11. NOISE AND VIBRATION

11.1 Introduction

11.1.1 Background and Objectives

This chapter of the rEIAR describes the assessment undertaken of the potential noise and vibration impacts associated with the constructed Cleanrath wind farm development. The Cleanrath wind farm development encompasses 9 No. wind turbines with a tip height of 150 metres above ground level. A full description of the Cleanrath wind farm development is provided in Chapter 4 of this rEIAR.

Noise and vibration impact assessments have been prepared for the construction, operational and decommissioning phases of the Cleanrath wind farm development to the nearest noise sensitive locations (NSL's). To inform the operational assessment, background noise levels have been measured at three representative NSL's in the vicinity of the Cleanrath wind farm development site.

Other wind farm developments (operational, permitted or proposed) with the potential for cumulative impacts were identified and assessed as part of this assessment. Only one development was identified with the potential for cumulative impacts, namely the Derragh wind farm, recently constructed. In line with best practice guidance the cumulative impact of the Derragh development has been included in the operational noise impact assessment of the Cleanrath wind farm development. Further details on all the developments considered for cumulative impacts is provided in Chapter 2 of this rEIAR.

11.1.2 Statement of Authority

This chapter has been prepared by Mike Simms of AWN Consulting Ltd:

Mike Simms (Senior Acoustic Consultant) holds a BE and MEngSc in Mechanical Engineering and is a member of the Institute of Acoustics and of the Institution of Engineering and Technology. Mike has worked in the field of acoustics for over 19 years. He has extensive experience in all aspects of environmental surveying, noise modelling and impact assessment for various sectors including, wind energy, industrial, commercial and residential.

The chapter has been reviewed by Dermot Blunnie and Damian Kelly of AWN Consulting Ltd:

Dermot Blunnie (Senior Acoustic Consultant) holds a BEng (Hons) in Sound Engineering, MSc in Applied Acoustics and has completed the Institute of Acoustics (IoA) Diploma in Acoustics and Noise Control. He has been working in the field of acoustics since 2008 and is a member of the Institute of Engineers Ireland (MIEI) and the Institute of Acoustics (MIoA). He has experience in both building and environmental acoustics and has extensive knowledge in all aspects of environmental surveying, noise modelling and impact assessment specialising in wind farm noise.

11.2 Fundamentals of Acoustics

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. To take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

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

The frequency of sound is the rate at which a sound wave oscillates is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250Hz. In order to rank the SPL of various noise sources, the measured level is adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. The 'A-weighting' system defined in the international standard, *BS ISO 226:2003 Acoustics. Normal Equal-loudness Level Contours* has been found to provide the best correlations with human response to perceived loudness. SPL's measured using 'A-weighting' are expressed in terms of dB(A).

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

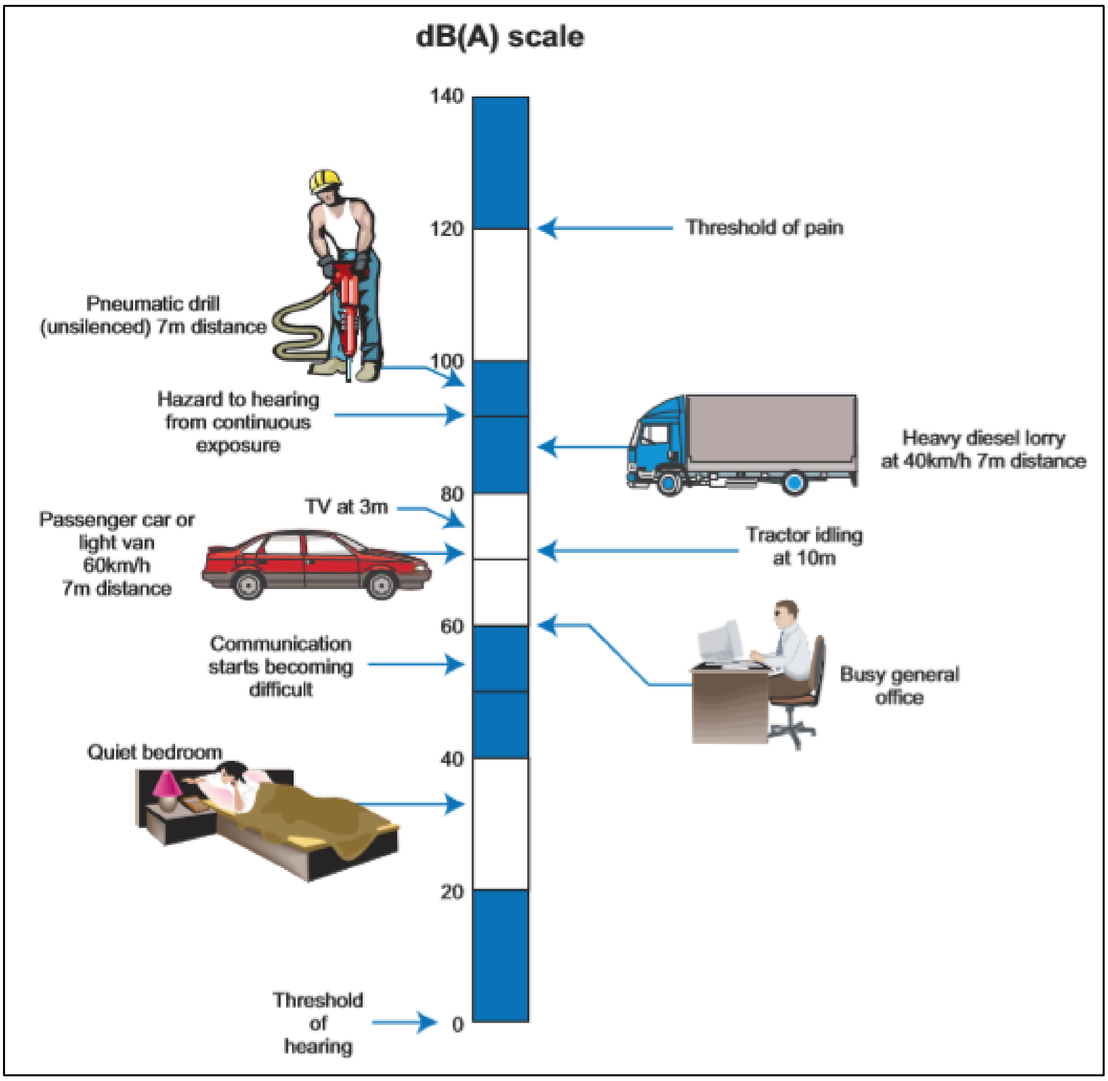

Figure 11-1 The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)

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

11.3 Assessment Methodology

The assessment of impacts for the Cleanrath wind farm development have been undertaken with reference to the most appropriate guidance documents relating to environmental noise and vibration which are set out in Section 11.3.2.

In addition to the specific guidance documents outlined in this chapter, the Environmental Impact Assessment (EIA) guidelines listed in Section 1.9 of Chapter 1 were considered and consulted for the purposes of preparing this rEIAR chapter.

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

- Review of appropriate guidance to identify appropriate noise and vibration criteria for both the construction, operational and decommissioning phases;
- Characterise the receiving environment through baseline noise surveys at various NSL's surrounding the Cleanrath wind farm development;
- Undertake predictive calculations to assess the potential impacts associated with the construction phase of the Cleanrath wind farm development at NSL's;
- Undertake predictive calculations to assess the potential impacts associated with the cumulative operation of the Cleanrath wind farm development along with Derragh Wind Farm at NSL's; Evaluate the noise and vibration impacts and effects.
- Specify mitigation measures to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the Cleanrath wind farm development;
- Compare the wind turbine noise level measured during the commissioning noise survey against the criteria adopted for the current assessment and those outlined in the 2017 planning permission associated with the development,
- Describe the significance of the residual noise and vibration effects associated with the Cleanrath wind farm development.

11.3.1 EPA Description of Effects

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

The effects associated with the Cleanrath wind farm development are described with respect to the EPA guidance in the relevant sections of this chapter.

11.3.2 Guidance Documents and Assessment Criteria

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

11.3.2.1 Construction and Decommissioning Phases

11.3.2.1.1 *Construction/Decommissioning Noise*

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

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

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

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

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

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

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

This assessment method is only valid for residential properties. For the appropriate period (e.g. daytime) the ambient noise level is determined and rounded to the nearest 5 dB. In this instance, with the rural nature of the site, properties near the development have daytime ambient noise levels that typically range from 40 to 50 dB $L_{Aeq,1hr}$. Therefore, all properties are afforded a Category A designation.

See Section 11.5.2 for the detailed assessment in relation to the Cleanrath wind farm development. If the specific construction noise level exceeds the appropriate category value (e.g. 65 dB $L_{Aeq,T}$ during daytime periods) then a significant effect is deemed to have occurred.

11.3.2.1.2 *Additional Vehicular Activity*

For the assessment of potential noise impacts from construction related traffic along public roads and haul routes it is proposed to adopt guidance from *Design Manual for Roads and Bridges (DMRB),* *Highways England, Transport Scotland, The Welsh Government and The Department of Infrastructure 2019.*

Table 11-2, taken from Section 13.7 of DMRB presents guidance as to the likely impact associated with any change in the background noise level ($L_{Aeq,T}$) at a noise sensitive receiver as a result of construction traffic.

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

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

Table 11-2 Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2011)

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

The DMRB guidance outlined is used to assess the predicted increases in traffic levels on public roads associated with the Cleanrath wind farm development and comment on the likely impacts during the construction and decommissioning phases.

11.3.2.1.3 Construction/Decommissioning Vibration

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

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

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

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15 mm/s at low frequencies rising to 20 mm/s at 15 Hz and 50 mm/s at 40 Hz and above.

BS 5228 recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak particle velocity of 15 mm/s for transient vibration at frequencies below 15 Hz and 20 mm/s at frequencies above than 15 Hz. Below these vibration magnitudes minor damage is unlikely, although where there is existing damage these limits may be reduced by up to 50%. In addition, where continuous vibration is generated the limits discussed above may need to be reduced by 50%.

The Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes* (2014) also contains information on the permissible construction vibration levels during the construction phase as shown in Table 11-3.

Table 11-3 Allowable Transient Vibration at Properties

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

11.3.2.2 Operational Phase

11.3.2.2.1 Noise

The noise assessment in this chapter has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document *Wind Energy Development Guidelines for Planning Authorities* published by the Department of the Environment, Heritage and Local Government in 2006. These guidelines are in turn based on detailed recommendations set out in the Department of Trade and Industry (UK) Energy Technology Support Unit (ETSU) publication *The Assessment and Rating of Noise from Wind Farms* (1996). The ETSU document has been used to supplement the guidance contained within the *Wind Energy Development Guidelines* publication where necessary.

The following section from the Cork County Council Cork County Development Plan 2014 should be noted:

***"County Development Plan Objective ED 3-1: National Wind Energy Guidelines** – Development of on-shore wind shall be designed and developed in line with the 'Planning Guidelines for Wind Farm Development 2006" issued by DoELG and any updates of these guidelines."*

11.3.2.2.2 Existing Planning Condition

Cleanrath Wind Farm previously had planning permission granted under in 2017. Condition 7 refers to environmental noise and is as follows:

> *"Wind turbine noise arising from the proposed development, by itself or in combination with other existing or permitted wind energy development in the vicinity, shall not exceed the greater of*
>
> - *5 dB(A) above background noise levels, or*
> - *43 dB(A)*
>
> *When measured externally at dwellings or other sensitive receptors.*
>
> *Prior to the commencement of the development, the developer shall submit to, and agree in writing with, the planning authority a noise compliance monitoring programme for the Cleanrath wind farm development. All noise measurements shall be carried out in accordance with ISO Recommendation 1996 "Acoustics – Description, measurement and assessment of environmental*

noise". The results of the initial noise compliance monitoring shall be submitted to, and agreed in writing with, the planning authority within six months of commissioning of the wind farm."

11.3.2.2.3 Wind Energy Development Guidelines

Section 5.6 of the *Wind Energy Development Guidelines* published by the Department of the Environment, Heritage and Local Government (2006) addresses noise and outlines the appropriate noise criteria in relation to wind farm developments.

The following extracts from this document should be considered:

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

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

A noise sensitive location is defined as follows in the *Wind Energy Development Guidelines*:

> "*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.*"

The paragraph below is extract from the *Wind Energy Development Guidelines* which outline current national guidance in relation to appropriate wind turbine noise. As will be seen from the calculations presented later in this chapter, the various issues identified in this extract have been incorporated into our assessment:

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

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

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

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

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

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

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

Therefore, a night time 5dB(A) above background allowance has also been adopted in the criteria for this assessment.

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

- The existing planning condition related to the site applies a 43dB(A) lower threshold during daytime periods. The proposed lower threshold here is 3dB more stringent than this level.
- 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 following criteria are proposed:

- 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 5 dB above background noise (whichever is higher) for night time periods.

Finally, in terms of landowners with interests in the project a relaxed criterion of 45dB $L_{A90,10min}$ for day and night time periods has been adopted.

The operational noise criteria curves for wind turbine noise at various noise sensitive locations are presented in Section 11.4.2.

