Phase

### 11.6.2.1 General Construction Noise

A variety of items of plant will be in use for the purposes of site preparation, construction of turbines substation and 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.

Due to the fact that the construction programme has been established in outline form only, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels using guidance set out in British Standard *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise*. In this instance, the noise-sensitive locations surrounding the site are located at varying distances with the closest occupied dwelling located approximately 750 metres to the nearest proposed turbine location (i.e. Location H257 from proposed turbine T17). Several indicative sources that would be expected on a site of this nature have been identified and noise predictions of their potential impacts prepared to nearby houses. The assessment is considered representative of a worst-case scenario, with construction noise at slightly lower levels at properties at a further distance from the works.

Table 11.7 outlines the noise levels associated with typical construction noise sources assessed in this instance along with typical sound pressure levels and spectra from BS 5228 – 1: 2009. The predicted noise levels from construction activities are in the range of 28 to 45dB $L_{Aeq,1hr}$ at these locations with a cumulative level of the order of 47dB $L_{Aeq,1hr}$.

In all instances, the predicted noise levels are below the appropriate Category A value (i.e. 65dB $L_{Aeq,1hr}$) and therefore a potential significant effect is not predicted in relation to the nearest noise sensitive locations in terms of construction noise.

Note that the predicted noise levels referred to in this section are indicative only and are intended to demonstrate that it will be possible for the contractor to comply with current best practice guidance. 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 the majority of the time at the majority of properties in the vicinity of the Proposed Development.

There are no items of plant that would be expected to give rise to noise levels that would be considered out of the ordinary or in exceedance of the levels outlined in Table 11.7.

**Table 11.7 Typical Wind Farm Turbine Construction Noise Emission Levels**

| Item (BS 5228 Ref.) | Activity/Notes | Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [10] | Predicted Noise Level at 750m (dB $L_{Aeq,1hr}$) |
|---|---|---|---|
| HGV Movement (C.2.30) | Removing spoil and transporting fill and other materials. | 79 | 35 |
| Tracked Excavator (C.4.64) | Removing soil and rubble in preparation for foundation. | 77 | 33 |
| Piling Operations (C.12.14) | Standard pile driving. | 88 | 45 |
| General Construction (Various) | All general activities plus deliveries of materials and plant. | 70 – 84 | 28 |
| Dewatering Pumps (D.7.70) | If required. | 80 | 37 |
| JCB (D.8.13) | For services, drainage and landscaping. | 82 | 39 |
| Vibrating Rollers (D.8.29) | Road surfacing. | 77 | 34 |
| **Total Construction Noise (cumulative for all activities)** | | | 47 |

Due to the distance of the proposed works from sensitive locations significant vibration impacts are not expected. It is noted that the option of piling is proposed in relation to turbine foundations however considering the distance between these construction activities and nearby noise sensitive locations vibration from these activities would not be perceptible and would be orders of magnitude below levels where cosmetic or structural damage would be expected.

In terms of these construction activities, the associated effect is:

| *Quality* | *Significance* | *Duration* |
|---|---|---|
| Negative | slight | Temporary |

#### 11.6.2.2 Haul Routes

This section has been prepared in order to review potential noise impacts associated with construction traffic on the local road network. Chapter 14 of this EIAR presents an assessment of traffic and transportation and reference has been made to this chapter to inform the following discussion. The following situations are commented upon here:

- Stage 1a – Concrete pouring;
- Stage 1b - Site preparation and groundworks;
- Stage 2a – Turbine Delivery
- Stage 2b – Other deliveries

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

Changes in traffic noise levels along the N15 road have been estimated and are commented upon. The following assumptions have been made in relation to the calculation of changes in traffic noise levels on the local road network due to the additional construction traffic volumes:

**Table 11.8 Assumptions for Construction Traffic Noise Assessment**

| Route | Stage | Traffic Units | %HGV |
|---|---|---|---|
| N15 between Ballybofey and Donegal | Existing | 7,146 | 5.8 |
| | 1a | 7,518 | 9.5 |
| | 1b | 7,230 | 5.9 |
| | 2a | 7,291 | 7.1 |
| | 2b | 7,206 | 6.0 |

Based on the assumptions presented above changes in noise level based on the existing flows have been estimated as presented in Table 11.9:

**Table 11.9 Estimated Changes in Traffic Noise Levels**

| Route | Stage | Change in Traffic Noise Level dB(A) | Estimated No. of Days |
|---|---|---|---|
| N15 between Ballybofey and Donegal | Existing | -- | -- |
| | 1a | +1 | 19 |
| | 1b | <1 | 363 |
| | 2a | <1 | 34 |
| | 2b | <1 | 19 |

The works programme for Stage 1a is expected to last approximately 19 days and therefore any effects are temporary. The increase in noise level along the delivery route due to additional construction traffic is predicted to be 1dB, which is considered to have a neutral effect as an increase of this order of magnitude would be imperceptible.

In relation to the other stages the same conclusion is reached, the increase in noise level along the delivery route due to additional construction traffic is considered to have a neutral effect as an increase of this order of magnitude would be imperceptible. This is due to the fact that the additional construction traffic is a small percentage of the existing traffic volumes on the road.

#### 11.6.2.3 Borrow Pits

In order to inform this aspect a comparative noise assessment has been prepared and is outlined in the following paragraphs. Two situations for breaking out material in the borrow pit are proposed and have been considered as follows:

- Scenario A: Blasting operations
- Scenario B: Rock breaking operations

In terms of these activities please note the following:

- A mobile crusher will operate on site for both options.
- In Scenario B at least one rock breaker will be in use on site during daytime periods for an estimated three-month period. For the purposes of this assessment we have assumed that two rock breakers will be utilised.

