



GALETECH
ENERGY SERVICES

Islandmore Wind Farm

Environmental Impact Assessment
Report

Chapter 12: Noise & Vibration

Islandmore Wind Farm Limited

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12.1 INTRODUCTION

12.1.1 OBJECTIVES

This chapter presents an assessment of the likely construction, operation and decommissioning noise effects arising from the Islandmore Wind Farm ('the project') on the residents of nearby dwellings. The chapter also provides a baseline evaluation of the environmental setting of the project. Where required, appropriate mitigation measures to limit any significant identified effects arising as a consequence of noise or vibration are presented. The residual effects of the project post-mitigation are also assessed.

In addition, the assessment of operational noise accounts for the cumulative total of the project as well as the adjacent Largan Hill Wind Farm. Other, more distant, wind farms were not assessed as their noise contributions are likely to be negligible due to separation distance.

Noise and vibration which arises from the construction of a wind farm is a factor which should be taken into account when considering the project. However, in assessing the impacts of construction noise, it is accepted that the associated works are of a temporary nature. The main work locations for construction of the turbines are distant from nearest noise sensitive residences and are unlikely to cause significant effect. The construction and use of access tracks and the construction of the underground electricity line may, however, occur at lesser separation distances.

Once constructed and operating, wind turbines may emit two types of noise. Firstly, aerodynamic noise is a 'broad band' noise, sometimes described as having a characteristic modulation, or 'swish', which is produced by the movement of the rotating blades through the air. Secondly, mechanical noise may emanate from components within the nacelle of a wind turbine. This is a less natural sounding noise which is generally characterised by its tonal content. Traditional sources of mechanical noise comprise gearboxes or generators. Due to the acknowledged lower acceptability of tonal noise in otherwise 'natural' noise settings such as rural areas, modern turbine designs have evolved to minimise mechanical noise radiation from wind turbines. Aerodynamic noise tends to be perceived when the wind speeds are low, although at very low wind speeds the blades do not rotate or rotate very slowly and so, at these wind speeds, negligible aerodynamic noise is generated. At higher winds, aerodynamic noise is generally masked by the normal sound of wind blowing through trees and around buildings. The level of this natural 'masking' noise relative to the level of wind turbine noise determines the subjective audibility of the wind farm. The relationship between wind turbine noise and the naturally occurring masking noise at residential dwellings in the environs of the project will therefore generally form the basis of the assessment of the levels of noise against accepted standards.

The main noise sources associated with the electricity substation is the power transformer. The transformer noise is generally fairly constant, once energised, and at a lower level than the noise from the wind turbines.

Noise and vibration generated during the decommissioning phase of the project will be similar in nature to that produced during construction. There are fewer and less disruptive operations associated with decommissioning and, as such, are unlikely to cause significant effect.

A glossary of noise terms are provided in **Annex 12.1**.

12.1.2 STATEMENT OF AUTHORITY

This chapter was prepared by Richard Carter CEng, BEng(Hons), MIOA, a Director at Bow Acoustics Limited. Richard has worked in the field of acoustics for over 20-years, with over 15-years' experience specialising in the assessment of wind farm noise. Richard has a Bachelor of Engineering (BEng (Hons)), a post graduate diploma in acoustics and noise control, is a member of the Institute of Acoustics (MIOA) and a Chartered Engineer (CEng). 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 baseline noise monitoring was undertaken by Cormac McPhillips, Technical Services Manager at Galetech Energy Services (GES). Cormac has extensive experience of undertaking noise monitoring programmes in accordance with relevant standards and best practice methods.

12.2 GUIDANCE DOCUMENTS AND ASSESSMENT CRITERIA

12.2.1 CONSTRUCTION NOISE AND VIBRATION GUIDANCE

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

In the absence of specific noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 1 Noise (BS5228-1)*. Annex E of BS 5228 places Noise Sensitive Receptors (NSRs) into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise, as discussed below. This then sets construction noise threshold values for the daytime, evening and weekends, and night-time, that, if exceeded, indicates the effect may be significant, as replicated in **Table 12.1**. These levels relate to construction noise only.

Assessment Category and Threshold Period	Threshold Values, dB L _{Aeq, T}		
	Category A	Category B	Category C
Night-time (23.00-07.00)	45	50	55
Evening & Weekends: Weekdays (19.00-23.00) Saturdays (13.00-23.00) Sundays (07.00-23.00)	55	60	65
Daytime (07.00-19.00) & Saturdays (07.00-13.00)	65	70	75

Table 12.1: BS5228-1 Example Values for Threshold of Significant Effect

Measured levels of existing ambient noise, in the absence of construction noise, for the 3 no. periods set out in **Table 12.1** are rounded to the nearest 5dB. When these levels are less than Category A values, the NSR is within Category A. If the rounded ambient noise levels equal Category A values, the NSR is within Category B. If the rounded ambient noise levels exceed Category A values, the NSR is within Category C.

Guidance relevant to construction vibration is contained in:-

- British Standard 7385 *Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration*, 1993;
- British Standard 5228 *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration*, 2009+A1:2014; and,
- Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) *Guidelines for the treatment of noise and vibration in national road schemes*, 2004

The above guidance documents consider the effect which construction vibration may have upon buildings and their occupants by assessing the magnitude of vibration in terms of Peak Particle Velocity (PPV) in mm/s.

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15mm/s at low frequencies rising to 20mm/s at 15Hz and 50mm/s at 40Hz and above. These guidelines relate to relatively modern buildings and should be reduced to 50% or less for more critical or sensitive buildings.

BS 5228 recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak particle velocity of 15mm/s for transient vibration at frequencies below 15Hz and 20mm/s at frequencies greater than 15Hz.

The guidelines for the treatment of noise and vibration in national road schemes recommends allowable vibration values to ensure that there is little to no risk of even cosmetic damage from vibration during construction. These values are shown in **Table 12.2**.

Allowable vibration velocity (PPV) at the closest part of any sensitive property to the source of vibration, at a frequency of		
Less than 10 Hz	10 to 50 Hz	50 to 100 Hz (and above)
8 mm/s	12 mm/s	20 mm/s

Table 12.2: Allowable Construction Vibration to Minimise Risk of Building Damage

12.2.2 OPERATIONAL NOISE AND VIBRATION GUIDANCE

This noise assessment has been undertaken in accordance with guidance in relation to acceptable levels of noise from wind farms as contained in the document *Wind Energy Development Guidelines for Planning Authorities* ('the 2006 Guidelines') published by the Department of the Environment, Heritage and Local Government in 2006. These guidelines are in turn based on detailed recommendations set out in the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication *The Assessment and Rating of Noise from Wind Farms (1996)* (ETSU-R-97). ETSU-R-97 has been superseded by Department for Energy Security and Net Zero (UK) document *Assessment and Rating of Wind Turbine Noise (2026)*, which has been used to supplement the guidance contained within the 2006 Guidelines where necessary.

12.2.2.1 Wind Energy Development Guidelines for Planning Authorities 2006

Section 5.6 of the 2006 Guidelines 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."