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

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

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

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

11.3.2.2.5 Institute of Acoustics Good Practice Guide

The guidance contained within the institute of Acoustics (IoA) document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (2013) (IOA GPG) and Supplementary Guidance Notes are considered to represent best practice and have been adopted for this assessment. The IOA GPG states, that at a minimum continuous baseline noise monitoring should be carried out at the nearest noise sensitive locations for typically a two-week period and should capture a representative sample of wind speeds in the area (i.e. cut in speeds to wind speed of rated sound power of the subject turbine). Background noise measurements (i.e. $L_{A90,10min}$) should be related to wind speed measurements that are collated at the site of the wind turbine development. Regression analysis is then conducted on the data sets to derive background noise levels at various wind speeds to establish the appropriate day and night time noise criterion curves.

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

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

For guidance on the methodology for the background noise survey and operation impact assessment for wind turbine noise the IoA GPG has been taking into account.

Assessment of Cumulative Turbine Noise Impacts

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

Section 5.1 of the relevant IoA GPG states the following:

"5.1.1 ETSU-R-97 states at page 58, "...absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question..."

5.1.2 The HMP [1] Report states that "If an existing wind farm has permission to generate noise levels up to ETSU-R-97 limits, planning permission noise limits set at any future neighbouring wind farm would have to be at least 10 dB lower than the limits set for the existing wind farm to ensure there is no potential for cumulative noise impacts to breach ETSU-R-97 limits (except in such cases where a higher fixed limit could be justified)". Such an approach could prevent any further wind farm development in the locality, and a more detailed analysis can be undertaken on a case by case basis.

5.1.3 As with the assessment of noise for all wind farm developments, sequential steps need to be taken, but such steps require more detailed attention due to the added complexity of cumulative noise impacts. The advice of the EHO [2] could be invaluable to this part of the assessment."

Cumulative impact assessment necessary

5.1.4 During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed

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

2 *Environmental Health Officer*

wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.

5.1.5 Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary."

11.3.2.2.6 Future Potential Guidance Change

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

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

The World Health Organisation (WHO) *Environmental Noise Guidelines for the European Region* (2018) provide guidance on protecting human health from exposure to environmental noise. They set health-based recommendations based on average environmental noise exposure of several sources of environmental noise, including wind turbine noise.

Recommendations are rated as either 'strong' or 'conditional'. A strong recommendation, *"can be adopted as policy in most situations"* whereas a conditional recommendation, *"requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply".*

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

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

> "*For average noise exposure, the GDG* ***conditionally*** *recommends reducing noise levels produced by wind turbines below 45 dB Lden, as wind turbine noise above this level is associated with adverse health effects.*
>
> *No recommendation is made for average night noise exposure Lnight of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.*
>
> *To reduce health effects, the GDG* ***conditionally*** *recommends that policymakers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another."*

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

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

> "*Even though correlations between noise indicators tend to be high (especially between LAeq-like indicators) and conversions between indicators do not normally influence the correlations between the noise indicator and a particular health effect, important assumptions remain when exposure to wind turbine noise in Lden is converted from original sound pressure level values. The conversion requires, as variable, the statistical distribution of annual wind speed at a particular height, which depends on the type of wind turbine and meteorological conditions at a particular geographical location. Such input variables may not be directly applicable for use in other sites. They are sometimes used without specific validation for a particular area, however, because of practical limitations or lack of data and resources. This can lead to increased uncertainty in the assessment of the relationship between wind turbine noise exposure and health outcomes. Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of Lden or Lnight may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes...*
>
> *...Further work is required to assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region.*"

It is therefore considered that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) if applied, as target noise criteria for an existing or subject wind turbine development in Ireland, should be done with caution. The L_{den} criterion has not been adopted as part of this assessment, this is based upon the review set out above and the conclusion that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes.

11.3.3 Special Characteristics of Turbine Noise

11.3.3.1 Infrasound/Low Frequency Noise

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

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

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

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

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

> *"Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.*

For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects."

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

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

The article concludes that:

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

A report released in January 2013 by the South Australian Environment Protection Authority namely, *Infrasound levels near windfarms and in other environments* (EPA and Resonate Acoustics, 2013)[3] found that the level of infrasound from wind turbines is insignificant and no different to any other

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

source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

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

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

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

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

A German report[4], titled "L*ow Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*" presents the details of a measurement project which ran from 2013. The report was published by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016 and concluded the following in relation to infrasound from wind turbines:

> "*The measured infrasound levels (G levels) at a distance of approx. 150 m from the turbine were between 55 and 80 dB(G) with the turbine running. With the turbine switched off, they were between 50 and 75 dB(G). At distances of 650 to 700 m, the G levels were between 55 and 75 dB(G) with the turbine switched on as well as off.*"

"*For the measurements carried out even at close range, the infrasound levels in the vicinity of wind turbines – at distances between 150 and 300 m – were well below the threshold of what humans can perceive in accordance with DIN 45680 (2013 Draft)*[5]"

> *"The results of this measurement project comply with the results of similar investigations on a national and international level."*

11.3.3.2 Amplitude Modulation

In the context of this assessment, amplitude modulation (AM) is defined in the IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) document *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (IOA, 2016) as:

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

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

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

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

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

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

'Normal' AM	An observer at ground level close to a wind turbine will experience 'blade swish' because of the directional characteristics of the noise radiated from the trailing edge of the blades as it rotates towards and then away from the observer. This effect is reduced for an observer on or close to the turbine axis, and therefore would not generally be expected to be significant at typical separation distances, at least on relatively level sites. The RenewableUK AM project (RenewableUK, 2013) has coined the term 'normal' AM (NAM) for this inherent characteristic of wind turbine noise, which has long been recognised and was discussed in ETSU-R-97 in 1996.
'Other' AM	In some cases AM is observed at large distances from a wind turbine (or turbines). The sound is generally heard as a periodic 'thumping' or 'whoomphing' at relatively low frequencies. On sites where it has been reported, occurrences appear to be occasional, although they can persist for several hours under some conditions, dependent on atmospheric factors, including wind speed and direction. It was proposed in the RenewableUK 2013 study that the fundamental cause of this type of AM is transient stall conditions occurring as the blades rotate, giving rise to the periodic thumping at the blade passing frequency. Transient stall represents a fundamentally different mechanism from blade swish and can be heard at relatively large distances, primarily downwind of the rotor blade. The RenewableUK AM project report adopted the term 'Other AM' (OAM) for this characteristic. The terms 'enhanced' or 'excess' AM (EAM) have been used by others, although such definitions do not distinguish between the source mechanisms and presuppose a 'normal' level of AM, presumably relating back to blade swish as described in ETSU-R-97.

11.3.3.2.1 Frequency of Occurrence of AM

Research by Salford University commissioned by the Department of Environment Food and Rural Affairs (DEFRA), the Department of Business, Enterprise and Regulatory Reform (BERR) and the Department of Communities and Local Government (CLG) investigated the issue of AM associated with wind turbine noise. The results were reviewed and published in the report *Research into Aerodynamic Modulation of Wind Turbine Noise* (2007). The broad conclusions of this report were that aerodynamic modulation was only considered to be an issue at 4, and a possible issue at a further 8, of 133 sites in the UK that were operational at the time of the study and considered within the review. At the 4 sites where AM was confirmed as an issue, it was considered that conditions associated with AM might occur between about 7 and 15% of the time. It also emerged that for three out of the four sites the complaints have subsided, in one case due to the introduction of a turbine control system. The research has shown that AM is a rare and unlikely occurrence at operational wind farms.

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

RenewableUK Research Document states the following in relation to matter:

Page 68 Module F	"*even on those limited sites where it has been reported, its frequency of occurrence appears to be at best infrequent and intermittent.*"
Page 6 Module F	"*It has also been the experience of the project team that, even at those wind farm sites where AM has been reported or identified to be an issue, its occurrence may be relatively infrequent. Thus, the capture of time periods when subjectively significant AM occurs may involve elapsed periods of several weeks or even months.*"
Page 61 Module F	"*There is nothing at the planning stage that can presently be used to indicate a positive likelihood of OAM occurring at any given proposed wind farm site, based either on the site's general characteristics or on the known characteristics of the wind turbines to be installed.*"

Cleanrath Wind Farm has operated during the early part of 2020. It is understood that during this time AM was not raised as a concern. Should any concern regarding AM be raised during the future operation of the wind farm, the operator will employ an independent acoustic consultant to assess the level of AM in accordance with the best-practice guidance described in the next section.

11.3.3.2.2 Assessment of AM

Research and Guidance in the area is ongoing with recent publications being issued by the Institute of Acoustics (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (August 2016) (The Reference Method). The document proposes an objective method for measuring and rating AM. The AMWG does not propose what level of AM is likely to result in adverse community response or propose any limits for AM. The purpose of the group is simply to use existing research to develop a Reference Methodology for the measurement and rating of amplitude modulation.

The definition of any limits of acceptability for AM, or consideration of how such limits might be incorporated into a wind farm planning condition, is outside the scope of the AMWG's work and is currently the subject of a separate UK Government funded study. In the absence of published guidance to date, it is considered best practice to adopt the penalty rating and assessment scheme contained in an article published in the Institute of Acoustics publication *Acoustics Bulletin* (Vol. 42 No. 2 March/April 2017) titled, *Perception and Control of Amplitude Modulation in Wind Turbines Noise*.

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

11.3.4 Comments on Human Health Impacts

11.3.4.1 The National Health and Medical Research Council

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

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

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

11.3.4.2 Health Canada

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014[6]. The study was initiated in 2012 specifically to gather new data on wind farms and health. The study considered physical health measures that assessed stress levels using hair cortisol, blood pressure and resting heart rate, as well as measures of sleep quality. More than 4,000 hours of wind turbine noise measurements were collected and a total of 1,238 households participated.

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

11.3.4.3 New South Wales Health Department

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

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

11.3.4.4 The Australian Medical Association

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

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

11.3.4.5 Journal of Occupational and Environmental Medicine

The review titled, *Wind Turbines and Health: A Critical Review of the Scientific Literature* was published in the Journal of Occupational and Environmental Medicine, 2014. An independent review of the literature was undertaken by the he Department of Biological Engineering of the Massachusetts Institute of Technology (MIT). The review took into consideration health effects such as stress, annoyance and sleep disturbance, as well as other effects that have been raised in association with living close to wind turbines. The study found that:

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

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

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

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

11.3.4.6 Summary

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

11.3.5 Vibration

A recent report published in Germany by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016, "*Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*", Conducted vibration measurements study for an operational Nordex N117 – 2.4 MW wind turbine. The report concluded that at distances of less than 300m from the turbine vibration levels had dropped so far that they could no longer be differentiated from the background vibration levels.

Considering the distances from nearest NSL's to any of the turbines (>600m), levels of vibration are likely to be significantly below any thresholds for perceptibility. Therefore, vibration criteria have not been specified for the operational phase of the Cleanrath wind farm development.

11.3.6 Noise Conditions for Other Wind Farm Developments

The Planning Permission noise conditions relating to the other wind farm developments are considered in this section. It is a requirement that turbine noise emissions from all existing, permitted and proposed wind energy developments are included in the noise impact assessment. As noted previously the cumulative wind farms review identified only one wind farm with potential for cumulative impacts to be experienced, namely the nearby Derragh Wind Farm.

11.3.6.1 Derragh Wind Farm

The permissible noise limits for the Derragh development are contained in Condition No. 7 of An Bord Pleanála Reference PL04.245082. This planning condition provides that,

"Wind turbine noise arising from the proposed development, by itself or in combination with any other permitted wind energy development in the vicinity, shall not exceed the greater of:

(a) 5 dB(A) above background noise levels or,
(b) 43 dB(A) L90,10min when measured externally at dwellings or other sensitive receptors."

For the assessment presented in this report the Derragh wind farm as built has been included in the cumulative noise model and the total wind turbine noise level of both wind farms is assessed at the houses listed in Table 11-23 against the noise criteria for Cleanrath wind farm.

11.3.7 Background Noise Assessment

An environmental noise survey was undertaken to determine typical background noise levels at representative NSL's surrounding the development site. The background noise survey was conducted through installing unattended sound level meters at 3 no. representative locations in the surrounding area.

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

11.3.7.1 Choice of Measurement Locations

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

The locations selected for the noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in Table 11-4 and illustrated in Figure 11-2. Wind speed measurements were obtained using a LIDAR system installed on site for the duration of the survey.

Table 11-4 Measurement Location Coordinates

Location	(ID Ref)	Coordinates – Irish Grid (IG)	
		Easting	Northing
A	C04	121,800	70,143
B	C18	119,493	70,292
C	C23	120,666	68,072
Wind Speed Measurement (LIDAR)	n/a	119,588	69,162

The NSL's are spread over a relatively large area and the noise monitoring locations were selected to obtain background noise levels representative of the noise environments at noise sensitive locations surrounding the site. Consideration was also given to the potential for noise from existing turbines effecting the survey when selecting the locations and no turbines were within range to influence the survey.

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

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

Figure 11-2 shows the noise measurement locations in relation to the wind farm. Plate 11-1 to Plate 11-3 illustrate the installed noise monitoring equipment at each location. Yellow ellipses are added to the photographs to highlight the position of the noise monitoring equipment.