- The rock breaker will move to various locations on the site. For the purposes of this assessment we have assumed the plant is working in the vicinity of each of the proposed borrow pit locations as indicated in 10.
- 11 outlines the assumed noise levels for the plant items as extracted from the British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.
- If the blasting option is undertaken, it is estimated that some 8 to 12 blasts will be required over a 3 to 4-week period at any one borrow pit location. It is expected that no more than 1 blast event would occur in a single working day.

**Table 11.10 Proposed Borrow Pit Plant Locations**

| Borrow Pit ID | Co – Ordinates | |
|---|---|---|
| | Easting | Northing |
| BUR1 | 207,386 | 385,155 |
| BUR2 | 207,738 | 386,362 |
| BUR3 | 208,619 | 386,534 |

**Table 11.11 Typical Construction Plant Noise Levels**

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

A construction noise model has been prepared to consider the expected noise emissions from the proposed construction works for the two scenarios outlined above. The predicted levels are detailed in Table 11.12to Table 11.14 at the noise sensitive locations identified within the study area. A percentage on-time of 100% has been assumed per hour. This represents a worst-case scenario. Each of the three borrow pit locations proposed for the site have been assessed in order to demonstrate the likely noise impacts associated with this aspect of the development.

Review of the predicted noise data confirms the following:

- Predicted construction noise levels for both Scenario A and B at the borrow pit are well within the best practice construction noise criteria outlined in Table 11.1 It is assumed that construction works at the borrow pits will only occur during daytime periods only (07:00 to 19:00hrs).
- The blasting proposal results in lower levels of construction noise due to the fact that the use of the rock breaking plant is not required in this instance. Predicted noise levels are lower at all assessed locations for Scenario A. Predicted levels of some 7 to 9dB(A) lower at the various locations assessed.
- It is accepted that the individual blast events will be audible at certain locations. Blast events will be designed and controlled such that the best practice limits values outlined in the mitigation section of this chapter are not exceeded.

**Table 11.12 Comparison of Predicted Borrow Noise Levels - Borrow Pit 1**

| Location | Predicted Construction Noise Level dB $L_{Aeq,1hr}$ | | Diff. dB(A) |
|---|---|---|---|
| | Scenario A | Scenario B | |
| H001 | 22 | 31 | -10 |
| H002 | 22 | 31 | -10 |
| H003 | 22 | 31 | -10 |
| H004 | 19 | 28 | -9 |
| H005 | 18 | 27 | -9 |
| H006 | 18 | 26 | -8 |
| H252 | 13 | 23 | -10 |
| H253 | 14 | 24 | -10 |
| H254 | 16 | 26 | -10 |
| H255 | 16 | 26 | -10 |
| H256 | 16 | 26 | -10 |
| H257 | 27 | 38 | -11 |
| H311 | 22 | 31 | -10 |
| H312 | 23 | 33 | -10 |

**Table 11.13 Comparison of Predicted Borrow Noise Levels - Borrow Pit 2**

| Location | Predicted Construction Noise Level dB $L_{Aeq,1hr}$ | | Diff. dB(A) |
|---|---|---|---|
| | Scenario A | Scenario B | |
| H001 | 28 | 39 | -11 |
| H002 | 28 | 39 | -11 |
| H003 | 28 | 38 | -11 |
| H004 | 23 | 34 | -10 |
| H005 | 22 | 32 | -10 |
| H006 | 22 | 31 | -10 |
| H252 | 15 | 25 | -10 |
| H253 | 17 | 28 | -11 |
| H254 | 20 | 31 | -11 |
| H255 | 20 | 31 | -11 |
| H256 | 21 | 32 | -11 |
| H257 | 36 | 48 | -12 |
| H311 | 27 | 38 | -11 |
| H312 | 30 | 41 | -11 |

**Table 11.14 Comparison of Predicted Borrow Noise Levels - Borrow Pit 3**

| Location | Predicted Construction Noise Level dB $L_{Aeq,1hr}$ | | Diff. dB(A) |
|---|---|---|---|
| | Scenario A | Scenario B | |
| H001 | 29 | 40 | -11 |
| H002 | 29 | 40 | -11 |
| H003 | 29 | 40 | -11 |
| H004 | 26 | 37 | -11 |
| H005 | 24 | 34 | -10 |
| H006 | 24 | 34 | -10 |
| H252 | 19 | 30 | -11 |

| Location | Predicted Construction Noise Level dB $L_{Aeq,1hr}$ | | Diff. dB(A) |
|---|---|---|---|
| | Scenario A | Scenario B | |
| H253 | 21 | 33 | -11 |
| H254 | 24 | 36 | -12 |
| H255 | 24 | 36 | -12 |
| H256 | 25 | 36 | -12 |
| H257 | 36 | 47 | -12 |
| H311 | 29 | 40 | -11 |
| H312 | 30 | 41 | -11 |

In terms of the borrow pit activities, the potential worst-case effects are:

| *Quality* | *Significance* | *Duration* |
|---|---|---|
| Negative | Slight | Temporary |

#### 11.6.2.4 Substation

A variety of items of plant will be used for construction of the substation. As previously stated, due to the fact that the construction programme has been established in outline form only, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels using guidance set out in British Standard *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise*.

The distance between the nearest noise-sensitive locations and the proposed substation is approximately 3km (H257). Therefore, it is expected that the noise levels from construction activities associated with the substation will be in the order of 32dB $L_{Aeq,1hr}$ at Location H257 i.e. the nearest noise sensitive location. This level of noise is significantly below the construction noise criterion outlined in Table 11.7.