"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."

"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.

In summary, the 2006 Guidelines outline the following guidance to identify appropriate wind turbine noise criteria curves at NSRs:-

- Identify an appropriate absolute limit level between 35–40dB $L_{A90,10min}$ for quiet daytime environments with background noise levels 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 above background noise (whichever is higher); and,
- 43dB $L_{A90,10min}$ or a maximum increase of 5dB above background noise (whichever is higher) for night-time periods.

It should be noted that while the caveat of an increase of 5dB(A) above background noise levels for night-time operation is not explicit within the current guidance, it is commonly applied to noise assessments prepared for wind energy developments and is detailed in numerous planning conditions issued by local planning authorities and An Coimisiún Pleanála.

The operational noise criteria curves for wind turbine noise at the project site at various NSRs are presented in **Annex 12.4**.

12.2.2.2 Assessment and Rating of Wind Turbine Noise

As stated previously, the core of the noise guidance contained within the 2006 Guidelines is based ETSU-R-97 which has been replaced by the UK DfESNZ document *Assessment and Rating of Wind Turbine Noise* ('the UK DfESNZ guidance document').

The UK DfESNZ guidance document calls for the control of wind turbine noise through the application of site-specific noise limits (SSNL) at the nearest noise sensitive properties. The SSNL is applicable only to the development proposed and should not exceed the total noise assessment criteria (TNAC) which applies to the cumulative effect of all wind turbines in the area contributing to the noise received at the NSRs in the vicinity of the project.

The TNAC is determined in recognition that wind turbines produce less noise at lower wind speeds than higher wind speeds, and also that background noise levels at NSR locations will typically increase with increasing wind speeds. The TNAC for NSRs are defined as the greater of: a lower limiting value (LLV); or 5 dB above the typical background sound level.

12.2.2.3 Institute of Acoustics Good Practice Guide

The guidance contained within the UK 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 NSRs for typically a 2-week period and should capture a representative sample of wind speeds in the area (i.e. cut in speeds to wind speed of rated sound power of the proposed turbine). Background noise measurements (i.e. $LA_{90,10min}$) 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 development can be predicted in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation* (1996). This is a noise prediction standard that considers noise attenuation offered, amongst others, by distance, ground absorption, directivity and atmospheric absorption. Noise predictions and contours are typically prepared for various wind speeds and the predicted levels are compared against the relevant noise criterion curve to demonstrate compliance with the appropriate noise criteria.

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

Reference has been made to the IOA GPG for guidance on the methodology for the background noise survey and operational phase impact assessment for wind turbine noise.

12.2.2.4 Future Potential Guidance Changes

In December 2019, the *Draft Revised Wind Energy Development Guidelines* were published for consultation, but have not yet to be finalised. Therefore, in accordance

with best practice, which includes the UK DfESNZ guidance document and IOA methodologies as described above, the assessment presented in this chapter is based on the current guidance outlined in Section 5.6 of the 2006 Guidelines.

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

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

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

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

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

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

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

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

The WHO *Environmental Noise Guidelines for the European Region* aim to support the legislation and policy-making process at a local, national and international level, and thus may be considered by Irish policy makers for any future revisions of Irish national guidelines.

There is potential for 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 L_{Aeq} - like indicators) and conversions between indicators do not normally influence the correlations between the noise indicator and a particular health effect, important assumptions remain when exposure to wind turbine noise in L_{den} is converted from original sound pressure level values. The conversion requires, as variable, the statistical distribution of annual wind speed at a

particular height, which depends on the type of wind turbine and meteorological conditions at a particular geographical location. Such input variables may not be directly applicable for use in other sites. They are sometimes used without specific validation for a particular area, however, because of practical limitations or lack of data and resources. This can lead to increased uncertainty in the assessment of the relationship between wind turbine noise exposure and health outcomes. Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes...

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

Based upon the review set out above, it is concluded that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) should not currently be applied as target noise criteria for the project.

12.2.3 SPECIAL CHARACTERISTICS OF WIND TURBINE NOISE

12.2.3.1 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 Environmental Protection Agency (EPA) document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)* (EPA, 2011) is noted:-

"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 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, 2013¹); found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

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

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

operating and switched off.

There were no noticeable differences in the levels of infrasound under 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 South Australian 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, titled *Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources* presents the details of a measurement project which ran from 2013. The report was published by the State Office for the Environment, Measurement and Nature Conservation of 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) "

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

The UK DfESNZ guidance document confirms:-

"Research has shown that, for modern upwind turbines (i.e. turbines where the rotor is positioned upwind of the tower when in operation), the levels of infrasound at typical receptor distances are well below the threshold of perception. The scoping review concluded that 'the findings from the existing evidence base indicate that infrasound from wind turbines at typical exposure levels has no direct adverse effects on physical or mental health'."

It also advises that receptors are suitably protected from low frequency noise by the proposed noise criteria and that no specific low frequency limits are necessary to control wind turbine noise.

12.2.4 Amplitude Modulation

In the context of this assessment, AM is defined in IOA 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)."

Research by Salford University commissioned by the United Kingdom 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 no., and a possible issue at a further 8 no., of 133 no. sites in the UK that were operational at the time of the study and considered within the review.

At the 4 no. 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 3 no. out of the 4 no. sites the complaints have subsided, in 1 no. 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.

This research was updated in 2013 by an in-depth study undertaken by RenewableUK, which considered 'other AM' (OAM). OAM is a now outdated term which was defined as AM with atypical characteristics which could not be explained by standard causal factors, and is now simply referred to as AM. Such characteristics include a greater depth of modulation, different directivity patterns or a changed noise character. The study identified that many of the previously suggested causes of AM have little or no association to the occurrence of OAM in practice. The generation of OAM was likely based upon the interaction of several factors, the combination and contributions of which are unique to each site. Based on current best engineering knowledge, it is not possible to predict whether any particular site is more or less likely to give rise to OAM.

RenewableUK Research Document, Work Package F, states the following:-

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

Page 6 *"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 *"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."*

Research and Guidance in the area is ongoing with publications being issued by the IOA AMWG *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (August 2016) (The Reference Method). As part of this study, all previous terms for AM, including OAM and normal AM, are grouped together as simply AM. 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 AM.

The IOA GPG, issued in May 2016 discusses AM. Section 7.2.1 of the IOA GPG remains

current best practice and states that *"The evidence in relation to 'Excess' or 'Other' Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM"*.

Subsequently, a report commissioned by the UK Department for Business, Energy & Industrial Strategy was published in February 2023 and concludes that the noise limits in ETSU-R-97 should be reviewed and that updated guidance on AM should be included but makes no firm recommendations with regards to any update. Therefore, until the UK or Irish governments conclude such a review, the ETSU-R-97 methodology continues to be applicable. The UK Government has also confirmed that ETSU-R-97 should continue to apply until the review recommendations are considered in further detail.