Figure 11-2 Noise Measurement Locations

11.3.7.1.1 Location A (C04)

The noise meter at Location A was positioned at the side of the house. The nearest turbine location is T03 at a distance of approximately 638m from the house. Distant road traffic and birdsong were noted to be the main noise sources at this location.

Plate 11-1 Location A

11.3.7.1.2 Location B (C18)

The noise meter at Location B was positioned at the eastern side of the house. The nearest turbine location is T06 at a distance of approximately 712m from the house. Distant road traffic and birdsong were noted to be the main noise sources at this location.

Plate 11-2 Location B

11.3.7.1.3 Location C (C23)

The noise meter at Location C was positioned at the eastern side of the house. The nearest turbine location is T10 at a distance of approximately 764m from the house. Distant road traffic and birdsong were noted to be the main noise sources at this location.

Plate 11-3 Location C

11.3.7.2 Measurement Periods

Noise measurements were conducted at each of the monitoring locations over the period outlined in Table 11-5.

Table 11-5 Measurement Periods

Location	Start Date	End Date
A	10 April 2019	30 June 2019
B	10 April 2019	30 June 2019
C	10 April 2019	30 June 2019

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

11.3.7.3 Personnel and Instrumentation

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

Table 11-6 Instrumentation Details

Location	Equipment	Serial Number	Maximum Calibration Drift Noted between Checks
A	RION – NL-52	575785	0.5
B	RION – NL-52	575802	0.1
C	RION – NL-52	186669	0.2

Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator where appropriate. Instruments were calibrated on each interim visit and any drift noted. All calibration drifts were less than ±0.5 dB and within acceptable tolerances outlined in the IOA GPG. Relevant calibration certificates are presented in Appendix 11-2.

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

Wind data was measured using a LiDAR wind measuring unit located within the site of the Cleanrath wind farm development and was supplied to AWN for the data analysis. Details of the LiDAR installation are provided in Appendix 11-3

11.3.7.4 Procedure

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

Survey personnel noted potential primary noise sources contributing to noise build-up during the installation and removal of the sound level meters from site. Description of the observed noise environment at each of the monitoring locations is presented below. $L_{Aeq,10min}$ and $L_{A90,10min}$ parameters were measured in this instance.

11.3.7.5 Analysis of Background Noise Data

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

The Derragh wind farm was not constructed at the time of the survey, thus the noise levels measured during the pre-construction survey for Cleanrath were not affected by the operation of the Derragh Wind Farm.

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

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

The background noise levels are derived for each location with reference to the standardised 10m height wind speed relative to the assessment hub height of 91m.

11.3.7.5.1 Consideration of Wind Shear

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

Wind speed measurements at a height of 91m (the hub height of the constructed turbines) in accordance with Method B of Section 2.6 of the IOA GPG. The calculated hub height wind speeds were then corrected to standardised 10 metre height wind speed.

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

Shear Exponent Profile:

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

Where:

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

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

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

Where:

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

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

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

11.3.8 Turbine Noise Calculations

A series of computer-based prediction models have been prepared to quantify the cumulative noise level associated with the operation of the Cleanrath wind farm development together with the nearby Derragh wind farm. This section discusses the methodology for the noise modelling process.

11.3.8.1 Noise Modelling Software

Proprietary noise calculation software was used for the purposes of this impact assessment. The selected software, DGMR iNoise Enterprise, calculates noise levels in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation*, (ISO, 1996).

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

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

11.3.8.2 Input Data and Assumptions

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

11.3.8.2.1 Turbine Details

Table 11-7 and Table 11-8 detail the co-ordinates of the 9 no. turbines in the Cleanrath wind farm development and the 6 no. turbines at Derragh Wind Farm that are being considered cumulatively in this assessment.

Table 11-7 Cleanrath wind farm development As-built Turbine Co-ordinates

Turbine Ref.	Coordinates – Irish Grid (IG)		Turbine Model	Hub Height (m)
	Easting	Northing		
T01	120871	70057	N117 2.4MW	91
T03	121213	69913	N117 2.4MW	91
T04	121200	69411	N117 2.4MW	91
T05	120682	69553	N117 2.4MW	91
T06	119466	69620	N117 3.6MW	91
T07	119610	69250	N117 3.6MW	91
T08	120493	69178	N117 2.4MW	91
T09	119952	68981	N117 3.6MW	91
T10	120288	68725	N117 3.6MW	91

Table 11-8 Derragh As-Built Turbine Co-ordinates

Turbine Ref.	Coordinates – Irish Grid (IG)		Turbine Model	Hub Height (m)
	Easting	Northing		
D-T01	116,066	70,721	N100 3.3MW	100
D-T02	116,437	70,643	N100 3.3MW	100
D-T03	116,773	70,394	N100 3.3MW	100
D-T04	117,461	70,421	N100 3.3MW	100
D-T05	117,207	70,079	N100 3.3MW	100
D-T06	117,478	69,831	N100 3.3MW	100

The turbine types at the subject site are the Nordex N117 2.4MW and the Nordex N117 3.6 MW. Both models are a pitch-regulated upwind turbines with a three-blade rotor. Noise calculations have accounted for the source of noise at a hub height as specified in Table 11-7.

The turbine type at the Derragh Wind Farm is the Nordex N100 3.3MW. Similarly, it is a pitch-regulated upwind turbine with a three-blade rotor. Noise calculations have accounted for the source of noise at a hub height as specified in Table 11-8.

Sound power levels (L_{WA}) used for noise modelling of the Nordex N117 2.4MW, Nordex N117 3.6MW and Nordex N100 3.3MW turbine model are provided in Table 11-9, Table 11-10 and Table 11-11. In all cases, the sound power level values are for the version of the turbines with Serrated Trailing Edges[8] on the blades, as constructed.

Table 11-9 L_{wa} Spectra Used for Prediction Model – Cleanrath wind farm development Turbine Noise Emissions for the Nordex N117 2.4MW at 91m hub height with Serrated Trailing Edge.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
3	77.9	81.4	83.8	85.1	88.0	88.4	86.1	71.8	94.0

[8] Serrations are thin, zig-zagged components attached to the rotor blade for sound reduction. They influence the turbulent trailing edge sound by replacing the straight edge of the rotor blade with a serrated one. This has the potential to reduce the sound power level associated with the wind turbine.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
4	80.9	84.4	86.8	88.1	91.0	91.4	89.1	74.8	97.0
5	83.4	88.5	90.5	92.1	95.0	96.0	92.4	76.7	101.0
6	85.0	89.4	91.6	93.3	95.4	96.4	91.5	77.3	101.5
7	85.5	91.6	92.9	93.4	96.2	96.2	91.8	76.5	102.0
8	85.4	92.2	93.5	92.8	95.1	96.7	92.4	75.2	102.0
≥9	85.3	92.0	93.3	93.4	96.5	95.9	90.9	73.1	102.0

Table 11-10 L_{wa} Spectra Used for Prediction Model - Cleanrath wind farm development Turbine Noise Emissions for the Nordex N117 3.6MW at 91m hub height with Serrated Trailing Edge.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
3	72.8	80.1	86.5	86.6	85.1	84.4	81.0	75.9	92.5
4	73.6	80.3	86.3	86.5	87.7	89.1	85.9	74.2	94.5
5	79.9	86.9	90.2	90.4	92.8	94.5	93.6	83.7	100.0
6	83.4	89.7	93.3	93.9	96.0	97.1	96.6	87.1	103.0
7	84.2	90.4	93.3	93.8	96.6	98.0	97.0	87.7	103.5
8	84.2	90.4	93.3	93.8	96.6	98.0	97.0	87.7	103.5
≥9	84.2	90.4	93.3	93.8	96.6	98.0	97.0	87.7	103.5

Table 11-11 L_{wa} Spectra Used for Prediction Model - Derragh Turbine Noise Emissions for the Nordex N100 3.3MW at 100m hub height with Serrated Trailing Edge.

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
3	73.0	79.4	83.5	83.5	84.4	84.5	84.3	77.0	91.6
4	75.1	81.5	85.6	85.6	86.5	86.6	86.4	79.1	93.7
5	78.6	85.0	89.1	89.1	90.0	90.1	89.9	82.6	97.2
6	82.7	89.1	93.2	93.2	94.1	94.2	94.0	86.7	101.3
7	83.3	89.7	93.8	93.8	94.7	94.8	94.6	87.3	101.9
8	84.1	90.5	94.6	94.6	95.5	95.6	95.4	88.1	102.7
≥9	84.4	90.8	94.9	94.9	95.8	95.9	95.7	88.4	103.0

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

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

Best practice specifies that a penalty should be added to the predicted noise levels, where any tonal component is present. The level of this penalty is described and is related to the level by which any tonal components exceed audibility. For this assessment, a tonal penalty has not been included within the predicted noise levels. A warranty was provided by the manufacturers of the selected turbine to ensure that the noise output does not require a tonal noise correction under best practice guidance.

11.3.8.3 Consideration of Wind Direction and Noise Propagation

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

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

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

Figure 11-3 illustrates the directivity attenuation factor that has been applied to turbines when considering noise propagation in downwind conditions (downwind is represented by 0° with upwind being 180°).

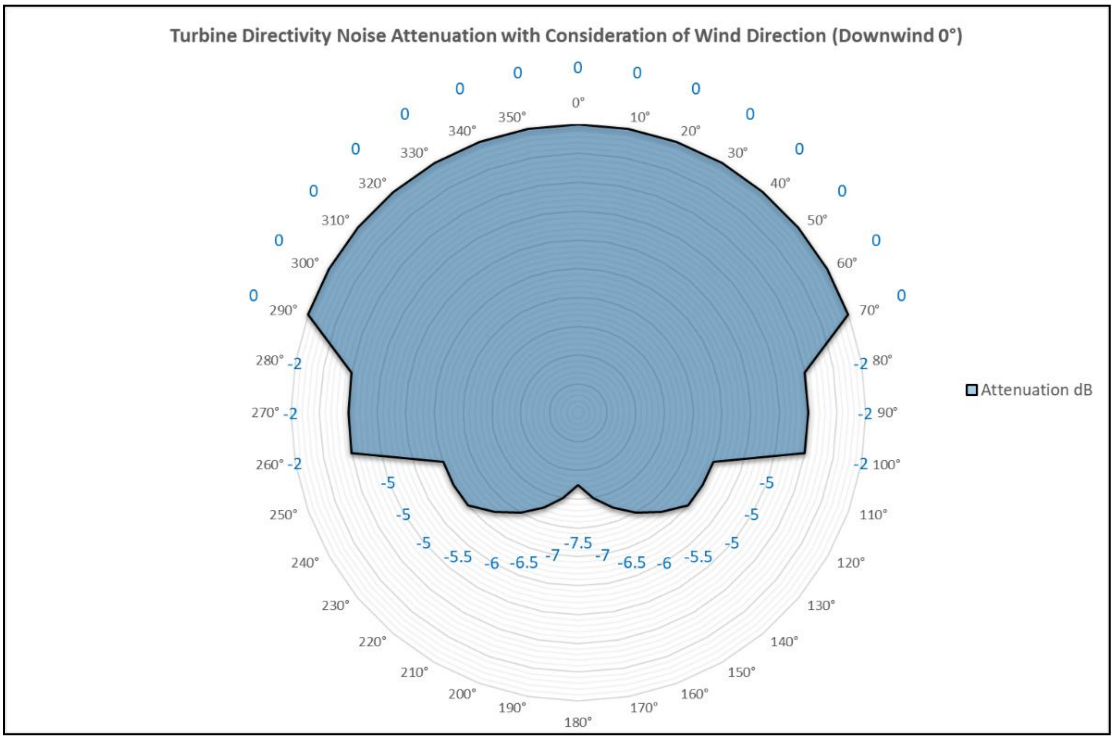


Figure 11-3 Turbine Directivity Attenuation with Consideration of Wind Direction

11.3.8.4 Assessment of Turbine Noise Levels

The predicted cumulative turbine noise level from the Cleanrath wind farm development and from Derragh Wind Farm are compared against the derived turbine noise limits to identify any exceedances of the limits.

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

- Screen the cumulative turbine noise predictions against the lowest potential (worst-case) criteria outlined in Table 11-11 to identify any locations with a potential exceedance.

- Undertake directional noise prediction calculations to refine the noise prediction results as described in Section 11.3.8.3.
- Identify locations, if any, with potential cumulative exceedances that occur as result of the Cleanrath wind farm development only (i.e. Cleanrath wind farm development turbines).

11.3.9 Assessment of Construction Impacts

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

11.4 Receiving Environment

This stage of the assessment was to determine typical background noise levels in the vicinity of the noise sensitive locations (NSL's) in proximity to the Cleanrath wind farm development. The methodology for the assessment is outlined in Section 11.3.7 and the results of the assessment are outlined in the following sections.

A variety of wind speed and weather conditions were encountered over the survey period outlined in Section 11.3.7.2. Figure 11-4 illustrates the distributions of wind speed and wind direction standardised to 10 metre height over the baseline noise survey period detailed in Table 11-15.