In terms of the substation construction, the potential effects are:

| *Quality* | *Significance* | *Duration* |
|---|---|---|
| Neutral | Not significant | Temporary |

#### 11.6.2.5 Grid Connection

The underground cable required to facilitate grid connection will mainly be laid beneath the surface of site and/or public roads. The full description of the grid connection arrangement for the Proposed Development is outlined in Section 4.3.7 of the EIAR. Construction activities will be carried out during normal daytime working hours (i.e. weekdays 0700 – 1900hrs and Saturdays 0700 – 1300hrs).

Construction noise predictions have been carried out using guidance set out in British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.

Table 11.15 outlines the noise levels associated with typical construction noise sources assessed in this instance along with typical sound pressure levels and spectra from BS 5228 – 1: 2009+A1:2014 at various distances from these works.

**Table 11.15 Indicative Noise Levels from Construction Plant at Various Distances from the Grid Connection Works**

| Item (BS 5228 Ref.) | Highest Predicted Noise Level at Stated Distance from Edge of Works (dB $L_{Aeq,1hr}$) | | | |
|---|---|---|---|---|
| | 20m | 40m | 60m | 100m |
| Pneumatic breaker (C.8.12) | 65 | 59 | 55 | 51 |
| Wheeled loader (C.3.51)* | 62 | 56 | 52 | 48 |
| Tracked excavator (C.3.43)* | 63 | 57 | 53 | 49 |
| Dozer (C.3.30)* | 64 | 58 | 54 | 50 |
| Dump truck (C.3.60)* | 60 | 54 | 50 | 46 |
| Compressor (C.7.27) | 61 | 55 | 51 | 47 |
| Road Roller (C.3.114) | 65 | 59 | 55 | 51 |
| HGV Movements (10 per hour) | 53 | 50 | 49 | 46 |

*Note ** Assume noise control measures as outlined in Table B1 of BS 5228 – 1 (i.e. fit acoustic exhaust).

The noise levels presented are within the potential significant noise impact values (i.e. 65dB $L_{Aeq,1hr}$) as outlined in Table 11.1, for daytime periods on weekdays, at distances of 20m or greater from the works. Where a noise sensitive location is within 20m of works detailed consideration to potential construction noise impacts will be required and appropriate mitigation measures implemented in order to manage associated impacts. Typical mitigation measures that can be considered are outlined in the mitigation section of this document with further guidance contained within the BS 5228 standards. It should be noted that these works will progress along the route and it is envisioned that would be carried out and completed in the vicinity of a property in 2 to 3 days.

At distances greater than 20m from the works the total predicted noise levels are predicted to be of the order of or below the 65dB $L_{Aeq,1hr}$ construction noise criterion for potential significant impacts adopted here and therefore a potential significant effect is not predicted in relation to the nearest noise sensitive locations in terms of this aspect of potential construction noise.

| *Quality* | *Significance* | *Duration* |
|---|---|---|
| Negative | Moderate | Temporary |

### 11.6.2.6 Construction Phase General Mitigation Measures

With regard to construction activities, reference will be made to British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*, which offers detailed guidance on the control of noise & vibration from demolition and construction activities. In particular, it is proposed that various practices be adopted during construction, including:

- 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.

#### 11.6.2.7 Mitigation Measures – Noise

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 considered, where necessary, to ensure compliance with the relevant construction noise criteria:

- No plant used on site will be permitted to cause an on-going public nuisance due to noise.
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract.
- Compressors will be attenuated models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.
- Any plant, such as generators or pumps, which is required to operate before 07:00hrs or after 19:00hrs will be surrounded by an acoustic enclosure or portable screen.
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Table 11.1 using methods outlined in British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 7:00hrs and 19:00hrs weekdays and between 7:00hrs and 19:00hrs on Saturdays. However, to ensure that optimal use is made of good weather period or at critical periods within the programme (i.e. concrete pours) it could occasionally be necessary to work out of these hours. Any such out of hours working would be agreed in advance with the local planning authority.

Where rock breaking is employed in relation to the proposed borrow pits locations, the following are examples of measures that will be considered, where necessary, to mitigate noise emissions from these activities:

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

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

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

The methods used to minimise complaints could consist of some or all of the following:

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

#### 11.6.2.8 Mitigation Measures – Vibration

It is recommended that vibration from construction activities be limited to the values set out in Table 11.2. It should be noted that these limits are not absolute, but provide guidance as to magnitudes of vibration that are very unlikely to cause cosmetic damage. Magnitudes of vibration slightly greater than those in the table are normally unlikely to cause cosmetic damage, but construction work creating such magnitudes should proceed with caution. Where there is existing damage these limits may need to be reduced by up to 50%.

With regards to piling it is considered that, taking into account the large distances between locations where piling will take place and the nearest noise sensitive locations, no significant impact will be experienced. Therefore, no mitigation measures are proposed.

Specific to blasting the following mitigation measures will be employed to control the impact during blasts:

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

### 11.6.3 Operational Phase

#### 11.6.3.1 Noise Model

A series of computer-based prediction models have been prepared in order to predict the noise level associated with the operational phase of the Proposed Development. This section discusses the methodology behind the noise modelling process and presents the results of the modelling exercise.

#### 11.6.3.2 Brüel & Kjaer Type 7810 Predictor

Proprietary noise calculation software was used for the purposes of this impact assessment. The selected software, Brüel & Kjær Type 7810 *Predictor*, calculates noise levels in accordance with ISO 9613*: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation, 1996*.

Brüel & Kjær Type 7810 *Predictor* is a proprietary noise calculation package for computing noise levels in the vicinity of noise sources. *Predictor* calculates noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated taking into account 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).