In 2024, the International Electrotechnical Commission (IEC) published *Technical Specification IEC/TS 61400-11-2 (Edition 1.0), Wind energy generation systems – Part 11-2: Acoustic noise measurement techniques – Measurement of wind turbine sound characteristics at receptor locations*. This document introduces a standardised methodology for measuring and rating AM at receptor locations. The method is technically consistent with the AM Working Group (AMWG) approach but includes some minor differences.

The UK DfESNZ guidance document proposes that AM analysis follows the AMWG Reference Method and provides a character correction based on the AM modulation depth. Furthermore, it confirms that it is not possible to predict the occurrence of elevated AM or tonality at the planning stage and that these characteristics are best controlled through the enforcement of planning conditions which include the application of character corrections.

In October 2025, Wind Energy Ireland published their position paper on AM planning conditions (WEI, 2025). This paper provides a background on AM and the various approaches taken by other countries on the subject. It notes that no other EU country regulates AM and whilst countries such as the UK and New Zealand have examples of planning conditions to control AM, no suitable precedents could be cited. 3 no. Irish wind farms that were consented in early 2025 included a condition that the *"wind farm shall not give rise to amplitude modulation..."*, which is noted to be unworkable due to:-

- the lack of Irish Government (or relevant expert body) endorsed scientific evidence, research or data to support the necessity of the condition;
- AM cannot be measured or predicted in advance of the operation of the wind farm. Therefore, developers can't know how much AM may be produced or commit to a condition that requires no AM; and,
- It is not achievable to have no AM, regardless of any measure implemented. AM may be measured at a property near to a wind farm, but may be of low level which would result in a low character correction.

The WEI paper supports a complaint driven approach to the control of AM and provides a sample planning condition that sets out a requirement for the developer to submit and agree with the planning authority a Noise Complaint Monitoring Programme (NCMP) prior to commissioning.

The above evidence shows that AM may occur in any wind farm, however the likelihood is low. There is no available method for predicting the probability of AM

occurring, or whether or not it would amount to a likely significant effect on the environment before the wind farm is constructed and operational. This is because AM depends on a number of factors that can only be ascertained through operation of the wind farm. Therefore, it is not possible to assess at this stage and it is appropriate to control the risk of AM through a complaint driven planning condition which references an NCMP to be agreed with the local authority prior to commissioning. The NCMP will include the details of how AM will be measured, quantified and the magnitude of correction applied to the wind turbine noise level due to AM.

12.2.4 HUMAN HEALTH EFFECTS

12.2.4.1 The National Health & Medical Research Council

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

"After careful consideration and deliberation, NHMRC concluded that there is no consistent evidence that wind farms cause adverse health effects in humans. This finding reflects the results and limitations of the direct evidence and also takes into account the relevant available parallel evidence on whether or not similar noise exposure from sources other than wind farms causes health effects"

12.2.4.2 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.

12.2.4.3 The Australian Medical Association

The Australian Medical Association put out a position statement, *Wind Farms and Health 2014*² which stated:-

"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."

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014³. The study was

² Australian Medical Association, 2014, Wind farms and health. Available at <https://ama.com.au/position-statement/wind-farms-and-health-2014>

³ Health Canada 2014, Wind Turbine Noise and Health Study: Summary of Results. Available at

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.

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

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

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

12.2.4.5 Health Service Executive (HSE)

In Ireland, the HSE Public Health Medicine Environment and Health Group drafted a position paper in 2017 titled *Position Paper on Wind Turbines and Public Health*. The group identified that there is no published scientific evidence to support adverse effects of wind turbines on health and concluded that:-

"Published scientific evidence is inconsistent and does not support adverse effects of wind turbines on health. However, adequate setback distances and meaningful engagement with local communities are recommended in order to address public concern."

In correspondence dated February 2026, the HSE advised that it undertook a review of the previously published health advice in autumn 2025. As a consequence of the review, the previously published advice was withdrawn pending a comprehensive reassessment. The HSE noted that the National Health Protection Office will conduct a *"targeted narrative review"* including an examination of national guidance, regulatory approaches and public health considerations of other European Union Member States. It is anticipated that the review will be completed and further advice provided in Q2 2026.

12.2.5 VIBRATION

A report published in Germany by the State Office for the Environment, Measurement

<https://www.canada.ca/en/health-canada/services/environmental-workplace-health/noise/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html>

and Nature Conservation of the Federal State of Baden-Württemberg in 2016 titled *Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*, conducted a vibration measurement study for an operational Nordex N117 2.4MW 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 the nearest NSRs to any of the subject wind turbines (the nearest NSR being NSR13 c. 530m from the nearest turbine), the level of vibration will be significantly below any thresholds for perceptibility. Therefore, vibration criteria have not been specified for the operational phase of the project.

12.3 METHODOLOGY

The method used to assess likely noise and vibration impacts from the construction, operation and decommissioning of a wind energy development is discussed in more detail below.

In summary, construction and decommissioning noise and vibration is calculated at nearby NSRs and assessed against threshold limits to determine magnitude and overall significance. The assessment of operational wind turbine noise:-

- Identifies the nearest NSRs;
- Determines the quiet daytime and night-time noise limits from measured background noise levels;
- Specifies the type and noise emission characteristics of the wind turbines proposed for the site;
- Calculates noise emission levels which would be due to the operation of the wind turbines as a function of wind speed at the nearest NSRs, including the cumulative effect of all turbines in the area; and,
- Compares the calculated wind turbine noise level with the derived limit at each NSR.

12.3.1 STUDY AREA

The study area for the construction and decommissioning noise is limited to the nearest NSR in each general direction during the construction or decommissioning phase. The calculation for construction and decommissioning noise assumes no reduction for screening and assumes downwind propagation; therefore, other, more distant NSRs would be exposed to lower levels of noise and do not need to be considered also.

The study area for the operational noise assessment, as defined in the IOA GPG, comprises the area where noise levels from the project are predicted to be within 10dB of those from other relevant wind energy developments, and the predicted cumulative wind farm noise level is greater than 35dB $L_{A90,10min}$. It should be noted that when 2 no. noise sources are present that produce noise levels at the same receptor location more than 10dB apart, the total noise will be equal to the higher of the 2 no. noise levels, when expressed as a whole number. Therefore, the IOA GPG confirms that a cumulative noise impact assessment is not necessary when there is a difference in noise level of at least 10dB.

This is, therefore, the reason why the IOA GPG specify that developments producing

noise levels more than 10dB than one another need not be considered cumulatively. The $LA_{90, 10min}$ parameter is used to describe wind turbine noise and it represents the level of noise exceeded for 90% of the measurement period, 10-minutes. 1 no. other wind energy development has been identified that would contribute to the cumulative noise levels, Largan Hill Wind Farm which is situated to the east of the project.

NSRs are properties within the study area which are potentially sensitive to noise and, as such, may require protection from nearby noise sources. The 2006 Guidelines list NSRs as dwellings, hostels, health buildings, places of worship and may also include areas of particular scenic quality or special recreational amenity importance.