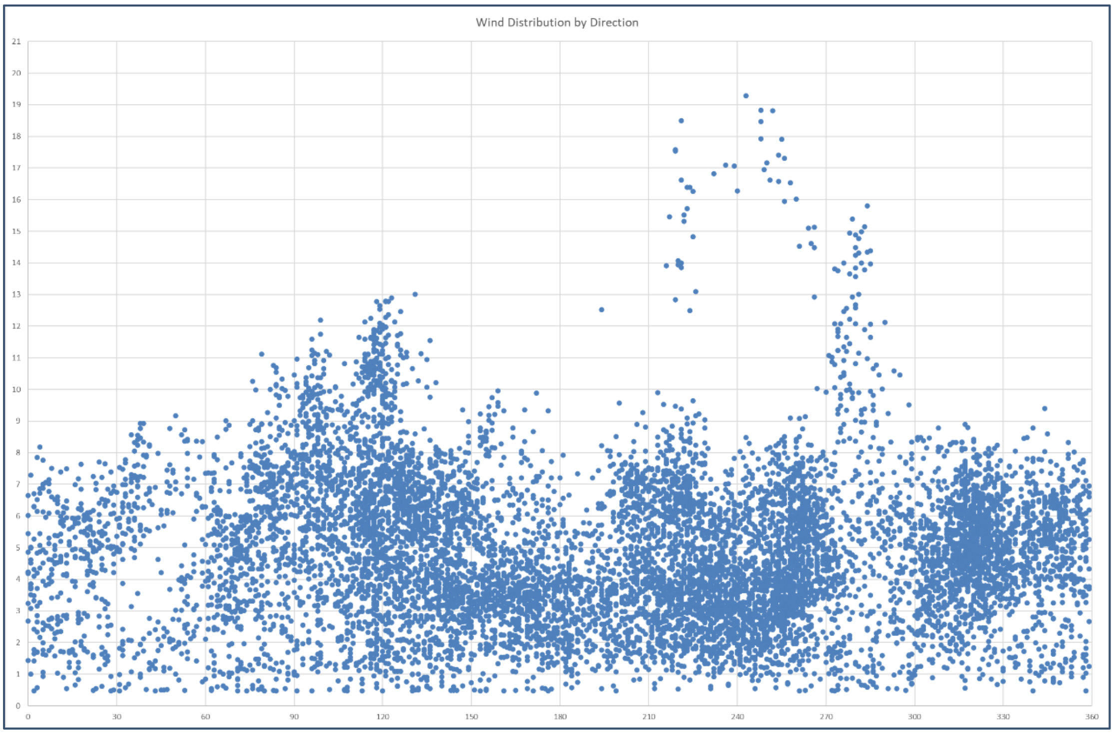


Figure 11-4 Distributions of Wind Speeds and Directions Over the Survey Period

11.4.1 Background Noise Levels

The following sections present an overview and results of the noise monitoring data obtained from the background noise survey in accordance with the methodology set out in Section 11.3.7 and 11.3.7.5. For each location two graphs are presented one shows the screened noise datasets used to derive the daytime background noise levels and the other shows the night time datasets.

11.4.1.1 Location A (C04)

11.4.1.1.1 *Daytime Quiet Periods*

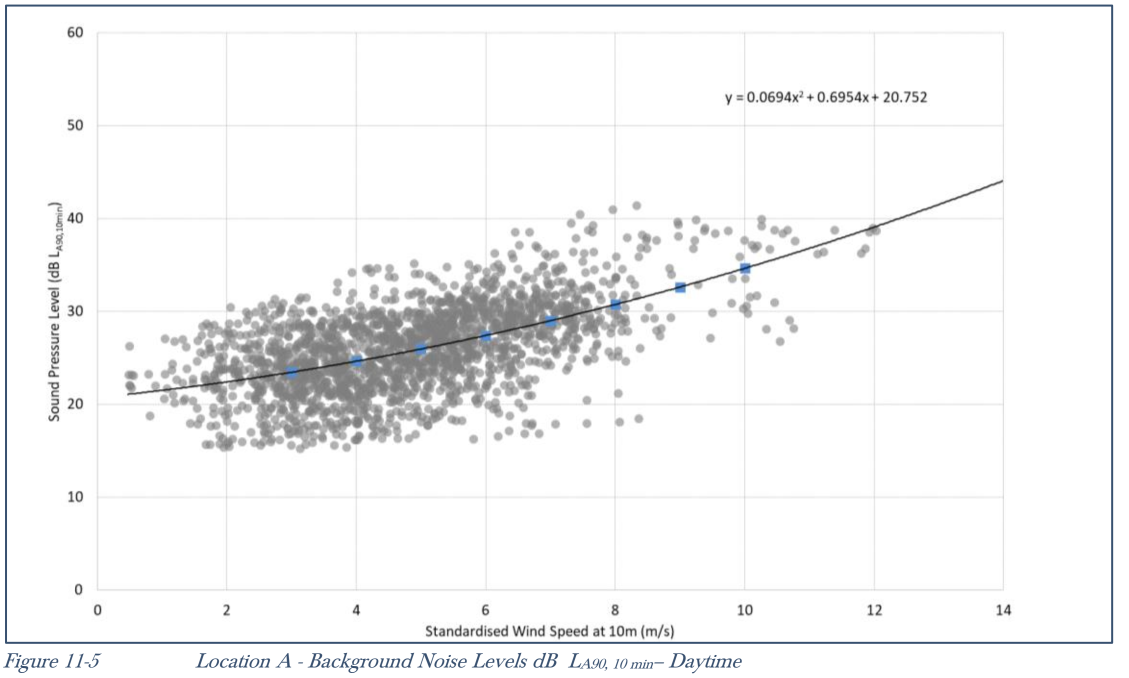


Figure 11-5 Location A - Background Noise Levels dB $L_{A90,\ 10\ min}$– Daytime

11.4.1.1.2 *Night-time Periods*

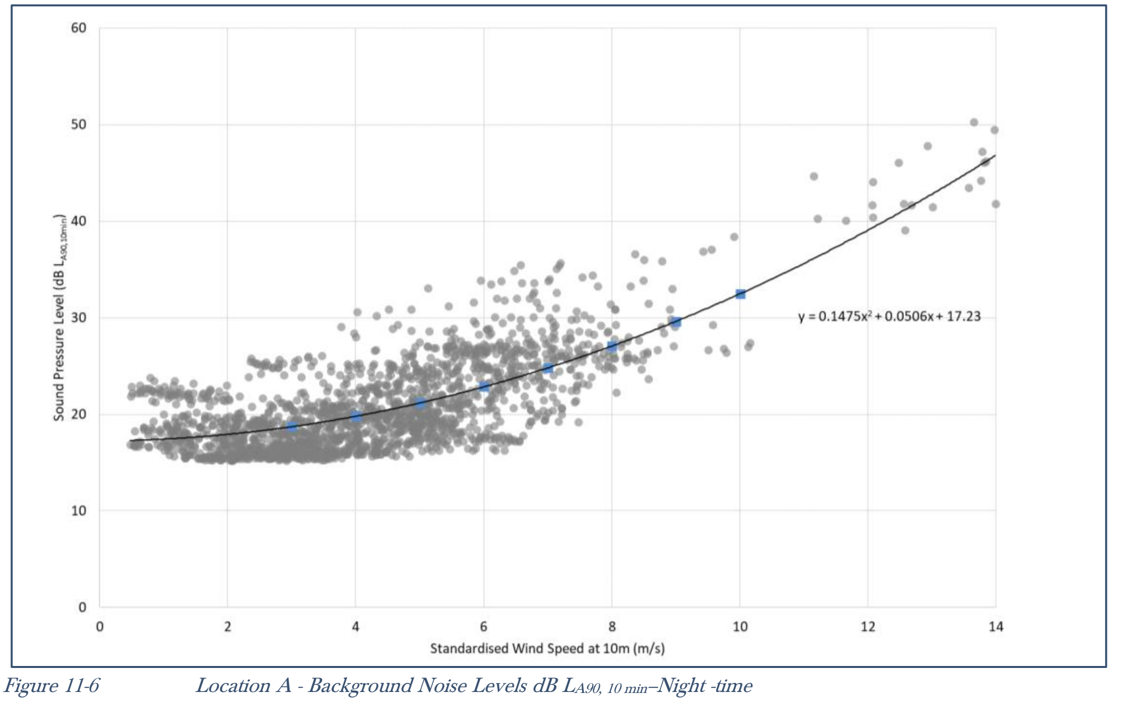


Figure 11-6 Location A - Background Noise Levels dB $L_{A90,\ 10\ min}$–Night -time

11.4.1.2 Location B (C18)

11.4.1.2.1 Daytime Quiet Periods

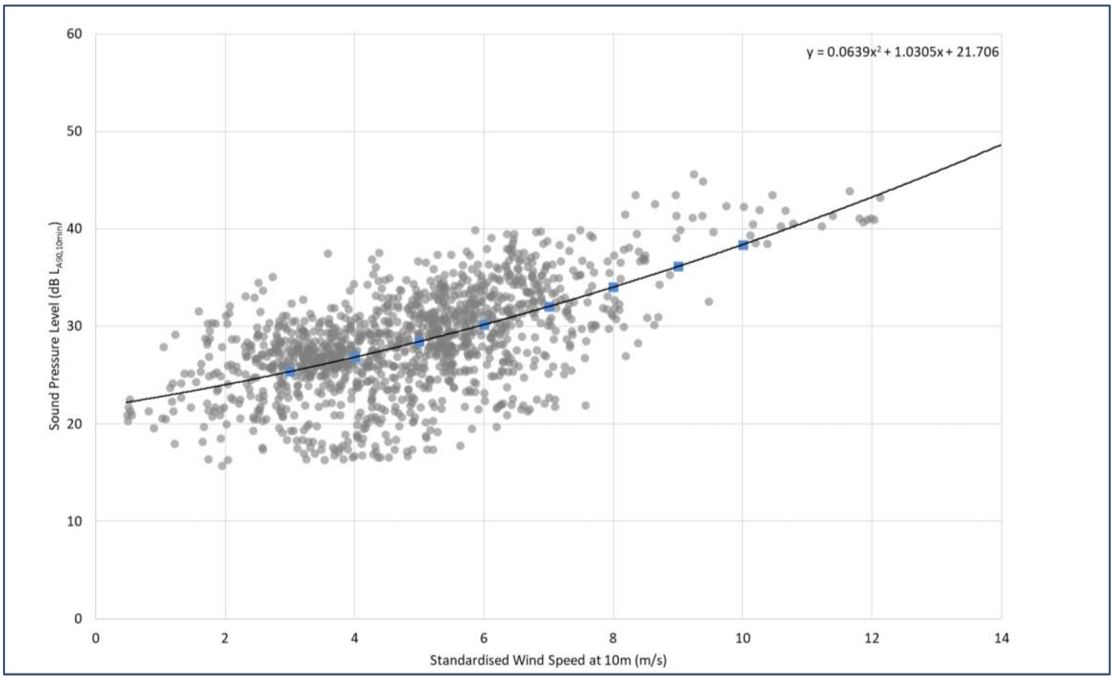


Figure 11-7 Location B - Background Noise Levels dB $L_{A90,\ 10\ min}$–Daytime

11.4.1.2.2 Night-time Periods

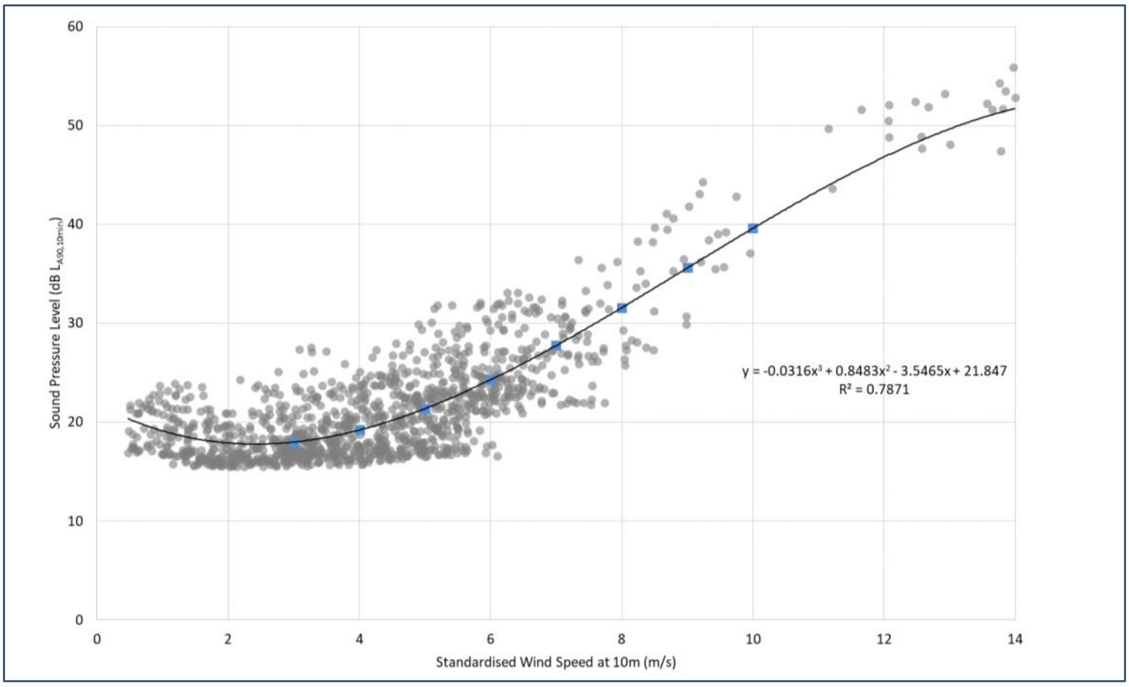


Figure 11-8 Location B - Background Noise Levels dB $L_{A90,\ 10\ min}$–Night -time