#### 11.6.3.3 Input Data and Assumptions

Contour and information available for the site has been inputted into our Brüel & Kjaer Type 7810 Predictor noise modelling software using the ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors: General method of calculation*. The proposal in question considers the construction of 19 No. turbine units on the site as detailed in Chapter 4 of this EIAR.

#### *11.6.3.3.1 Proposed Turbine Details*

Table 11.16 details the co-ordinates of the turbines that are being considered as part of this assessment.

**Table 11-16 Turbine Co-Ordinates**

| Ref. | Co-ordinates IG | | Ref. | Co-ordinates IG | |
|---|---|---|---|---|---|
| | Easting | Northing | | Easting | Northing |
| T01 | 207,133 | 384,174 | T11 | 208,183 | 385,999 |
| T02 | 207,689 | 384,214 | T12 | 207,583 | 386,083 |
| T03 | 206,859 | 384,619 | T13 | 208,379 | 386,526 |
| T04 | 208,106 | 384,825 | T14 | 206,983 | 386,559 |
| T05 | 207,241 | 385,034 | T15 | 207,800 | 386,648 |
| T06 | 207,639 | 385,286 | T16 | 208,946 | 386,668 |
| T07 | 208,261 | 385,494 | T17 | 208,631 | 387,051 |
| T08 | 207,155 | 385,589 | T18 | 207,448 | 387,070 |
| T09 | 208,732 | 385,899 | T19 | 209,173 | 387,212 |
| T10 | 206,803 | 385,952 | -- | -- | -- |

The following sections detail the noise spectra used for modelling purposes for various potential turbine units under consideration.

For the purposes of this assessment, consideration has been given to the number of potential turbine technologies. 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. Regardless of the make or model of the turbine eventually selected for installation on site, the noise it shall give rise to should be of no greater significance than that used for the purposes of this assessment, to ensure the required noise limits are achieved at all noise sensitive locations.

Sound power levels ($L_{WA}$) have been supplied for a number of potential turbine units under consideration. Based on the sound power data provided, an assessment envelope has been derived to identify the worst-case potential source noise spectra emissions of the turbine units. For the purposes of this assessment, predictions have assumed a turbine HH of 98m.

Table 11.17 details the noise spectra used for noise modelling purposes for the proposed Carrickaduff development. As outlined, appropriate guidance is couched in terms of a $L_{A90,10mim}$ criterion. The provided turbine noise data, in terms of $L_{Aeq}$, has been adjusted by subtracting 2dB to give a representative $L_{A90}$ as outlined in best practice guidance for the purposes of the data inputted into the developed noise model:

> *"The Noise Working Group is agreed that the $L_{A90(10\ minutes)}$ descriptor should be used for both the background noise and the wind farm noise and that when setting limits, it should be borne in mind that the $L_{A90(10\ minutes)}$ from the wind farm is likely to be 1.5 – 2.5dB(A) less than the $L_{Aeq}$ measured over the same period."*

**Table 11-17 $L_{WA}$ Spectra Used for Prediction Model – Meenbog Turbines**

| Wind Speed (m/s) | Octave Band Centre Frequencies (Hz) | | | | | | | | dB $L_{WA}$ |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| 4 | 78.4 | 86.0 | 89.8 | 89.8 | 88.7 | 88.6 | 86.0 | 75.9 | 96.3 |

| Wind Speed (m/s) | Octave Band Centre Frequencies (Hz) | | | | | | | | dB $L_{WA}$ |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| 5 | 82.9 | 90.4 | 94.0 | 94.5 | 94.1 | 93.1 | 90.0 | 79.5 | 100.9 |
| 6 | 86.8 | 94.3 | 97.3 | 98.8 | 99.3 | 97.0 | 93.1 | 81.8 | 105.0 |
| 7 | 87.9 | 95.4 | 98.4 | 100.1 | 100.7 | 98.1 | 94.1 | 82.6 | 106.3 |
| ≥8 | 89.1 | 95.8 | 98.3 | 99.8 | 100.6 | 98.5 | 94.7 | 84.0 | 106.3 |

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 values in line with best practice wind turbine noise assessment.

Best practice also 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 the purposes of this assessment a tonal penalty has not been included within the predicted noise levels. A warranty will be sought from the manufacturers of the selected turbine for the Meenbog site to ensure that the noise output will not require a tonal noise correction under best practice guidance.

A number of other existing and proposed windfarm developments have been identified in the vicinity of the development as follows:

- Lough Golagh – operating development of 25 turbines with an associated HH of 44m.
- Meenablagh – Proposed Development at appeal stage in the planning process. The development consists of some 11 proposed turbines with an associated HH of 80m.
- Meenakeeran – Proposed Development in the planning process. The development consists of some 4 proposed turbines with an associated HH of 75m.
- Straness – consented development of some 28 turbines with an associated HH of 70m.

The following noise data was assumed for the other proposed and permitted developments within the noise assessment study area as identified above, see Chapter 2 of this EIAR for further details.