The NSRs identified within this assessment are all residential dwellings. During the operational phase, wind turbine noise immission levels are predicted to a location representative of each outdoor amenity area rather than the façade of the property. This is in line with the IOA GPG which states (at paragraph 4.3.8) that “*calculations should be made at points representative of the relevant outdoor amenity area (as defined in ETSU-R-97) at locations nearest to the proposed wind farm development*”.

It is not always appropriate to assess operational wind turbine noise impacts at all nearby NSRs, as a worst-case can be presented with a selection of NSRs. Where multiple NSRs are in the same general direction from the project, it may be appropriate to present results for just 1 no. of these which represents the highest noise levels that could be experienced at any of them.

Table 12.3 details the identified NSRs for the assessment of operational and construction noise and **Figure 12.1** shows the location of each NSR in relation to the project. In addition, **Figure 12.1** also illustrates the noise measurement locations in green, which are discussed below, and the wind turbines within the Largan Hill Wind Farm as blue circles.

NSR ID	Eircode	Easting (ITM)	Northing (ITM)
NSR01	F56 TF38	561045	801135
NSR02	F56 RX85	561065	800644
NSR03	F56 KO98	560583	800404
NSR04	F45 FP20	560555	799122
NSR05	F45 R127	560591	799059
NSR06	F45 HC98	560642	798996
NSR07	F45 W720	560903	798841
NSR08	F45 A078	561506	798758
NSR09	F45 YK65	561219	798531
NSR10	F45 H291	561255	798176
NSR11	F45 X076	561285	797906
NSR12	F45 KV02	561476	796863
NSR13	Static caravan	561738	797003
NSR14	F45 NW45	562703	796749
NSR15	F45 T992	562707	796965
NSR16	F45 HC56	562686	797103
NSR17	F45 VK61	562806	797342
NSR18	F45 KX60	563659	798200

NSR19	F45 D427	563182	798633
NSR20	F45 HF62	563112	798694
NSR21	F45 NP49	562887	798884
NSR22	F45 PD60	562813	798950
NSR23	F45 X002	562979	799288
NSR24	F45 RT06	563710	799552
NSR25	F45 FH39	563853	799522
NSR26	F45 F294	563914	799550
NSR27	F45 PX83	563944	799594
NSR28	F56 TH76	564286	800897
NSR29	F56 PW80	563679	801314
NSR30	F56 PX33	562562	801856

Table 12.3: Noise Sensitive Receptors

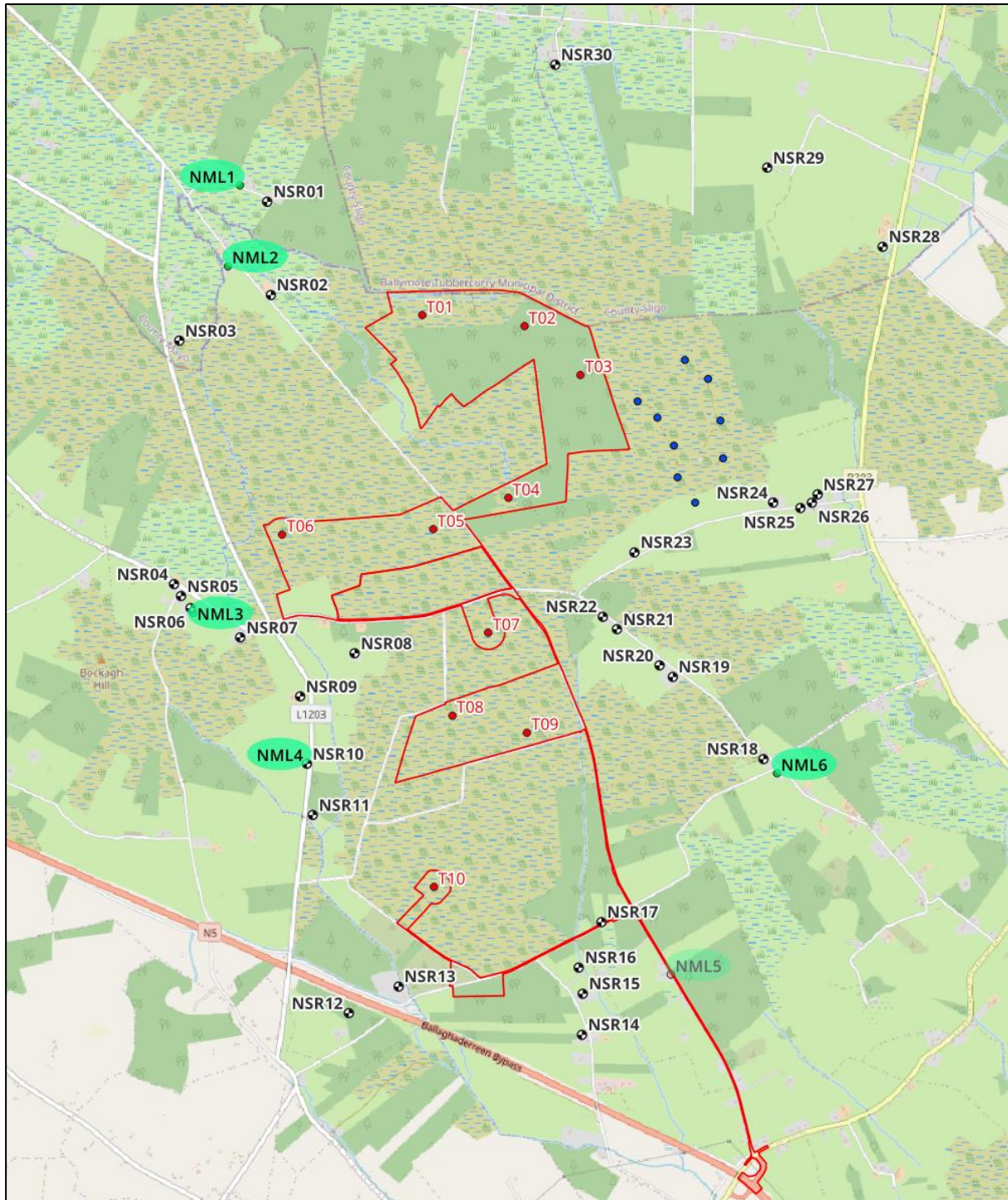


Figure 12.1: Noise Sensitive Receptor Locations

12.3.2 CONSTRUCTION AND DECOMMISSIONING PHASES

There is no statutory Irish guidance relating to the calculation and assessment of construction and decommissioning noise. In the absence of specific guidance, BS 5228-1 has been used as the appropriate reference for the method of calculation and assessment of construction and decommissioning noise effects. At this stage of a project, it is not feasible to accurately specify exact techniques or locations where particular activities are likely to take place. Therefore, various assumptions have been

made based on best practice and typical wind farm construction projects. The calculation follows Annex F of BS 5228-1 and assumes the following:-

- there would be no screening effects around construction activities;
- propagation over mixed ground (50% hard 50% soft); and,
- activity is assumed to occur at a single point from receiver (closest point to the nearest receiver to represent a highly conservative approach).