11.4.1.3 Location C

11.4.1.3.1 Daytime Quiet Periods

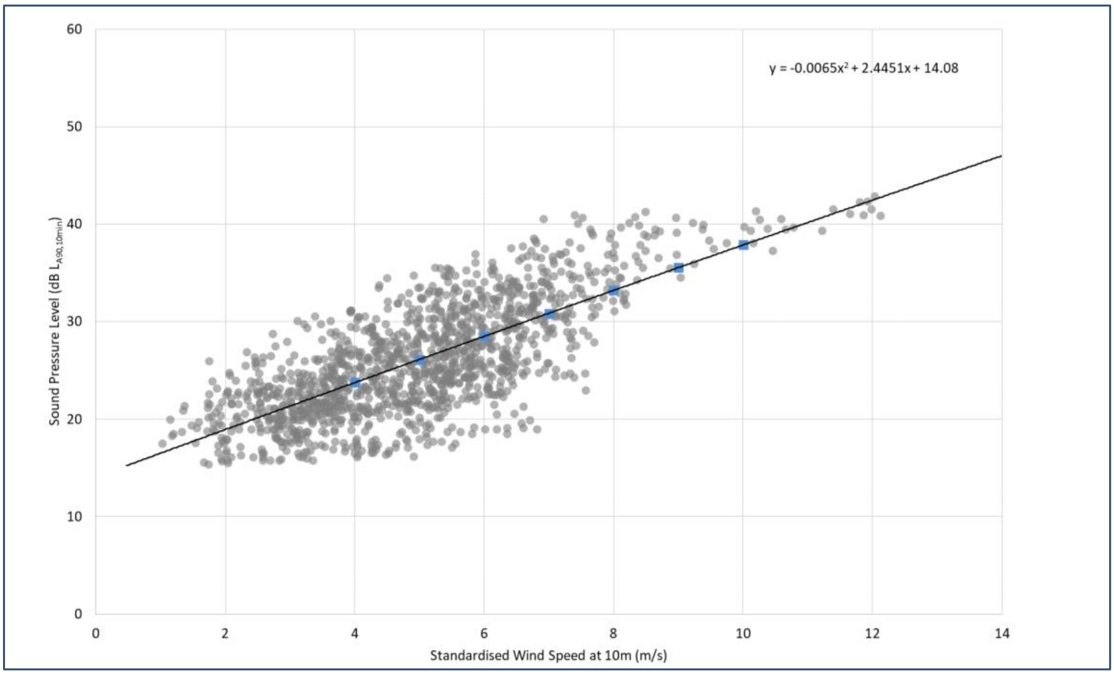


Figure 11-9Location C - Background Noise Levels dB $L_{A90,\ 10\ min}$–Daytime

11.4.1.3.2 Night-time Periods

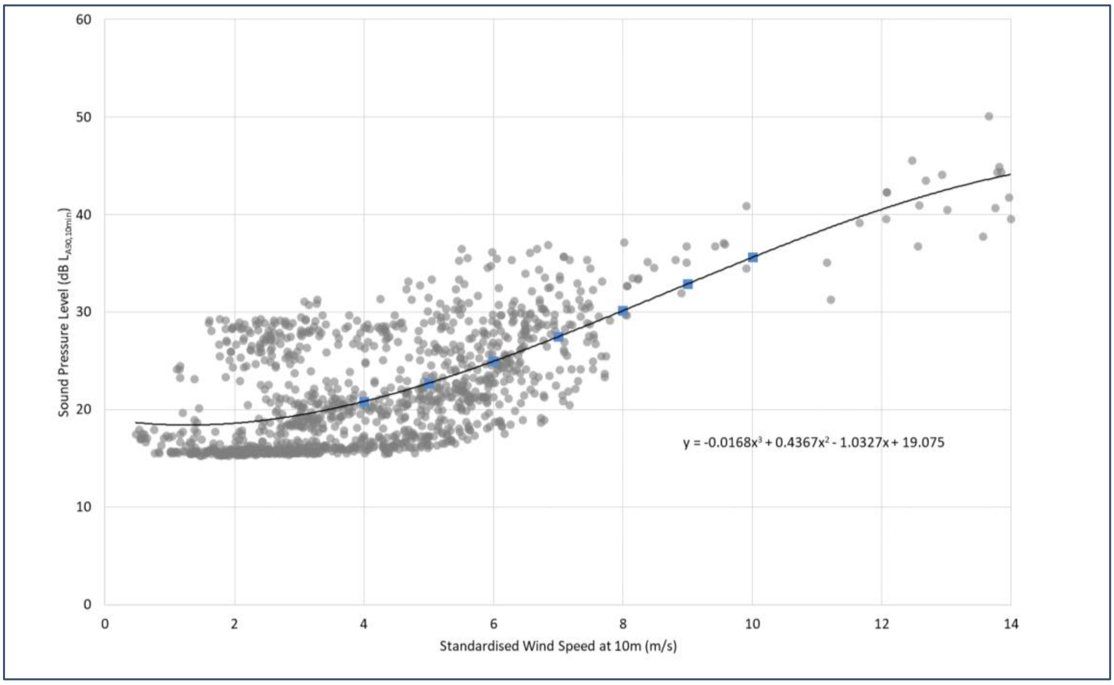


Figure 11-10 Location C - Background Noise Levels dB $L_{A90,\ 10\ min}$– Night -time

11.4.1.4 Summary of Background Noise Levels

Table 11-12 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 guidance contained the IoA GPG and the *Supplementary Guidance Note (SGN) No. 2 Data Processing & Derivation of ETSU-R-97 Background Curves.*

Table 11-12 Derived Background Noise Levels

Location	Period	Derived $L_{A90,\ 10\ min}$ Levels (dB) at various Standardised 10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A	Day	23.5	24.6	26.0	27.4	29.0	30.8	32.6	34.6
	Night	18.7	19.8	21.2	22.8	24.8	27.1	29.6	32.5
B	Day	25.4	26.8	28.5	30.2	32.0	34.0	36.2	38.4
	Night	18.0	19.2	21.4	24.3	27.7	31.6	35.6	39.6
C	Day	21.4	23.8	26.1	28.5	30.9	33.2	35.6	37.9
	Night	19.5	20.9	22.7	25.0	27.5	30.2	32.9	35.6
Envelope	Day	21.4	23.8	26.0	27.4	29.0	30.8	32.6	34.6
	Night	18.0	19.2	21.2	22.8	24.8	27.1	29.6	32.5

Review of the background noise levels confirms they are the order of magnitude expected considering the location of the meters and the existing soundscapes in the areas. In order to provide a worst case review based on the data to hand a worst-case envelope based on the lowest average levels measured at the three locations at various wind speeds for both day and night time is presented in Table 11-12.

It is proposed to adopt this envelope limit to derive turbine noise thresholds for the initial screening phase of the assessment. In a situation where measurements have been conducted near another receiver or the location is deemed to be representative of the measured background noise levels at other locations, these can be used for establishing appropriate noise limits at other locations.

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

11.4.2 Wind Turbine Noise Criteria

Noise criteria curves in Table 11-13 have been derived for the NSL's surrounding the Cleanrath wind farm development. These limit values are determined through applying the following criteria:

- 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 5 dB above background noise (whichever is higher) for night time periods.

Table 11-13 Noise Criteria Curves

Location	Period	Derived $L_{A90,\ 10\ min}$ Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A	Day	40.0	40.0	40.0	40.0	40.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
B	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.6
C	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Envelope	Day	40.0	40.0	40.0	40.0	40.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

11.5 Likely Significant Effects and Associated Mitigation Measures

11.5.1 Do-Nothing Scenario

A do-nothing option to developing the Cleanrath wind farm development would have been to leave the site as it was prior to construction, with no changes made to the land-use practices of low-intensity agriculture, turf cutting and commercial forestry. This option would have no positive impact with regards to the production of renewable energy or the offsetting of greenhouse gas emissions. On the basis of the positive environmental effects arising from the Cleanrath wind farm development, the do–nothing scenario was not the chosen option.

The Cleanrath wind farm development has been constructed, has been operational and is now operating in Sleep Mode with the site essentially in a shut-down mode with no export of electricity pending the outcome of the Substitute Consent process. In the event that Substitute Consent is obtained, the intention is to recommence and continue the full operation of the Cleanrath wind farm development until the end of 25 years from the formal commissioning of the turbines in July 2020 and implement the decommissioning plan for the Cleanrath wind farm development at the end of the operational period.

In the event that Substitute Consent is not granted and full operation of the development is not recommenced, it will remain in Sleep Mode which is, in effect, the "do nothing" option insofar as it represents the current situation as at the date of the application for Substitute Consent. There is the possibility that the decommissioning plan may need to be implemented early, should Substitute Consent not be granted and therefore this is also assessed in this rEIAR and below.

11.5.2 Construction Phase Potential Impacts

A variety of items of plant were used for the purposes of site preparation, construction of turbines, roads and other site works. There were vehicular movements to and from the site that made use of existing roads. Due to the nature of these activities, was is potential for generation of significant levels of noise. These are discussed in the following Sections.

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

It should also be noted that the estimated "worst case" levels are expected to have occurred for only short periods of time at a very limited number of properties. It is concluded that construction noise levels were lower than these limits for the construction phase of the Cleanrath wind farm development.

There are several stages and elements associated with the construction phase of the Cleanrath wind farm development which includes the following:

- Turbines and Hardstands;
- Grid connection works.;
- Internal roads,
- Borrow Pits
- Temporary Construction Compound and;
- Works along transport route

Detailed information is included in Chapter 4: Description of the Cleanrath wind farm development.

In general, the distances between the construction activities associated with the Cleanrath wind farm development and the nearest NSL's are such that there was no significant noise and vibration impacts at NSL's. The following sections present an assessment of the main stages of the construction phase that had the potential for associated noise and vibration impacts, all other stages and element are considered not to have significant noise and vibration impacts at NSL's.

11.5.2.1 Turbines Construction and Associated Works

11.5.2.1.1 Noise

Turbine and Hardstands

Several indicative noise levels for the types of machinery that were used on site have been identified and predictions of the potential noise emissions calculated at the nearest sensitive receptor. The nearest sensitive location (C15) is situated approximately 613m from Turbine 6.

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

Table 11-14 Typical Construction Noise Emission Levels for Turbine Construction and Associated Works

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$)
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77
Excavator Mounted Rock Breaker (C9.12)	Breaking Rock	85
General Construction (Various)	All general activities plus deliveries of materials and plant.	84
Dewatering Pumps (D.7.70)	Removal of water ingress from excavation area	80
JCB (D.8.13)	For services, drainage and landscaping.	82
Vibrating Rollers (D.8.29)	Road surfacing.	77

Assuming as a worst-case that all turbines and hardstands had been constructed simultaneously, the noise levels for the houses with the top 5 noise levels are presented in Table 11-15. The values are well below the construction noise criteria in Table 11-1.

Table 11-15 Worst-case predicted noise levels for turbine and hardstand construction

NSL Ref.	Predicted Noise Level (dB $L_{Aeq,T}$)
C28	49
C15	49
C14	49
C23	47

NSL Ref.	Predicted Noise Level (dB $L_{Aeq,T}$)
C24	47

It is concluded that there were no significant noise impacts associated with the construction of the turbine and hardstands and therefore no specific mitigation measures were required. Moreover, in respect of the construction of Derragh Wind Farm including Derragh substation, it is concluded that due to the additional distance between the NSLs at Cleanrath Wind Farm and the Derragh site, cumulative noise levels remain within criteria even if the construction periods for both sites coincided.

Grid Connection Works

The Cleanrath wind farm development connects to the electricity substation at Derragh Wind Farm and subsequently on to the national grid via an Coomataggart electricity substation in the townland of Grousemount Co. Kerry. Indicative noise levels for the types of machinery that were used on site have been identified. The grid connection route passed by houses along local roads. To provide an indication of the potential noise impact, the noise levels due to the grid connection construction machinery have been calculated and a number of distances as show in Table 11-16.

Table 11-16 Typical Construction Noise Levels for Grid Connection Construction

Item (BS 5228 Ref.)	Plant Noise Level at reference 10m Distance (dB $L_{Aeq,T}$) [9]	20m	40m	60m	80m
HGV Movement (C.2.30)	79	68	60	56	53
Excavator Mounted Rock Breaker (C9.12)	85	74	66	62	59
Vibrating Rollers (D.8.29)	77	66	58	54	51
Total	-	75	68	63	60

The table shows that within a distance of 60m, noise levels were in excess of the construction noise criteria in Table 11-1 and therefore the impact was significant. However, the impact was brief as the grid connection construction proceeded at a typical rate of 150 – 300 metres per day.