**Table 11.18 $L_{WA}$ Spectra Used for Prediction Model – Lough Golagh (Vestas 600kW)**

| Wind Speed (m/s) | Octave Band Centre Frequencies (Hz) | | | | | | | | dB $L_{WA}$ |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| 4 | 78.9 | 86.8 | 89 | 91.4 | 89.2 | 88.2 | 80.8 | 65.7 | 96.4 |
| 5 | 79.3 | 87.2 | 89.4 | 91.8 | 89.6 | 88.6 | 81.2 | 66.1 | 96.8 |
| 6 | 79.6 | 87.5 | 89.7 | 92.1 | 89.9 | 88.9 | 81.5 | 66.4 | 97.1 |
| 7 | 80 | 87.9 | 90.1 | 92.5 | 90.3 | 89.3 | 81.9 | 66.8 | 97.5 |
| 8 | 80.3 | 88.2 | 90.4 | 92.8 | 90.6 | 89.6 | 82.2 | 67.1 | 97.8 |
| 9 | 80.7 | 88.6 | 90.8 | 93.2 | 91 | 90 | 82.6 | 67.5 | 98.2 |
| 10 | 81 | 88.9 | 91.1 | 93.5 | 91.3 | 90.3 | 82.9 | 67.8 | 98.5 |
| 11 | 81.4 | 89.3 | 91.5 | 93.9 | 91.7 | 90.7 | 83.3 | 68.2 | 98.9 |
| 12 | 81.7 | 89.6 | 91.8 | 94.2 | 92 | 91 | 83.6 | 68.5 | 99.2 |

**Table 11.19 Derived $L_{WA}$ Spectra Used for Prediction Model – Meenablagh (Nordex N90 2.5MW)**

| Wind Speed (m/s) | Octave Band Centre Frequencies (Hz) | | | | | | | | dB $L_{WA}$ |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| 4 | 82.7 | 86.8 | 91.2 | 91.6 | 90.1 | 89 | 85 | 77.4 | 97.5 |
| 5 | 86.2 | 90.3 | 94.7 | 95.1 | 93.6 | 92.5 | 88.5 | 80.9 | 101.0 |
| 6 | 89.2 | 93.3 | 97.7 | 98.1 | 96.6 | 95.5 | 91.5 | 83.9 | 104.0 |
| 7 | 90.2 | 94.3 | 98.7 | 99.1 | 97.6 | 96.5 | 92.5 | 84.9 | 105.0 |
| ≥8 | 90.7 | 94.8 | 99.2 | 99.6 | 98.1 | 97 | 93 | 85.4 | 105.5 |

**Table 11.20 Derived $L_{WA}$ Spectra Used for Prediction Model – Meenakeeran (Nordex N80 2.5MW)**

| Wind Speed (m/s) | Octave Band Centre Frequencies (Hz) | | | | | | | | dB $L_{WA}$ |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| 4 | 85.2 | 91.8 | 92.6 | 90.4 | 90.1 | 89.2 | 85.6 | 77.7 | 98.5 |
| 5 | 87.7 | 94.3 | 95.1 | 92.9 | 92.6 | 91.7 | 88.1 | 80.2 | 101.0 |
| 6 | 89.7 | 96.3 | 97.1 | 94.9 | 94.6 | 93.7 | 90.1 | 82.2 | 103.0 |
| 7 | 90.4 | 97 | 97.8 | 95.6 | 95.3 | 94.4 | 90.8 | 82.9 | 103.7 |
| 8 | 90.9 | 97.5 | 98.3 | 96.1 | 95.8 | 94.9 | 91.3 | 83.4 | 104.2 |
| 9 | 91.4 | 98 | 98.8 | 96.6 | 96.3 | 95.4 | 91.8 | 83.9 | 104.7 |
| ≥10 | 91.7 | 98.3 | 99.1 | 96.9 | 96.6 | 95.7 | 92.1 | 84.2 | 105.0 |

**Table 11.21 $L_{WA}$ Spectra Used for Prediction Model – Straness (Enercon E70 2.5MW)**

| Wind Speed (m/s) | Octave Band Centre Frequencies (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | dB $L_{WA}$ |
| 4 | 77.2 | 83.8 | 86.8 | 87 | 84 | 81 | 76.7 | 72.4 | 92.3 |
| 5 | 80.5 | 87.1 | 90.1 | 90.3 | 87.3 | 84.3 | 80 | 75.7 | 95.6 |
| 6 | 85.9 | 92.5 | 95.5 | 95.7 | 92.7 | 89.7 | 85.4 | 81.1 | 101.0 |
| 7 | 87.6 | 94.2 | 97.2 | 97.4 | 94.4 | 91.4 | 87.1 | 82.8 | 102.7 |
| 8 | 89.6 | 96.2 | 99.2 | 99.4 | 96.4 | 93.4 | 89.1 | 84.8 | 104.7 |
| 9 | 88.7 | 95.3 | 97.8 | 100.5 | 98.1 | 94.1 | 90.7 | 87.3 | 105.1 |
| 10 | 88.3 | 95.3 | 97 | 100.6 | 99.9 | 95.6 | 94.0 | 87.2 | 105.5 |
| 11 | 88.4 | 95.5 | 95.3 | 99.3 | 100.4 | 97.9 | 92.8 | 87.7 | 105.5 |
| 12 | 88.5 | 95.3 | 94.7 | 98.7 | 100.3 | 98.5 | 93.4 | 88.3 | 105.5 |

Coordinates for other turbines considered in the noise modelling are presented in Appendix 11.3.

#### 11.6.3.4 Modelling Calculation Parameters[11]

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

In terms of calculation a ground attenuation factor (general method) of 0.5 and no metrological correction were assumed for all calculations. The atmospheric attenuation outlined in Table 11.22 was assumed for all calculations.

**Table 11.22 Atmospheric Attenuation Assumed for Noise Calculations (dB per km)**

| Temp (°C) | % Humidity | Octave Band Centre Frequencies (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| 10 | 70 | 0.12 | 0.41 | 1.04 | 1.93 | 3.66 | 9.66 | 32.77 | 116.88 |

#### 11.6.3.5 Additional Information

Noise Sensitive locations, ground topography, geographical features have been taken from survey information supplied by McCarthy Keville O'Sullivan and Ordnance Survey maps.