Table 12.4 lists the primary noise generating construction activities, the associated types of plant normally involved, and the expected worst-case collective sound power level of all items of plant associated with the construction activity over a working day.

Construction Activity	Plant in use	Sound Power Level, dB L _{WA}
Construct temporary construction compounds	Excavators/dump trucks/tippers/rollers/delivery trucks	118
Construct access tracks	Excavators/dump trucks/tippers/dozers/vibrating rollers	118
Construct substation	Excavators/concrete trucks/delivery trucks	112
Construct crane hardstandings and crane pads	Excavators/dump trucks	116
Construct turbine foundations	Piling rigs/excavators/tippers/concrete trucks/mobile cranes/water pumps/pneumatic hammers/compressors/vibratory pokers	121
Erect turbines	Cranes/turbine delivery vehicles/articulated trucks for crane movement/generators/torque guns	117
Reinstate crane pads	Excavator/dump truck	116
Processing of quarried stone	Primary and secondary stone crushers/excavators/screening systems/pneumatic breakers/conveyors	127
Forestry felling around tracks and turbines	Harvesters and forwarders, characterised by saw noise diesel engine noise emissions commonly associated with tractors and excavation noise	115

Table 12.4: Construction Activity Sound Power Levels

As described at **Chapter 3**, it is proposed to develop a borrow pit adjacent to turbine T5. While it is likely that rock will be extracted via conventional excavation means, it is anticipated that some rock extraction by means of blasting operations could be required. Blasting operations can generate airborne pressure waves or 'air overpressure'. This covers both those pressure waves generated which are in the frequency range of human audibility (approximately 20Hz to 20kHz) as well as infrasonic pressure waves (those with a frequency of below 20Hz), which, although outside the range of human hearing, can sometimes be felt.

Noise from blasting (i.e. pressure waves in the human audible range) is not considered in the same way as noise from other construction activities due to the fact that a large proportion of the energy contained within pressure waves generated by a blast is at frequencies that are below the lower frequency threshold of human hearing, and that the portion of energy contained within the audible range is generally of low frequency and of smaller magnitude than the infrasonic pressure variations.

The relevant guidance documents advise controlling air overpressure, and hence noise from blasting, through the use of good practices during the setting and

detonation of charges as opposed to absolute limits on the levels produced, therefore no absolute limits for air overpressure or noise from blasting will be presented in this assessment.

For all other construction activities, including the processing of stone quarried from borrow pits, the calculated construction noise levels are compared with Category A set out in BS 5228-1 and above in **Table 12.1**. If the specific construction noise level exceeds the category value (e.g. 65dB $L_{Aeq,T}$ during daytime periods) then a significant effect is assessed as likely to have occurred.

Additional consideration is also given to the possible noise effects of construction-related traffic passing to and from the project site along local surrounding roads. Information presented at **Chapter 14**, regarding vehicle types and predicted traffic volumes, have been used to inform this assessment.

The likely noise effects of HGV movements are assessed through consideration of the cumulative noise level associated with a series of individual events. The noise level associated with an event of short duration, such as a vehicle drive-by, may be expressed in terms of its Sound Exposure Level (SEL; L_{Ax}). The SEL can be used to calculate the contribution of an event or series of events to the overall noise level in a given period. The appropriate formula is as follows:-

$$L_{Aeq,T} = L_{Ax} + 10\log_{10}(N) - 10\log_{10}(T) - 20\log_{10}(r_2/r_1) \text{ dB}$$

Equation 12.1: Overall Noise Level Based on SEL Events

Where:-

- $L_{Aeq,T}$ is the equivalent continuous sound level over the time period T (s);
- L_{Ax} is the "A-weighted" Sound Exposure Level of the event under consideration (dB);
- N is the number of events over the course of time period T.
- r_2 is the distance from the edge of the entrance road to the facade of nearest property
- r_1 is the distance from vehicle to the point of original measurement

The mean value of SEL for a HGV movement is of the order of 82dB L_{Ax} at a distance of 5m from the vehicle. This figure is based on a series of measurements conducted under controlled conditions. The overall noise level calculated from this SEL and the number of HGV movements during the busiest day of the construction period is compared with Category A set out in BS 5228-1 and above in **Table 12.1**. If the noise from construction vehicles exceeds the category value (e.g. 65dB $L_{Aeq,T}$ during daytime periods) then a significant effect is assessed as likely to have occurred.

The project will include an electricity substation, which will be connected to the national electricity network via an underground electricity line routed south towards Ballaghaderreen to the Tonroe 110-kilovolt (kV) substation. The plant and machinery likely to be in operation during the laying of underground electricity line are provided in **Table 12.5**.

Construction Activity	Plant in use	Sound Power Level, dB L_{WA}
Dust suppression	Road Sweeper	104
Breaking road surfaces	Mini excavator with hydraulic breaker	111

Rolling and compacting	Vibratory roller	105
Trenching	Wheeled/tracked excavator	98
Cutting concrete	Hand held circular saw	114
Tipping fill	Dump truck tipping fill	107
Compaction	Petrol vibratory plate	108

Table 12.5: Electricity Line Route Construction Activity Sound Power Levels

The construction associated with the installation of the underground electricity line will be transient as works moves along the route. Construction noise will be greatest when plant passes closest to the NSR. As a result, construction noise associated with the electricity line has been calculated at set distances back using the same method described above, and assessed in the same way as construction noise generated within the site, as described above.

The noise levels generated during the decommissioning of a wind farm are lower than those generated during its construction due to the reduced number of operations required. Therefore, it is conservatively assessed that the noise and vibration impacts calculated for the construction phase will equally apply to the decommissioning phase.

12.3.3 OPERATION PHASE

The operational noise assessment applies the current 2006 Guidelines and is supplemented by the UK DfESNZ guidance document and the IOA GPG, as set out below.

The UK DfESNZ guidance document provides a robust basis for assessing impacts of operational noise from wind turbines. Operational wind turbine TNAC for NSRs are derived from background measurements and fixed values, and wind turbine immission levels are calculated for the NSRs in the assessment. Consequently, the test applied to operational noise is whether or not the calculated total cumulative wind farm noise levels at nearby NSRs lie below the TNAC derived in accordance with the guidance document. Where cumulative noise levels can be shown to comply with the TNAC at each NSR, SSNLs relating to noise from the proposed project are then derived.

A background noise survey was conducted by installing unattended sound level meters at 6 no. representative locations surrounding the project site.

The installation, retrieval and management of all measurement instrumentation detailed in this section has been carried out by GES. GES has confirmed that all measurement data collected during the baseline noise surveys has been carried out in accordance with the IOA GPG. The analysis and assessment of all survey data has been carried out by Bow Acoustics, also in accordance with the IOA GPG.

Details of the background noise measurement locations are provided in **Annex 12.2**, coordinates of the sound level meter positions are summarised in **Table 12.6** and illustrated in **Figure 12.1**.