It is concluded that while there were significant noise impacts on some noise-sensitive locations along the grid connection route, the impact was brief and therefore no specific mitigation measures were required beyond the best-practice measures in Section 11.5.5.

Internal Roads

An internal road to access the turbines and associated infrastructure was constructed as part of the Cleanrath wind farm development. Review of the internal road layout has identified that the nearest NSL is C28 which is located 180m from the section of the internal road. All other locations are at

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

greater distances with the majority at significantly greater distances. The full description of the constructed internal roads is outlined in Chapter 4 of the rEIAR.

The items of plant used for the construction of the internal roads were similar to those used for the turbines hardstands. Table 11-17 shows that at distances of 80m or greater, the construction noise levels were below the criteria in Table 11-1 and therefore the impact was not significant.

Table 11-17 Typical Construction Noise Levels for Internal Road Construction

Item (BS 5228 Ref.)	Plant Noise Level at reference 10m Distance (dB $L_{Aeq,T}$)	20m	40m	60m	80m
HGV Movement (C.2.30)	79	68	60	56	53
Tracked Excavator (C.4.64)	77	66	58	54	51
Excavator Mounted Rock Breaker (C9.12)	85	74	66	62	59
General Construction (Various)	84	73	65	61	58
Dewatering Pumps (D.7.70)	80	69	61	57	54
JCB (D.8.13)	82	71	63	59	56
Vibrating Rollers (D.8.29)	77	66	58	54	51
Total	-	**79**	**71**	**67**	**64**

Borrow Pits

The Borrow Pit was located near turbine T5. The nearest NSL to this location is house C21 at a distance of approximately 1070m. Table 11-18 outlines the assumed noise levels for the plant items as extracted from *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.*

Table 11-18 Typical Construction Noise Levels for Borrow Pits

~~Item~~	~~BS 5228 Ref:~~	~~dB L_w Levels per Octave Band (Hz)~~								~~dB(A)~~
		~~63~~	~~125~~	~~250~~	~~500~~	~~1k~~	~~2k~~	~~4k~~	~~8k~~	
Crusher	C1.14	121	114	107	109	103	99	94	87	110
Rock Breaker	C9.11	119	117	113	117	115	115	112	108	121
Dozer	C8.9	78	90	97	95	99	94	89	82	103
Dewatering	D7.70	90	95	102	102	104	100	97	83	109
Generator	C6.39	81	86	93	89	83	80	74	67	96

A construction noise model has been prepared to consider the expected noise emissions from the borrow pits. A percentage on-time of 66% has been assumed for the noise calculations. The noise levels for the houses with the top 5 predicted noise levels due to borrow pit activity are presented in Table 11-19. The values are well below the construction noise criteria in Table 11-1 and therefore the impact was not significant.

Table 11-19 Worst-case predicted noise levels for borrow pit activity

NSL Ref.	Predicted Noise Level (dB $L_{Aeq,T}$)
C03	40
C24	40
C28	39
C01	38
C21	38

Temporary Construction Compound

A temporary construction compound was located near T1. For the construction of the temporary compound, the same items of plant were used as for the turbines, hardstands and associated works as shown in Table 11-14. Once again, the noise levels for the houses with the top 5 noise levels due to the construction of the temporary compound are presented in Table 11-20. The values are well below the construction noise criteria in Table 11-1.

Table 11-20 Worst-case predicted noise levels due to the construction of the temporary compound

NSL Ref.	Predicted Noise Level (dB $L_{Aeq,T}$)
C28	47
C21	41
C20	40
C19	40
C18	39

Works along Transport Route

Road and junction upgrade works were completed to facilitate delivery of the turbine components to the Cleanrath wind farm development at the exiting junction between the L-7435 and the local road in the townland of Cloontycarthy adjacent to an existing operational sawmill. The works comprised a new section of road on the eastern site of the junction to reduce the turning area required by abnormal loads. The temporary junction accommodation works were only be used by the turbine delivery/abnormal load vehicles and other vehicles associated with the delivery process. The extent of this junction upgrade is outlined within the Layout Drawings in Appendix 4-1. Also included in the works along the transport was the construction of the site entrances.

Review of the extent of these works has identified that the nearest NSL is C30 at a distance of approximately 10m, C08, C09 at a distance of approximately 80m, and others at least 100m from the works including C08A, C34, C33, C32, and C31.

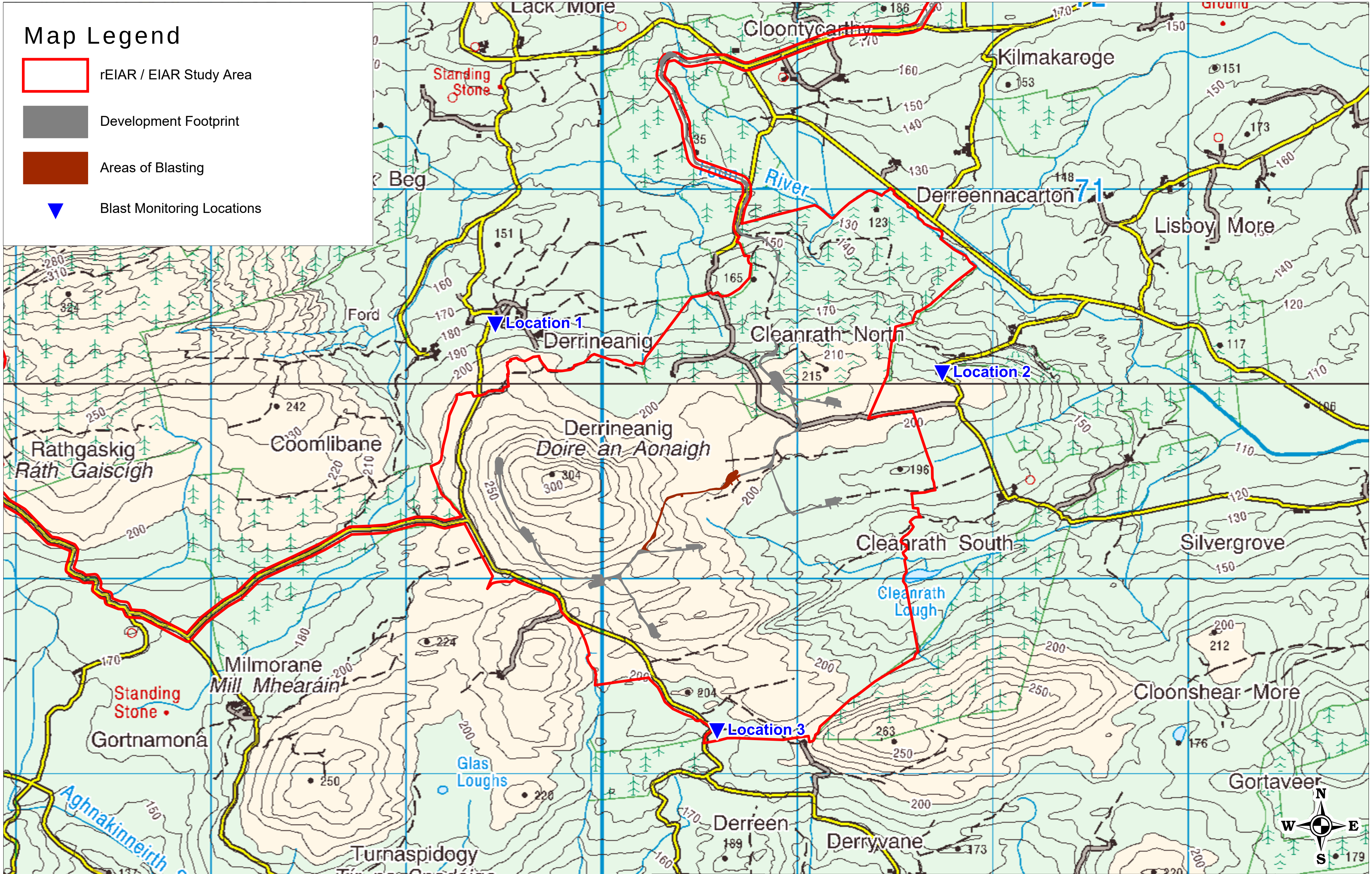
Once again, the items of plant used for the junction upgrade works were similar to those used for the internal site roads. Table 11-17shows that at distances of 60m or greater, the construction noise levels were below the criteria in Table 11-1 and therefore the impact was not significant. At the one location closer than 60m (C30), the noise levels were in excess of the criterion, however the section of works adjacent to this property lasted 10 days, therefore the impact was temporary.

11.5.2.1.2 Vibration

Blasting

Blasting was limited to the borrow pit area and a section of roadway approximately around T05 to T08, as shown in Figure 11-11. Vibration and air overpressure were monitored during four blast events as described in the report 20_0537VL02A prepared by CLV Consulting Ltd (See Appendix 11-5). Measured vibration and air overpressure were found to be compliant with the relevant conditions in the 2017 Permission in all cases.

It is concluded that there were no significant noise or vibration impacts associated with blasting.



MAP TITLE: **Blast Monitoring Locations** | MAP NO.: **Figure 11-11** | SCALE: **1:25,000**

PROJECT TITLE: **Cleanrath Wind Farm** | DATE: **01-04-2020**

DRAWING BY: **Owen Cahill** | CHECKED BY: **Michael Watson** | ISSUE NO.: **191223-a-2020.04.01-F**

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11.5.2.1.3 Description of Effects

With respect to the EPA criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive locations associated with the construction of Turbines, Hardstands, Grid Connection and Internal Roads of the Cleanrath wind farm development are described below.

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

It is concluded that there were no significant noise or vibration effects due to the construction of the project.

11.5.2.2 Construction Traffic

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

The following situations are commented upon here:

- Stage 1a – Concrete delivery for Turbine Foundations
- Stage 1b – Concrete delivery for Cable
- Stage 1c – Site Preparation and ground works
- Stage 2a – Extended Artic Deliveries (large turbine components)
- Stage 2b – Other Deliveries (small turbine components)

Changes in the traffic noise levels associated with the additional traffic for each of the construction stages listed above have been calculated for several routes. Table 11-21 presents a summary of the data used for the calculations in this assessment. The figures in Table 11-21 have been derived from the traffic data in Chapter 14 with factors applied for the passenger car unit (PCU) factors. Details of the calculations are shown in Appendix 11-6.

In respect of Stage 1a, with 66 loads of concrete and associated equipment and materials required for each turbine base, delivered to the site over a 12 hour period, resulting in just over 5 to 6 HGV trips to and from the site per hour.

Table 11-21 Construction Phase Traffic Data

Stage	Route	Background Flows		Total Flows (background + development)	
		Daily vehicles	%HGV	Daily Vehicles	%HGV
1a - Concrete delivery for foundations	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,675	8.0%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,852	12.6%
	Local road east of woodmill	1,213	6.5%	1,505	14.0%

Stage	Route	Background Flows		Total Flows (background + development)	
		Daily vehicles	%HGV	Daily Vehicles	%HGV
	Local road south of wood mill	304	6.5%	596	25.4%
Stage 1b - Concrete delivery for Cable[10]	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,388	6.6%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,565	6.8%
	Local road east of woodmill	1,213	6.5%	1,218	6.9%
	Local road south of wood mill	304	6.5%	309	8.2%
Stage 1c - Site preparation and groundworks[11]	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,566	6.7%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,743	7.1%
	Local road east of woodmill	1,213	6.5%	1,396	7.3%
	Local road south of wood mill	304	6.5%	487	8.9%
Stage 2 - Extended Artics	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,549	6.4%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,726	6.2%
	Local road east of woodmill	1,213	6.5%	1,379	6.2%
	Local road south of wood mill	304	6.5%	470	5.6%

[10] Concrete delivery occurred across the entire cable route from Cleanrath Wind Farm Development to the Coomataggart substation. Background traffic data is not available for this route but the noise impact associated with the known traffic volumes associated with concrete is considered in Table 11-22.

[11] The transport of spoil material excavated from the cable route trench utilised public roads other than those listed in Table 11-17 for which background traffic data is not available but the noise impact associated with the known traffic volumes associated with concrete is considered in Table 11-22.

Stage	Route	Background Flows		Total Flows (background + development)	
		Daily vehicles	%HGV	Daily Vehicles	%HGV
Stage 2 - Other Deliveries	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,552	6.5%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,729	6.3%
	Local road east of woodmill	1,213	6.5%	1,382	6.3%
	Local road south of wood mill	304	6.5%	473	6.1%

Based on the traffic data presented in Table 11-21 the changes in noise level relative to the traffic levels existing at the time of the construction period have been calculated and are outlined in Table 11-22.