#### 11.6.3.6 Assessment of Operational Phase

In the first instance, a worst-case assessment assuming all receptors are downwind of all turbines at the same time, has been completed for all noise sensitive receivers identified within 2.5km of the proposed turbines. Table 11.23 presents the omnidirectional results of the exercise at all locations considering the impact of the proposed Meenbog turbines in isolation.

11 See Appendix 11.3 for further discussion of calculation parameters and settings.

**Table 11.23 Omni-directional Predicted Levels from Proposed Meenbog Turbines**

| Location | Predicted $L_{A90,\ 10\ min}$ (dB) at various Standardised 10m Height Wind Speed (m/s) | | | | | |
|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 |
| H001 | 25.7 | 30.2 | 34.2 | 35.4 | 35.5 | 35.5 |
| H002 | 26.0 | 30.5 | 34.6 | 35.8 | 35.8 | 35.8 |
| H003 | 25.9 | 30.5 | 34.5 | 35.7 | 35.7 | 35.7 |
| H004 | 22.7 | 27.2 | 31.1 | 32.3 | 32.4 | 32.4 |
| H005 | 21.1 | 25.6 | 29.5 | 30.6 | 30.8 | 30.8 |
| H006 | 20.7 | 25.1 | 29.0 | 30.2 | 30.3 | 30.3 |
| H252 | 16.4 | 20.8 | 24.7 | 25.9 | 26.0 | 26.0 |
| H253 | 24.3 | 28.8 | 32.8 | 34.0 | 34.0 | 34.0 |
| H254 | 27.9 | 32.4 | 36.5 | 37.8 | 37.8 | 37.8 |
| H255 | 28.0 | 32.6 | 36.7 | 37.9 | 37.9 | 37.9 |
| H256 | 28.7 | 33.3 | 37.4 | 38.6 | 38.6 | 38.6 |
| H257 | 32.7 | 37.3 | 41.4 | 42.7 | 42.7 | 42.7 |
| H311 | 25.9 | 30.4 | 34.5 | 35.7 | 35.7 | 35.7 |
| H312 | 27.0 | 31.5 | 35.6 | 36.8 | 36.8 | 36.8 |

The next step in the assessment is to consider the impact of the proposed Carrickaduff Turbines and the cumulative impacts from the other turbines in the wider vicinity in line with best practice guidance. Table 11.27 11.24 presents the results of this omni-directional cumulative noise assessment.

**Table 11.24 Omni-directional Predicted Noise Levels (Existing and Proposed Wind Farms)**

| Location | Predicted $L_{A90,\ 10\ min}$ (dB) at various Standardised 10m Height Wind Speed (m/s) | | | | | |
|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 |
| H001 | 26.3 | 30.6 | 34.4 | 35.6 | 35.7 | 35.7 |
| H002 | 26.5 | 30.9 | 34.8 | 36.0 | 36.0 | 36.0 |
| H003 | 26.5 | 30.8 | 34.7 | 35.9 | 36.0 | 36.0 |
| H004 | 23.7 | 27.8 | 31.6 | 32.8 | 32.9 | 32.9 |
| H005 | 22.5 | 26.5 | 30.1 | 31.3 | 31.5 | 31.5 |
| H006 | 21.9 | 25.9 | 29.5 | 30.7 | 30.9 | 30.9 |
| H252 | 21.3 | 25.0 | 28.3 | 29.4 | 29.7 | 29.7 |
| H253 | 25.1 | 29.4 | 33.2 | 34.4 | 34.5 | 34.5 |
| H254 | 28.1 | 32.6 | 36.7 | 37.9 | 37.9 | 37.9 |
| H255 | 28.2 | 32.7 | 36.8 | 38.0 | 38.0 | 38.0 |
| H256 | 28.9 | 33.5 | 37.5 | 38.7 | 38.8 | 38.8 |
| H257 | 32.8 | 37.3 | 41.5 | 42.7 | 42.7 | 42.7 |
| H311 | 26.5 | 30.8 | 34.7 | 35.9 | 35.9 | 35.9 |
| H312 | 27.4 | 31.8 | 35.7 | 36.9 | 37.0 | 37.0 |

In line with best practice guidance, the study area for this assessment has been selected to cover the area within which predicted noise levels from the proposed, consented and existing wind turbines may exceed 35 dB $L_{A90}$ at rated power windspeed. It is noted that the predicted cumulative noise levels at the two noise sensitive locations situated in Northern Ireland are below the 35dB $L_{A90,10mins}$ assessment threshold.

Following review of noise predictions outlined in Table 11.24, nine noise sensitive locations have been identified for the wind turbine operational impact and these are outlined in Table 11.25

**Table 11.25 Noise Sensitive Locations within the Study Area**

| Name | Description |
|---|---|
| H001 | Derelict |
| H002 | Involved |
| H003 | Involved |
| H254 | Derelict |
| H255 | Involved |
| H256 | Involved |
| H257 | Involved |
| H311 | involved |
| H312 | Derelict |

As previously stated guidance in relation to acceptable levels of noise from wind farms is contained in the documents Department of the Environment, Heritage and Local Government "*Wind Energy Development Guidelines"* and Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication "*The Assessment and Rating of Noise from Wind Farms*" (1996).

The following noise criteria has been adopted for the noise sensitive locations listed in Table 11.25 in line with best practice guidance:

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

In relation to noise sensitive properties where the owner has an interest in the development, the IOA GPG allows for the fixed limits to be increase to 45dB $L_{A90,10min}$ or 5dB(A) above background noise (whichever is higher) for both day and night time periods.