Location ID	Eircode	Coordinates (ITM)	
		Easting	Northing
NML1	F56 W354	560902	801221
NML2	F56 RC79	560839	800795

NML3	F45 HC98	560655	798971
NML4	F45 H291	561257	798177
NML5	F45 YW77	563171	797067
NML6	F45 CH96	563731	798126

Table 12.6: Background Noise Measurement Coordinates

The background noise monitoring exercise was conducted over a period of just over 5-weeks between 28 February 2025 and 8 April 2025. All logging sound level meters were enclosed in environmental cases with batteries to enable continuous logging at the required 10-minute averaging periods. Outdoor enhanced windshield systems were used to reduce wind induced noise on the microphones and provide protection from rain. These windshield systems were supplied by the sound level meter manufacturer and maintain the required performance of the whole measurement system when fitted. The microphones were installed at a height of approximately 1.2 to 1.5 metres above ground level, in accordance with current best practice.

The sound level meters were located on the wind farm side of the property in question where possible, never closer than 3.5 metres from the façade of the property and as far away as was practical from obvious atypical localised sources of noise such as running water, trees or boiler flues. Details and photographs of the measurement locations are presented in **Annex 12.2**.

All measurement systems were calibrated on their deployment on 28 February 2025 and upon collection of the equipment on the 8 April 2025. This equates to a total minimum analysis period of 39-days, which is in excess of the minimum of 2-week suggested by current best practice. NML5 observed a large drift in calibration of 3.1dB(A), which renders the data measured at this location to be unreliable; therefore, it was removed from the assessment, hence why this location is shown in **Figure 12.1** washed out. No acoustically important drifts in calibration (>1dB(A)) were found to have occurred on any of the other systems.

All measurement systems were set to log the $L_{A90,10min}$ and $L_{Aeq,10min}$ noise levels continuously over the deployment period. The internal clocks on the sound level meters were all synchronized with Coordinated Universal Time (UTC). Simultaneous measurements of wind data were taken during the noise survey using a LiDAR system installed within the project site at a location that is representative of the wind turbines (approximate coordinates 561978, 799408 ITM). A separate tipping bucket rain gauge was also installed at the LiDAR location to detect any rainfall in a measurement period. The clocks on the LiDAR and rain gauge were also set to UTC.

Wind data was measured directly at 104m which was taken as the hub height wind reference. Wind shear, which is the increase of wind speed with height above ground, was accounted for following best practice found in the IOA GPG. This involves the derivation of standardised 10m wind speeds from hub height wind data using the log law equation, reproduced below in **Equation 12.2**. The wind data reference height of 104m was used to determine standardised wind speeds for typical background noise levels at the monitoring locations on the assumption that all turbines have a hub height of 104m. It is noted that a number of turbines have a lower hub height of 82m, which would result in a lower standardised wind speed given a typical positive wind shear profile. This would result in background noise levels increasing at a lower wind speed, when compared to the higher hub height. Whilst the difference would be extremely minor, the selection of the higher hub height is considered to be a

conservative approach and presents a worst case scenario. Notwithstanding this, all turbines have been modelled at their proposed hub heights; therefore the predicted immission levels reflect those that would occur in practice.

$$v_{10} = v_{hh} \times \left(\frac{\ln(10/z_0)}{\ln(hh/z_0)} \right)$$

Equation 12.2: Standardised 10m Wind Speed From Hub Height Using Log Law

where:-

- v_{10} standardised 10m wind speed
- v_{hh} hub height (hh) wind speed
- z_0 standard ground roughness length of 0.05m

A series of computer-based prediction models have been prepared to quantify the cumulative noise level associated with the operation of the project. 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).

The ISO 9613-2 model has been used to calculate the noise immission levels at the NSRs as advised in the IOA GPG. The model accounts for the attenuation due to geometric spreading, atmospheric absorption, and barrier and ground effects and assumes the following parameters:-

- octave band data which accounts for the sound frequency characteristics of the turbines;
- receiver height of 4 m above local ground;
- mixed ground ($G=0.5$);
- an air absorption based on a temperature of 10°C and 70 % relative humidity;
- attenuation due to terrain screening has been limited to a maximum of 2dB(A); and,
- in situations of propagation above concave ground, a correction of +3dB was added.

The above method is consistent with the recommendations of the IOA GPG. The IOA GPG also allows for directional effects to be taken into account within the noise modelling which can reduce the noise immission level at a receptor. However, predictions have been made assuming downwind propagation from every turbine to every receptor at the same time as a highly conservative approach.

The coordinates of the 10 no. wind turbines which form the project are provided in **Table 12.7**.

Turbine ID	Coordinates (ITM)	
	Easting	Northing
T1	561862	800538
T2	562401	800480
T3	562695	800222

Turbine ID	Coordinates (ITM)	
	Easting	Northing
T4	562316	799576
T5	561920	799411
T6	561124	799382
T7	562209	798866
T8	562021	798429
T9	562413	798339
T10	561924	797528

Table 12.7: Wind Turbine Coordinates

As noted above, noise generated by the Largan Hill Wind Farm is likely to act cumulatively with the project and has been included in this assessment. The 9 no. turbines within the Largan Hill Wind Farm have been modelled as Vestas V47 660 kW machines at the locations specified in **Table 12.8** with a hub height of 45.7m.

Turbine ID	Coordinates (ITM)	
	Easting	Northing
T1	563299	799551
T2	563207	799684
T3	563188	799851
T4	563100	799998
T5	562996	800084
T6	563245	800301
T7	563367	800202
T8	563432	799983
T9	563446	799784

Table 12.8: Largan Hill Wind Farm Turbine Coordinates

An important component of the calculation of noise immission level is the selection of an appropriate wind turbine. The IOA GPG notes that most sites at the planning stage will not have selected a preferred turbine, therefore a representative candidate turbine should be selected to provide appropriate noise levels. Once noise levels have been predicted at the potentially affected properties, compliance with noise limits can be assessed and design advice provided if compliance with the limits is considered unlikely. However, in this case, the Vestas V162-7.2MW on a hub height of 104 m has been selected as the turbine model/type for installation at turbines T1 to T3, and Vestas V136-4.5MW on a hub height of 82 m for turbines T4 to T10. Both models/types are assumed to be fitted with trailing edge serrations, as is standard.

During the design stage of the project, the layout and number of turbines were refined to minimise noise impacts at nearby NSRs. However, under certain wind conditions, predicted noise levels at a limited number of nearby NSRs may exceed the relevant noise limit if all turbines operate in unconstrained mode. As such, a suite of noise reduced modes has been included as embedded mitigation, as detailed in **Annex 12.5**. For a limited number of wind speeds, one Vestas V162-7.2MW turbines (turbine T3) will operate in noise reduced mode SO1; while a number of the V136-4.5MW turbines will operate in noise reduced mode SO11.