Table 11-22 Calculated Changes in Traffic Noise Levels

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
1a - Concrete delivery for foundations	N22 east of Gortanaddan (at Mors Bar)	0.8	9
	Gortanaddan Road (at Mors Bar)	2.9	9
	Local road east of woodmill	3.5	9
	Local road south of wood mill	7.5	9
Stage 1b - Concrete delivery for Cable	N22 east of Gortanaddan (at Mors Bar)	0.0	191
	Gortanaddan Road (at Mors Bar)	0.2	191
	Local road east of woodmill	0.2	191
	Local road south of wood mill	0.7	191
Stage 1c - Site preparation and groundworks	N22 east of Gortanaddan (at Mors Bar)	0.2	103
	Gortanaddan Road (at Mors Bar)	0.8	103
	Local road east of woodmill	1.0	103
	Local road south of wood mill	2.9	103
Stage 2 - Extended Artics	N22 east of Gortanaddan (at Mors Bar)	0.1	28
	Gortanaddan Road (at Mors Bar)	0.3	28
	Local road east of woodmill	0.5	28
	Local road south of wood mill	1.4	28
Stage 2 - Other Deliveries	N22 east of Gortanaddan (at Mors Bar)	0.1	9
	Gortanaddan Road (at Mors Bar)	0.4	9
	Local road east of woodmill	0.5	9
	Local road south of wood mill	1.7	9

The predicted increases in traffic noise levels during each of the construction stages of the Cleanrath wind farm development are less than 3 dB in almost all cases. With reference to the criteria set out in Section 11.3.2.1.2 the potential impacts in these cases are minor and no additional mitigation measures were necessary.

During Stage 1a, along the local road south of wood mill, there was an increase in the traffic noise level just under +8dB. These activities occurred mainly during daytime periods. There are two mitigating factors to consider here: a) this phase of the construction lasted for only 9 days and b) the overall noise level at 5m from the road edge due the total traffic was calculated to be 58dB $L_{Aeq,1hr}$, which is below the 65dB $L_{Aeq,T}$ used as a daytime limit for construction noise in Table 11-1. Concrete pouring typically commenced at 05:00 hrs when the applicable limit was 45dB $L_{Aeq,1hr}$ (Table 11-1), thus the noise levels at the 5m from the road edge were in excess of this criterion for a period of 2 hours, with a maximum of 12 loads delivered on each of the 9 days.

Stages 1b and 1c also made used of roads other than those listed in the tables in this section. Assuming that similar the noise level increases applied along these other roads, the worst-case increase in noise level during Stage 1b is +0.7dB(A) and during Stage 1c is +2.9dB(A), then the impacts for each of these stages are considered negligible and minor respectively,

It is concluded that there were no significant noise impacts associated with the additional traffic generated during the construction phase of the Cleanrath wind farm development and therefore no specific mitigation measures were required.

11.5.2.2.1 Description of Effects

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

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

11.5.3 Operational Phase Potential Impacts

The effects set out below relate to the operational phase of the Cleanrath wind farm development should Substitute Consent be granted. This includes the previous period of short-term operation and the current period of Sleep Mode and also assesses the future full operation.

11.5.3.1 Turbine Noise Assessment

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

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

Coordinates for all NSLs used in this assessment are presented in Table 11-23 below

Table 11-23 List of Coordinates for all Noise Sensitive Locations

NSL Ref.	Coordinates – Irish Grid (IG)	
	Easting	Northing
C01	122262	69438
C03	122046	69412
C04	121812	70132

NSL Ref.	Coordinates – Irish Grid (IG)	
	Easting	Northing
C05	122091	70263
C06	121472	71134
C07	121824	71178
C07a	120982	71379
C08	120933	71612
C08a	120926	71560
C09	120836	71588
C10	119985	71697
C11	119587	71734
C12	119404	71709
C13	119392	71283
C14	119146	70163
C15	119160	70151
C16	119273	70396
C16a	119298	70358
C17	119324	70326
C18	119454	70319
C18a	119418	70330
C19	119567	70308
C20	119628	70320
C21	119674	70252
C23	120645	68050
C24	121036	68169
C25	118171	68346
C26	118145	68366
C27	118095	68367
C28	120591	70627
C30	121124	71744
C31	121212	71559
C32	121090	71507
C33	121115	71552
C34	120983	71563
C35	122024	71817
C36	122046	71699

NSL Ref.	Coordinates – Irish Grid (IG)	
	Easting	Northing
C37	121868	71177
C38	122819	70677
C39	122626	70775
C40	122541	70813
C41	122471	70918
C42	122532	70933
C43	122564	70974
C44	122780	71015
C45	122863	71041
C46	122874	70999
C47	122905	71001
C48	123012	71123
C49	123095	71193
C50	123163	71205
C51	123363	71229
C52	123375	71049
C53	120358	67153
C54	120372	67144
C55	120403	67134
C56	120715	67194
C57	120759	67234
C58	120856	67262
C59	121407	67611
C60	121469	67523
C61	121496	67500
C62	121459	67422
C64	121632	67472
C65	121705	67431
C66	121756	67411
C67	121636	67226
C68	121815	66918
C69	122614	67651
C70	124048	68677
C70a	122521	70473

NSL Ref.	Coordinates – Irish Grid (IG)	
	Easting	Northing
C71	123599	69357
C72	122689	69624
C73	122683	69605

The omni-directional cumulative turbine noise predictions for both the Cleanrath wind farm development and Derragh wind farms in operation are presented in Appendix 11.7. A noise contour for the standard mode of operation at 9m/s has been presented in Appendix 11.8.

Table 11-24 presents the predicted noise levels compared against the adopted criteria for the location with the highest noise level at 9 m/s standardised wind speed, which is NSL C28.

It should be noted that the assessment has been undertaken in accordance with best practice guidance outlined in the IOA GPG and as previously stated, calculated using the ISO 9613-2 standard and relate to worst-case conditions favourable to noise propagation (typically downwind propagation from source to receiver and/or downward refraction under temperature inversions).

The cumulative predicted turbine noise emissions are all below the adopted criteria curves for day and night time periods at all properties.

Table 11-24 Predicted Noise Levels compared against adopted Noise Criteria (house C28)

NSL	Description	Predicted Noise Level dB L_{A90} at Standardised Wind Speed at 10m A.G.L.						
		3.0	4.0	5.0	6.0	7.0	8.0	9.0
C28	Predicted Noise Level	29.6	31.0	34.9	36.1	36.8	36.7	37.0
	Daytime Noise Criteria	40.0	40.0	40.0	40.0	40.0	45.0	45.0
	Potential Daytime Exceedance	–	–	–	–	–	–	–
	Night time Noise Criteria	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Potential Night time Exceedance	–	–	–	–	–	–	–

To ensure compliance with the noise condition applied to the development, commissioning noise surveys were carried out between 26th March to 7th May 2020. Full details of the noise surveys and analysis are presented in report ref: MS/18/10355NR01 dated 14 July 2020 by AWN Consulting included here in Appendix 11-9. The planning condition in the 2017 permission relating to noise is presented in Section 11.3.2.2.6. A summary of the results of this monitoring survey are presented here.

An operational survey of noise levels was carried out at three locations: C04, C18 and C23. The monitoring was carried out in accordance with the IoA GPG Supplementary Guidance Note 5: Post-Completion Measurements. The noise levels in the following table compares the measured noise levels against the noise criteria applied to the site in the 2017 Permission. It was found that the total noise levels measured i.e. the noise due to the wind farm and the background noise together, were comfortably below the limit values in the 2017 Permission in all cases, as shown in Table 11-25, without the need to consider the issue of the influence of existing background noise levels.

Table 11-25 Comparison of Measured Cumulative Noise Levels against 2017 Planning Noise Criteria

NSL	Description	Total Noise Level dB L_{A90} at Standardised Wind Speed at 10m A.G.L.					
		3.0	4.0	5.0	6.0	7.0	≥8.0
C04	Measured Cumulative Noise Level	26.1	28.4	31.3	34.1	36.6	38.1
	Noise Criterion Curve	43.0	43.0	43.0	43.0	43.0	43.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes
C18	Measured Cumulative Noise Level	24.1	25.5	27.8	30.4	32.8	34.4
	Noise Criterion Curve	43.0	43.0	43.0	43.0	43.0	43.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes
C23	Measured Cumulative Noise Level	22.3	26.2	29.4	31.8	33.6	34.5
	Noise Criterion Curve	43.0	43.0	43.0	43.0	43.0	43.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes

As discussed here, the current assessment has applied a more onerous daytime noise criterion to the site activities. The following table reviews the measured cumulative noise levels against the noise criteria curves proposed in the current assessment:

Table 11-26 Comparison of Measured Cumulative Noise Levels against Current Assessment Noise Criteria

NSL	Description	Total Noise Level dB L_{A90} at Standardised Wind Speed at 10m A.G.L.					
		3.0	4.0	5.0	6.0	7.0	≥8.0
C04	Measured Cumulative Noise Level	26.1	28.4	31.3	34.1	36.6	38.1
	Daytime Noise Criterion Curve	40.0	40.0	40.0	40.0	40.0	45.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes
	Night time Noise Criterion Curve	43.0	43.0	43.0	43.0	43.0	43.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes
C18	Measured Cumulative Noise Level	24.1	25.5	27.8	30.4	32.8	34.4
	Daytime Noise Criterion Curve	40.0	40.0	40.0	40.0	40.0	45.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes
	Night time Noise Criterion Curve	43.0	43.0	43.0	43.0	43.0	43.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes
C23	Measured Cumulative Noise Level	22.3	26.2	29.4	31.8	33.6	34.5
	Daytime Noise Criterion Curve	40.0	40.0	40.0	40.0	40.0	45.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes
	Night time Noise Criterion Curve	43.0	43.0	43.0	43.0	43.0	43.0
	Complies?	Yes	Yes	Yes	Yes	Yes	Yes

As shown above, the measured noise levels show that the cumulative operation of the Cleanrath wind farm development complies with the standard interpretation of the WEDG06 guidelines, where the daytime noise criterion would have a lower daytime limit (e.g. 40dB(A)) at wind speeds where the background noise is than less than 30dB L_{A90} once consideration is given to the issue of background noise as adopted for this assessment.

The measured noise levels are below the predicted noise levels; this can be due to a number of factors:

- the predicted levels include an allowance for uncertainty, in accordance with guidance in the Institute of Acoustics document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*;

- the calculations predict noise levels using ISO 9613: Acoustics – Attenuation of sound during propagation outdoors which predicts noise levels "under conditions favourable to noise propagation" which due to variations in meteorological conditions, do not apply at all times during a noise survey; and
- the calculations assume that the wind turbine noise emissions are uniform in all directions. Real wind turbine noise emissions have a directional pattern relative to the wind direction, as explained in Section 11.3.8.3. However, it should be noted that the measured noise levels presented in the commissioning report are based on downwind conditions.

The conclusion from the discussion above is that if the Cleanrath wind farm development were to recover its planning permission, it has been demonstrated 'in advance' that the noise levels at the noise sensitive locations in the vicinity of the wind farm would be in compliance with the adopted criteria in this assessment and the 2017 permission.

11.5.3.1.1 Description of Effects

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

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

11.5.3.2 Internal Roads

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

11.5.3.2.1 Description of Effects

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

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

11.5.3.3 Operational Phase Maintenance and Associated Works

For a short period of approximately three weeks during the operational phase, the restoration of peatland habitat will be carried out at a forested area near turbine T8, as described in Chapter 4 Section 4.9.1. This will involve an excavator and a HGV. The distance to any noise-sensitive location is over 1km and therefore the noise impacts will not be significant.

During the operational phase generally, both scheduled and unscheduled maintenance of the wind turbines will involve visits to site using four-wheel drive vehicles or vans, accessing the turbines using the constructed internal roads. Occasionally, major components including generators or turbine blades may be necessary and may require the use of cranes and extended articulated trucks. Due to the infrequency of major component replacements, it is considered that the noise impact of maintenance activities is not significant.

11.5.3.3.1 Description of Effects

With respect to the EPA criteria for description of effects, the potential worst-case effects at the nearest noise sensitive location associated with the operational phase maintenance and associated works are described below.

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

11.5.3.4 Operational Phase Traffic for Maintenance and Associated Works

Similar to Section 11.5.2.2, section reviews noise impacts associated with additional traffic on the local road network during the operational phase. The information presented in Chapter 14 (Section 14.1.5.2) has been used to inform the assessment here.

Changes in the traffic noise levels associated with the additional traffic for the period of peatland habitat restoration have been calculated. Table 11-25presents a summary of the data used for the calculations in this assessment. The figures in Table 11-25 have been derived from the traffic data in Chapter 14 with factors applied for the passenger car unit (PCU) factors.

Table 11-27 Operational Traffic Data for Peatland Habitat Restoration

Stage	Route	Background Flows		Total Flows (background + development)	
		Daily vehicles	%HGV	Daily vehicles	%HGV
Peatland restoration works and general maintenance during operation	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,395	6.6%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,572	6.8%
	Local road east of woodmill	1,213	6.5%	1,225	6.9%
	Local road south of wood mill	304	6.6%	316	8.2%

Based on the traffic data presented in Table 11-25 the changes in noise level relative to the traffic levels existing at the time of the construction period have been calculated and are outlined in Table 11-26.