Table 11.26 outlines the derived noise criteria curves based on the information contained within Table 11.6. Note the curves are based on the baseline noise levels which represent the lowest baseline noise levels measured as part of the noise monitoring programme.

**Table 11.26 Noise Criteria Curves**

| Period | $L_{A90, 10 min}$ (dB) Limits at various Standardised 10m Height Wind Speed (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Day | 40 | 40 | 40 | 45 | 45 | 45 | 45 |
| Night | 43 | 43 | 43 | 43 | 43 | 43 | 43 |

Table 11.27 11.27 presents the results of the assessment against the adopted noise criteria.

**Table 11.27 Review of Predicted Levels against Relevant Criteria**

| Name | Description | dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 4 | 5 | 6 | 7 | 8 | 9 |
| H001 | Predicted Level | 26.3 | 30.6 | 34.4 | 35.6 | 35.7 | 35.7 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H002 | Predicted Level | 26.5 | 30.9 | 34.8 | 36.0 | 36.0 | 36.0 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H003 | Predicted Level | 26.5 | 30.8 | 34.7 | 35.9 | 36.0 | 36.0 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H254 | Predicted Level | 28.1 | 32.6 | 36.7 | 37.9 | 37.9 | 37.9 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H255 | Predicted Level | 28.2 | 32.7 | 36.8 | 38.0 | 38.0 | 38.0 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H256 | Predicted Level | 28.9 | 33.5 | 37.5 | 38.7 | 38.8 | 38.8 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H257 | Predicted Level | 32.8 | 37.3 | 41.5 | 42.7 | 42.7 | 42.7 |
| | Daytime Criterion[Note 1] | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H311 | Predicted Level | 26.5 | 30.8 | 34.7 | 35.9 | 35.9 | 35.9 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |

| Name | Description | dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 4 | 5 | 6 | 7 | 8 | 9 |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |
| H312 | Predicted Level | 27.4 | 31.8 | 35.7 | 36.9 | 37.0 | 37.0 |
| | Daytime Criterion | 40.0 | 40.0 | 40.0 | 45.0 | 45.0 | 45.0 |
| | Daytime Excess | -- | -- | -- | -- | -- | -- |
| | Night time Criterion | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Night time Excess | -- | -- | -- | -- | -- | -- |

*Note 1*: In relation to the predicted noise levels at Location H257, this is an involved property where the owner has provided consent for an increase in noise limits at this property as outlined below. As previously discussed in Section 11.4.2.1, for this scenario, best practice Guidance from the IOA GPG allows for the fixed limits to be increase to 45dB $L_{A90,10min}$ or 5dB(A) above background noise (whichever is higher) for both day and night time periods.

A noise contour for the rated power wind speed of 8 m/s (i.e. highest noise emission) has been presented in Appendix 11.4.

The cumulative predicted noise levels at various wind speeds have been compared against the noise criteria curves outlined in Table 11.27. The predicted omni-directional noise levels for the various wind speeds are complied with at all noise sensitive locations.

it is not considered that a significant effect is associated with the operation of this development, since the predicted noise levels associated with the Proposed Development will be within the relevant best practice noise criteria curves for wind farms. As previously discussed, the following guidance is relevant for this assessment, "*Wind Energy Development Guidelines*" published by the Department of the Environment, Heritage and Local Government in 2006 and in the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication "*The Assessment and Rating of Noise from Wind Farms*" (1996).

While noise levels at low wind speeds will increase due to the development the predicted levels will remain low, albeit a new source of noise will be introduced into the soundscape.

The predicted operational noise effects are summarised as follows at the closest noise sensitive locations to the site:

| *Quality* | *Significance* | *Duration* |
|---|---|---|
| Negative | Moderate | Long Term |

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

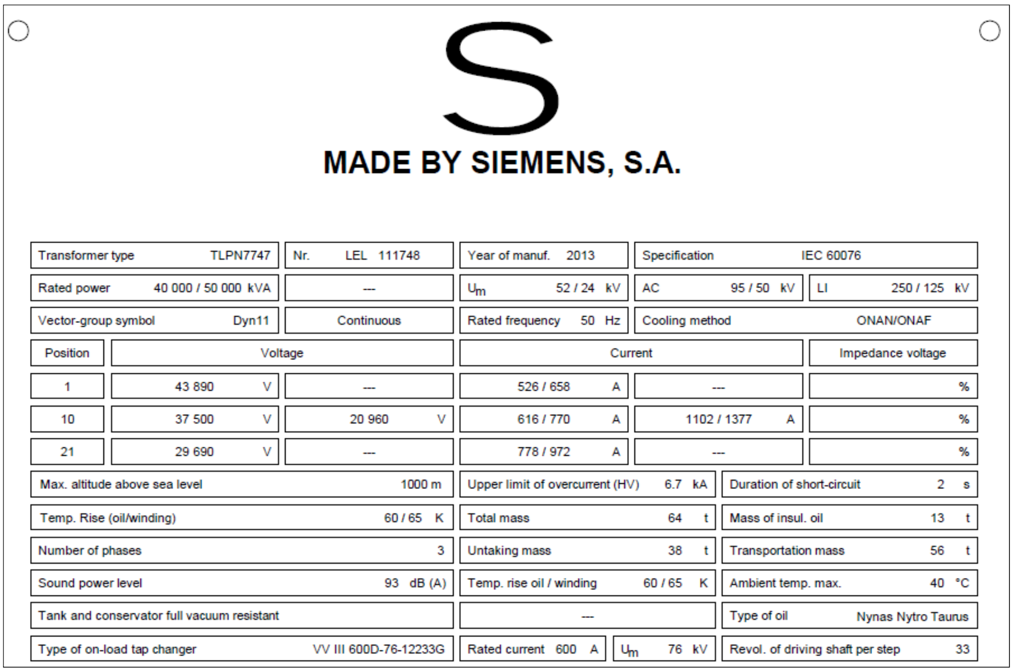
For the majority of locations assessed here the effect of the operational turbines can be considered to be as follows:

| *Quality* | *Significance* | *Duration* |
|---|---|---|
| Negative | Slight | Long Term |

#### 11.6.3.7 Substation

The proposed substation location is shown in Figure 4.1 of the EIAR.