Vestas has provided noise emission data for hub height wind speeds of 3m/s to 15m/s and excludes any margin for uncertainty, and as such an additional 1dB has been included in the sound power levels in this assessment. The manufacturer's noise emission data for operational modes included in this assessment are detailed in **Table 12.9**, which includes the additional uncertainty. Vestas has also provided noise emission data for the V47 turbine on a 45.7m high hub (Largan Hill Wind Farm), using the standardised 10 m wind reference, for a wind speed range of 4m/s to 11m/s. A further 1dB has been added to the values provided to account for uncertainty. The manufacturer's noise emission data for the V47 turbine are detailed in **Table 12.10**, which includes the additional uncertainty.

Note that in the above, and subsequently in this assessment, the term 'noise emission' relates to the sound power level of a wind turbine, whereas the term 'noise immission' relates to the sound pressure level experienced at a receptor location. Furthermore, unless specified otherwise, all wind speed data is expressed using the standardised 10m wind reference. Where appropriate, hub height wind data is re-expressed as standardised 10m wind data in accordance with current best practice, IOA GPG Supplementary Guidance Note 4, Wind Shear, as summarised earlier and in **Equation 12.2**.

Hub height wind speed, m/s	Emission Level, dB L _{WA} for Turbine Type and Operational Mode				
	V162-7.2MW Unconstrained	V162-7.2MW Mode SO1	V162-7.2MW Mode SO5	V136-4.5MW Mode SO11	V136-4.5MW Unconstrained
3	97.0	97.0	91.9	93.1	97.0
4	97.0	97.0	92.1	93.4	97.0
5	97.0	97.0	93.8	93.9	97.0
6	99.0	99.0	96.9	95.5	99.0
7	101.3	101.3	100.5	96.5	101.3
8	103.8	103.8	103.8	97.8	103.8
9	106.1	104.5	104.9	99.0	106.1
10	107.3	104.3	104.9	99.8	107.3
11	107.3	104.5	104.9	100.0	107.3
12	107.3	104.5	104.9	100.2	107.3
13	107.3	104.5	104.9	100.2	107.3
14	107.3	104.5	104.9	100.2	107.3
15	107.3	104.5	104.9	100.2	107.3

Table 12.9: Overall Noise Emission Data V162-7.2MW and V136-4.5MW Turbines

Turbine	Emission Level, dB L _{WA} for Standardised Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
V47	95.1	99.9	100.3	100.6	101.0	101.4	101.7	102.1	102.5

Table 12.10: Overall Noise Emission Data Largan Hill V47 Turbines

Vestas has also supplied the octave band frequency spectrum equivalent to the maximum sound power level, detailed in **Table 12.9** and **Table 12.10**. The values specified in **Table 12.11** also include 1dB uncertainty.

Turbine	Emission Level, dB L _{WA} at Octave Band Centre Frequency, Hz								
	63	125	250	500	1000	2000	4000	8000	dB(A)

V162-7.2MW	91.4	98.4	99.8	99.6	100.6	100.4	95.8	84.4	107.3
V136-4.5MW	84.3	92.6	97.8	100.1	99.2	95.3	88.5	78.4	104.9
V47	79.8	87.7	91.4	96.8	98.6	94.5	89.5	70.8	102.5

Table 12.11: Octave Band Noise Emission Data

The assessment of significance of effects from operational wind turbine noise at an NSR is:-

- not significant if the noise limits derived according to the 2006 Guidelines are not exceeded; or,
- significant if the noise limits derived according to the 2006 Guidelines are exceeded.

12.4 DESCRIPTION OF EXISTING ENVIRONMENT

Full details of the background noise survey are provided in **Annex 12.2**. The noise climate around the project site and at the monitoring locations can be described as fairly typical for rural amenity with natural noises such as birds and wind disturbed vegetation, with noise from other sources also present including distant and occasional passing traffic.

The noise data sets for each of the NMLs have been combined with the concurrent wind and rain data sets. For each NML, the combined data sets were inspected to identify periods which may have been influenced by extraneous noise sources, giving rise to atypical and elevated levels. Examples of such atypical sources would be short, isolated periods of raised noise levels attributable to local sources, agricultural activity, boiler flues and the operation of gardening or farm equipment.

Sample periods affected by rainfall or when rainfall resulted in prolonged periods of atypical noise levels have also been excluded from the data sets. The assessment methods outlined above are in line with the guidance contained in the IOA GPG.

The results presented in **Annex 12.3** refer to the noise data collated during 'quiet periods' of the day and night as defined in the UK DfESNZ guidance document. These periods are defined as follows:-

- Daytime amenity hours (quiet periods) are:-
 - All evening from 18:00 to 23:00hrs;
 - Saturday afternoons from 13:00 to 18:00hrs;
 - Sunday from 07:00 to 18:00hrs; and,
- Night-time hours are 23:00 to 07:00hrs.

Any data that has been discarded as described above is shown on **Graph 12.3** to **Graph 12.12** of **Annex 12.3** as red circles.

Following the removal of extraneous data points, best fit lines were generated using a polynomial fit of a maximum of 3rd order, in accordance with guidance contained the IOA GPG and its *Supplementary Guidance Note No. 2: Data Processing & Derivation of ETSU-R 97 Background Curves* (2014). These lines of best fit define the typical background noise levels and are illustrated on Graph 12.3 to Graph 12.12 of **Annex 12.3** and set out in **Table 12.12** and **Table 12.13** for the daytime and night-time periods respectively. Note, as set out in **Section 12.3.3**, NML5 has been excluded from the

assessment.

Location ID	Daytime Background Noise Level, dB LA90, at Standardised wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
NML1	22.7	24.0	26.0	28.6	31.7	35.2	38.9	42.7	46.3	49.8
NML2	28.1	29.4	31.0	33.1	35.4	38.2	41.3	44.8	48.6	52.8
NML3	25.2	26.3	27.7	29.4	31.3	33.4	35.8	38.5	41.4	44.5
NML4	26.3	27.3	28.5	29.9	31.6	33.6	35.8	38.2	40.9	43.8
NML5	-	-	-	-	-	-	-	-	-	-
NML6	29.1	29.6	30.5	31.6	33.1	34.9	37.1	39.5	42.3	45.4

Table 12.12: Derived Daytime Background Noise Levels at Various Wind Speeds

Location ID	Night-time Background Noise Level, dB LA90, at Standardised wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
NML1	19.0	20.7	23.0	25.9	29.2	32.9	37.0	41.2	45.7	50.3
NML2	26.5	27.3	29.0	31.3	34.1	37.2	40.2	43.0	45.4	47.1
NML3	25.3	25.6	26.4	27.6	29.2	31.1	33.3	35.8	38.5	41.5
NML4	22.9	23.9	25.1	26.4	28.0	29.8	31.9	34.4	37.3	40.7
NML5	-	-	-	-	-	-	-	-	-	-
NML6	26.3	27.0	27.7	28.5	29.6	31.0	32.8	35.0	37.8	41.3

Table 12.13: Derived Night-time Background Noise Levels at Various Wind Speeds

The above prevailing background noise levels inform the TNAC for operational wind turbine noise. The 2006 Guidelines contain recommended noise limits to control operational noise from wind farms as discussed earlier.