Table 11-28 Calculated Changes in Traffic Noise Levels – Peatland Habitat Restoration

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
Peatland Habitat Restoration	N22 east of Gortanaddan (at Mors Bar)	0.0	2
	Gortanaddan Road (at Mors Bar)	0.2	2
	Local road east of woodmill	0.3	2
	Local road south of wood mill	0.8	2

The predicted increases in traffic noise levels during the peatland habitat restoration are less than 1 dB along all routes. With reference to the criteria set out in Section 11.3.2.1.2 the potential impacts are negligible are worst case and no additional mitigation measures are proposed.

The period of 2 days referred to in Table 11-26 applies to the delivery of and removal of vehicles required to carry out the peatland habitat restoration. During the restoration works period of 3 weeks, there will be maximum of three vehicles access in the site per day, as described in Chapter 14. The effect of the additional traffic noise due to these site visits is negligible.

Once the peatland habitat restoration works are completed, the ongoing maintenance of the Cleanrath wind farm development will require a maximum of three staff on site on any one time, as described in Chapter 14. Similarly, the effect of the additional traffic noise due to these site visits is negligible.

It is concluded that there will be no significant noise impacts associated with the additional traffic generated during the operational phase of the Cleanrath wind farm development and therefore no specific mitigation measures are required.

11.5.3.4.1 Description of Effects

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

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

11.5.4 Decommissioning Phase Potential Impacts

The wind turbines installed as part of the Cleanrath wind farm development are expected to have a lifespan of approximately 25 years. Following the end of their useful life, they may be replaced with new turbines, subject to planning permission being obtained, or the site may be decommissioned, with the exception of the 38kV grid connection cabling which will be an ESB networks asset. Should early decommissioning be required the same process as outlined below will be followed. A full description of the decommissioning phase is presented in Section 4.10 of Chapter 4.

Criteria for decommissioning noise are the those presented in Section 11.3.2.1.1. Expected noise levels are similar to those presented in Table 11-15, that is, well within the criteria for construction and decommissioning noise.

11.5.4.1 Description of Effects

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

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

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

11.5.4.2 Decommissioning Phase Traffic

Similar to previous sections on traffic noise, impacts associated with noise due to additional traffic on the local road network during the decommissioning phase are reviewed here. The information presented in Chapter 14 (Section 14.2.5.3) has been used to inform the assessment.
Changes in the traffic noise levels associated with the additional traffic decommissioning phase have been calculated. Table 11-27 presents a summary of the data used for the calculations in this assessment. The figures in Table 11-27 have been derived from the traffic data in Chapter 14 with factors applied for the passenger car unit (PCU) factors.

Table 11-29 Decommissioning Phase Traffic Data

Stage	Route	Background Flows		Total Flows (background + development)	
		Daily vehicles	%HGV	Daily vehicles	%HGV
Extraction of Wind Turbine Plant - Extended Artics	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,409	6.6%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,586	6.8%
	Local road east of woodmill	1,213	6.5%	1,239	6.9%
	Local road south of wood mill	304	6.6%	330	7.9%
Extraction of Wind Turbine Plant - Standard Artics	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,412	6.6%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,589	6.9%
	Local road east of woodmill	1,213	6.5%	1,242	7.1%
	Local road south of wood mill	304	6.6%	333	8.6%
Preparation of temporary accommodation areas and foundation backfill	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,450	7.1%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,627	9.1%
	Local road east of woodmill	1,213	6.5%	1,280	9.8%

Stage	Route	Background Flows		Total Flows (background + development)	
		Daily vehicles	%HGV	Daily vehicles	%HGV
	Local road south of wood mill	304	6.6%	371	18.0%
Removal of cables from ducting	N22 east of Gortanaddan (at Mors Bar)	7,383	6.5%	7,405	6.5%
	Gortanaddan Road (at Mors Bar)	1,560	6.5%	1,582	6.5%
	Local road east of woodmill	1,213	6.5%	1,235	6.6%
	Local road south of wood mill	304	6.6%	326	6.9%

Based on the traffic data presented in Table 11-27, the changes in noise level relative to the traffic levels existing at the time of the construction period have been calculated and are outlined in Table 11-28.

Table 11-30 Calculated Changes in Traffic Noise Levels – Decommissioning Phase

Stage	Route	Change in Traffic Noise Level dB(A)	Estimated Number of Days
Extraction of Wind Turbine Plant - Extended Artics	N22 east of Gortanaddan (at Mors Bar)	0.0	28
	Gortanaddan Road (at Mors Bar)	0.2	28
	Local road east of woodmill	0.3	28
	Local road south of wood mill	0.9	28
Extraction of Wind Turbine Plant - Standard Artics	N22 east of Gortanaddan (at Mors Bar)	0.0	9
	Gortanaddan Road (at Mors Bar)	0.3	9
	Local road east of woodmill	0.4	9
	Local road south of wood mill	1.2	9
Preparation of temporary accommodation areas and foundation backfill	N22 east of Gortanaddan (at Mors Bar)	0.3	5
	Gortanaddan Road (at Mors Bar)	1.2	5
	Local road east of woodmill	1.5	5
	Local road south of wood mill	4.2	5
	N22 east of Gortanaddan (at Mors Bar)	0.0	15

Removal of cables from ducting[12]	Gortanaddan Road (at Mors Bar)	0.1	15
	Local road east of woodmill	0.2	15
	Local road south of wood mill	0.4	15

The predicted increases in traffic noise levels during each of the construction stages of the Cleanrath wind farm development are less than 3 dB in almost all cases. With reference to the criteria set out in Section 11.3.2.1.2 the potential impacts in these cases are minor no additional mitigation measures are proposed.

During the preparation of temporary accommodation areas and foundation backfill, along the local road south of wood mill, an increase in the traffic noise level just over +4dB is predicted. These construction activities will occur during daytime periods. Again there are two mitigating factors to consider here: a) this phase of the decommissioning will last for only 5 days and b) the overall noise level at 5m from the road edge due the total traffic is calculated to be 58dB $L_{Aeq,1hr}$, which is below the 65dB $L_{Aeq,T}$ used as a daytime limit for construction noise in Table 11-1.

Similarly, to certain stages in the construction phase, removal of cables from ducting will make use of roads other than those listed in the tables in this section. Assuming that similar the noise level increases applied along these other roads, the worst-case increase in noise level during this decommissioning stage is +0.4dB(A), and the impacts for this stage are considered negligible.

It is concluded that there will be no significant noise impacts associated with the additional traffic generated during the decommissioning phase of the Cleanrath wind farm development and therefore no specific mitigation measures are proposed.

11.5.4.2.1 Description of Effects

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

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

11.5.5 Construction Phase Mitigation

The assessment of potential impacts has demonstrated that the Cleanrath wind farm development is expected to comply with the identified criteria for the construction phase. However, a schedule of mitigation measures was developed and is set out in the following sections.

Regarding construction activities, BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise* and BS 5228-2:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Vibration* have been taken into account.

[12] *The removal of cables may be required across the entire cable route from Cleanrath Wind Farm Development to the Coomataggart substation. Background traffic data is not available for this route but the noise impact associated with the known traffic volumes associated with cable removal is considered in Table 11-28.*

11.5.5.1 Construction Phase Mitigation Measures – Noise

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

- limited the hours during which site activities likely to create high levels of noise or vibration are permitted;
- established channels of communication between the contractor/developer, Local Authority and residents;
- appointed a site representative responsible for matters relating to noise and vibration;
- monitored vibration and air overpressure during blasting operations as discussed in Section 11.5.2.1.2;
- kept site access roads even to mitigate the potential for vibration from lorries.

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

- selected of plant with low inherent potential for generation of noise and/ or vibration;
- placed of noisy / vibratory plant as far away from sensitive properties as permitted by site constraints, and;
- carried out regular maintenance and servicing of plant items.

The contractor took specific noise abatement measures and complied 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 were implemented on site, to ensure compliance with the relevant construction noise criteria:

- No plant used on site was permitted to cause an on-going public nuisance due to noise.
- The best means practicable, including proper maintenance of plant, was employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant were fitted with effective exhaust silencers and maintained in good working order for the duration of the contract.
- Compressors were attenuated models fitted with properly lined and sealed acoustic covers which were kept closed whenever the machines were in use and all ancillary pneumatic tools were fitted with suitable silencers.
- Machinery that was used intermittently was shut down or throttled back to a minimum during periods when not in use.
- During the course of the construction programme, supervision of the works included ensuring compliance with the limits detailed in Section 11.3.2 using methods outlined in British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.*
- The hours of construction activity were limited to avoid unsociable hours where possible. Construction operations was generally restricted to between 7:00hrs and 19:00hrs Monday to Saturday. However, to ensure that optimal use is made of good weather periods or at critical periods within the programme (i.e. concrete pours, rotor/tower deliveries) it was necessary on occasion to work outside of these hours.

11.5.5.2 Construction Phase Mitigation Measures – Vibration

The blast monitoring report discussed in Section 11.5.2.1.2 shows that vibration and air overpressure were within the planning condition limits in the 2017 Permission and the below the best practice criteria. Mitigation measures were not required.

11.5.6 Operational Phase Mitigation Measures

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

The findings of the assessment confirmed that the cumulative predicted operational noise levels from the Cleanrath wind farm development and the Derragh Wind Farm Acting together are within the relevant noise criteria associated with their operation. Therefore, no mitigation measures are required.

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

11.5.6.1 Low Frequency Noise

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

11.5.6.2 Amplitude Modulation

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

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

11.5.6.3 Monitoring

Should Substitute Consent be granted for the Cleanrath wind farm development, further noise commissioning measurements would be carried out to ensure compliance with the relevant noise criteria curves.

11.5.6.4 Operational Phase Maintenance and Associated Works

As shown in Section 11.5.3.3, the effects of the operational phase maintenance and associated works are negative, imperceptible and long-term. Mitigation measures are not required.

11.5.7 Decommissioning Phase Mitigation Measures

The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those that were implemented for the construction phase of the development, i.e. as per Section 11.5.5.

11.5.8 Description of Residual Effects

11.5.8.1 Construction Phase

During the construction of the project there was some effect on nearby noise sensitive properties due to noise emissions from site traffic and other construction activities. However, given the distances between the main construction works and nearby noise sensitive locations and the fact that the construction phase of the development is temporary in nature, the various noise sources were not excessively intrusive. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, ensured that noise and vibration effects were kept to a minimum. It is reiterated here that the assessment has concluded that the calculated noise and vibration levels were well within the criteria outlined in Section 11.3.2.1 and therefore there were no significant effects associated with the construction phases.

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

11.5.8.2 Turbine Construction and Associated Works

The predicted residual noise and vibration effect associated with the construction of the turbines hardstands, the grid connection and internal roads is described follows:

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

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

11.5.8.3 Construction Traffic

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

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

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

11.5.8.4 Operational Phase

11.5.8.4.1 *Wind Turbine Noise*

The assessment has demonstrated that the turbine noise emissions from the Cleanrath wind farm development are within best practice noise criteria curves recommended in Irish guidance '*Wind Energy Development Guidelines for Planning Authorities*' published by the Department of the Environment, Heritage and Local Government in 2006. Therefore, it is not considered that a significant effect is associated with the development.

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

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

For NSLs beyond a distance of approximately 1.2 km from a turbine, the noise effect of the operational turbines can be described as follows:

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

11.5.8.4.2 Operational Phase Maintenance and Associated Works

As discussed in Section 11.5.6.4, the effect of the peatland restoration works, the maintenance visits to site and the infrequent replacement of major components does not generate significant noise impacts. The associated residual effects are as follows

Quality	*Significance*	*Duration*
Negative	Imperceptible	Long Term

11.5.8.5 Vibration

There are no expected sources of vibration associated with the operational phase of the Cleanrath wind farm development. In relation to of vibration the associated residual effect is summarised as follows:

Quality	*Significance*	*Duration*
Negative	Imperceptible	Long Term

11.5.8.6 Decommissioning Phase

During the decommissioning phase of the project there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other construction activities. However, given the distances between the main construction works and nearby noise sensitive properties and the fact that the decommissioning phase of the development is temporary in nature, it is expected that the various noise sources will not be excessively intrusive. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that noise and vibration effect is kept within the limits in Section 11.3.2.1.

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

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

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

11.5.9 Cumulative Effects

In respect of the construction of Derragh wind farm, as discussed in Section 11.5.2.1 the additional distance between the NSLs at Cleanrath at the Derragh turbine locations implies that construction noise levels remained within the criterion, even with both sites being constructed concurrently. Similarly, Grousemount wind farm is again further from the NSLs at Cleanrath. No significant cumulative effects occurred during the construction phase.

A review of existing, proposed and permitted wind turbine developments in the wider study has been undertaken in accordance with the guidance contained in the IOA GPG. This assessment has considered the potential cumulative impacts of the Cleanrath wind farm development in combination with other wind energy developments in the area as required by best practice guidance discussed in Section 11.3.2.2. The Derragh wind farm is accounted for in the predicted operational noise levels in Table 11-24 and Appendix 11-7.

The underground grid connection cabling connects to the Derragh substation and also passes through the Grousemount wind farm. Due to the distance from the underground cabling to the closest NSLs at these locations, no cumulative impacts occurred. A similar conclusion applies to decommissioning noise.