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


MADE BY SIEMENS, S.A.

| | | | |
|---|---|---|---|
| Transformer type TLPN7747 | Nr. LEL 111748 | Year of manuf. 2013 | Specification IEC 60076 |
| Rated power 40 000 / 50 000 kVA | --- | Um 52 / 24 kV | AC 95 / 50 kV; LI 250 / 125 kV |
| Vector-group symbol Dyn11 | Continuous | Rated frequency 50 Hz | Cooling method ONAN/ONAF |

| Position | Voltage | | Current | | Impedance voltage |
|---|---|---|---|---|---|
| 1 | 43 890 V | --- | 526 / 658 A | --- | % |
| 10 | 37 500 V | 20 960 V | 616 / 770 A | 1102 / 1377 A | % |
| 21 | 29 690 V | --- | 778 / 972 A | --- | % |

| | | |
|---|---|---|
| Max. altitude above sea level 1000 m | Upper limit of overcurrent (HV) 6.7 kA | Duration of short-circuit 2 s |
| Temp. Rise (oil/winding) 60 / 65 K | Total mass 64 t | Mass of insul. oil 13 t |
| Number of phases 3 | Untaking mass 38 t | Transportation mass 56 t |
| Sound power level 93 dB (A) | Temp. rise oil / winding 60 / 65 K | Ambient temp. max. 40 °C |
| Tank and conservator full vacuum resistant | --- | Type of oil Nynas Nytro Taurus |
| Type of on-load tap changer VV III 600D-76-12233G | Rated current 600 A; Um 76 kV | Revol. of driving shaft per step 33 |

**Figure 11.10 Statement of $L_w$ for Typical Sub Station Used for Assessment**

An iteration of the noise model has been developed to consider the expected noise level from the operation of the substation at the noise sensitive locations. These levels are presented in Table 11-28 11.28.

**Table 11-28 Predicted Noise Levels Associated with Substations**

| Name | Height (m) | Predicted $L_{Aeq,T}$ dB |
|---|---|---|
| H001 | 4 | 6 |
| H002 | 4 | 5 |
| H003 | 4 | 5 |
| H004 | 4 | 0 |
| H005 | 4 | 0 |
| H006 | 4 | 0 |
| H252 | 4 | 0 |
| H253 | 4 | 0 |
| H254 | 4 | 3 |
| H255 | 4 | 3 |
| H256 | 4 | 3 |
| H257 | 4 | 10 |
| H311 | 4 | 5 |

| Name | Height (m) | Predicted $L_{Aeq,T}$ dB |
|---|---|---|
| H312 | 4 | 8 |

Due to the distances between the substation and the noise sensitive locations the predicted noise levels are inaudible at all noise sensitive locations. To inform the assessment, a sample receiver position has been created at a distance of 1km from the substation and the predicted noise level at this distance are in the order of 23dB. This level is comparable to the lower noise levels measured in the area as part of the survey work undertaken for this assessment. In essence, the noise from such an installation would not be expected to be audible at any of the noise sensitive locations and will not add to the overall noise levels associated with the proposed wind turbines themselves. The associated cumulative noise impact from the operation of the wind farm and the substations is not considered significant and is summarised as follows:

| *Quality* | *Significance* | *Duration* |
|---|---|---|
| Neutral | Imperceptible | Long Term |

#### 11.6.3.8 Site Roads

Considering that there is no significant traffic expected on site roads during the operational phase and the significant distances from any site road to the nearest NSL; there are no noise and vibration impacts anticipated from site roads during the operational phase.

#### 11.6.3.9 Grid Connection

There are no noise and vibration impacts anticipated from the operation of the grid connection.

#### 11.6.3.10 Operational Phase Mitigation Measures

An assessment of the operation noise levels has been undertaken in accordance with best practice guidelines and procedure as outlined in Section 11.6.3.6 of this Chapter. The findings of the assessment confirmed that the predicted operational noise levels will be within the relevant best practice noise criteria curves for wind farms. Therefore, noise mitigation measures are not required for the operational phase of this development.

### 11.6.4 Monitoring

#### 11.6.4.1 Construction Phase

Noise and vibration monitoring should be considered in accordance with the guidance contained in British Standard BS5528 during the construction phase.

#### 11.6.4.2 Operational Phase

Post commissioning operational noise monitoring is recommended to ensure compliance with the relevant planning noise criteria. In relation to assessment of operational wind turbine noise, the guidance outlined in the IoA GPG and Supplementary Guidance Note 5: Post Completion Measurements (July 2014) should be followed. Should the assessment identify any exceedances of the appropriate criteria, relevant corrective actions will be taken.

### 11.6.5 Decommissioning Phase

The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those proposed for the construction phase of the development, i.e. as per Section 11-21.

### 11.6.6 Cumulative Effects

Cumulative assessment has been considered here with due consideration of the Proposed Development in combination with any existing and permitted wind turbine developments in the wider study area as noted in Section 11.6.3.3. The effects summarised in Section 11.6.3.6 have due consideration of cumulative effects.