It is proposed that a value of 40dB LA90 is set for the fixed element of the daytime noise limit for wind speeds where the background noise is less than 30dB LA90. This value has been selected in light of the 2006 Guidelines, which states that "An appropriate balance must be achieved between power generation and noise impact.". Given the potential energy generation of the project, a value for the fixed limit at the upper end of the available range is considered suitable. Where the prevailing background noise levels exceed 30dB LA90 during the daytime, the fixed portion of the limit is set to 45dB LA90. Furthermore, NSR08 is financially involved with the project and, for such properties, the UK DfESNZ guidance document and the IOA GPG advise it is appropriate to apply an increased lower limiting value of 45 dB LA90 during the daytime and the night-time.

In summary, the TNAC are:-

- 40dB LA90 for daytime windspeeds where the typical background noise is less than 30dB LA90;
- 45dB LA90 for daytime windspeeds where the typical background noise is greater than 30dB LA90 or a maximum increase of 5dB(A) above background noise (whichever is the higher); and,
- 43dB LA90 for night-time periods or a maximum increase of 5dB(A) above background noise (whichever is the higher); and,
- For financially involved properties (applicable to NSR08 only), 45dB LA90 for daytime and night-time periods or a maximum increase of 5 dB(A) above

background (whichever is the higher).

This set of criteria has been chosen as it is in line with the 2006 Guidelines and best practice, and is comparable to noise-related planning conditions applied to similar projects previously granted planning permission by An Coimisiún Pleanála. **Table 12.14** and **Table 12.15** summarises the operational wind turbine noise limits for the daytime and night-time periods respectively, for each of the assessment locations, and includes the survey location used as the appropriate proxy to inform these limits.

NSR ID	Survey Proxy	Noise Limit, dB L _{A90} , at Standardised wind speed, m/s								
		4	5	6	7	8	9	10	11	12
NSR01	NML1	40.0	40.0	40.0	45.0	45.0	45.0	47.7	51.3	54.8
NSR02	NML2	40.0	45.0	45.0	45.0	45.0	46.3	49.8	53.6	57.8
NSR03	NML2	40.0	45.0	45.0	45.0	45.0	46.3	49.8	53.6	57.8
NSR04	NML3	40.0	40.0	40.0	45.0	45.0	45.0	45.0	46.4	49.5
NSR05	NML3	40.0	40.0	40.0	45.0	45.0	45.0	45.0	46.4	49.5
NSR06	NML3	40.0	40.0	40.0	45.0	45.0	45.0	45.0	46.4	49.5
NSR07	NML3	40.0	40.0	40.0	45.0	45.0	45.0	45.0	46.4	49.5
NSR08	NML3	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.4	49.5
NSR09	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR10	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR11	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR12	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR13	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR14	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR15	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR16	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR17	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR18	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR19	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR20	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR21	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR22	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR23	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR24	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR25	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR26	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR27	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR28	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR29	NML6	40.0	45.0	45.0	45.0	45.0	45.0	45.0	47.3	50.4
NSR30	NML1	40.0	40.0	40.0	45.0	45.0	45.0	47.7	51.3	54.8

Table 12.14: Daytime TNAC at Various Wind Speeds

NSR ID	Survey Proxy	Noise Limit, dB L _{A90} , at Standardised wind speed, m/s								
		4	5	6	7	8	9	10	11	12
NSR01	NML1	43.0	43.0	43.0	43.0	43.0	43.0	46.2	50.7	55.3

NSR02	NML2	43.0	43.0	43.0	43.0	43.0	45.2	48.0	50.4	52.1
NSR03	NML2	43.0	43.0	43.0	43.0	43.0	45.2	48.0	50.4	52.1
NSR04	NML3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.5	46.5
NSR05	NML3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.5	46.5
NSR06	NML3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.5	46.5
NSR07	NML3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.5	46.5
NSR08	NML3	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.5
NSR09	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR10	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR11	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR12	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR13	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR14	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR15	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR16	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR17	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR18	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR19	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR20	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR21	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR22	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR23	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR24	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR25	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR26	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR27	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR28	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR29	NML6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
NSR30	NML1	43.0	43.0	43.0	43.0	43.0	43.0	46.2	50.7	55.3

Table 12.15: Night-time TNAC at Various Wind Speeds

12.5 DESCRIPTION OF LIKELY EFFECTS

12.5.1 DO NOTHING SCENARIO

If the project is not progressed, the existing noise environment in the vicinity of the subject site and at NSRs will remain largely unchanged. The existing noise environment is noted in **Section 12.4** to be typical of that for rural locations with no particular noise source dominating. Natural changes to the wider environment that occur over time would not affect the baseline noise environment. Changes to the number of vehicles using local roads through normal annual adjustments is not expected to alter the baseline noise environment as the total traffic flow would have to be doubled or halved before the contribution from this source may begin to be perceived.

12.5.2 CONSTRUCTION PHASE

A variety of items of plant and machinery will be in use for the purposes of site

preparation, construction/installation of turbines, access tracks, electricity substation and underground electricity line, forestry felling and other site works. There will be vehicular movements to and from the project site that will make use of existing roads. Due to the nature of these activities, noise will be generated and is likely to be experienced at NSRs. These are discussed in the following sections.

The predicted noise levels referred to in this section are indicative only and are intended to demonstrate that it will be possible for the contractor to comply with current best practice guidance. It should also be noted that the predicted 'worst case' levels are expected to occur for only short periods of time at a very limited number of properties. Construction noise levels will be lower than these levels for the vast majority of the time at most properties in the vicinity of the project.

The predicted construction noise levels at the NSR which would be closest to that activity for a portion of the construction phase are presented in **Table 12.16**. It must be emphasised that these predictions only relate the noise level occurring during the time when the activity is closest to the referenced NSR. In many cases such as access track construction and turbine installation, the separation distances will be considerably greater for the majority of the construction period and the predictions are therefore highly conservative and representative of a 'worst case' scenario.

Construction Activity	Nearest NSR	Minimum distance, m	Noise Level, dB LAeq at nearest NSR
Construct temporary construction compounds	NSR13	340	57
Construct access tracks	NSR08	290	58
Construct Substation	NSR07	280	53
Construct crane hardstandings and crane pads	NSR14	530	51
Construct turbine foundations	NSR14	530	56
Install turbines	NSR14	530	52
Reinstate crane pads	NSR14	530	48
Processing of quarried stone	NSR08	720	59
Forestry felling around tracks and turbines	NSR23	630	45

Table 12.16: Predicted Construction Noise Levels from Onsite Activity

Comparing the above predicted construction noise levels to the range of background noise levels measured around the project site suggests that the noisier construction activities will be audible at various times throughout the construction phase. However, comparing these levels to those for BS 5228-1 Category A, as repeated in **Table 12.1**, the construction noise generated will be below the threshold for the daytime. As such, no significant effect, in EIA terms, is assessed as likely to occur.

In addition to on-site activities, upgrade works to existing roads along the construction haul route will take place. The nature of the road upgrade work will be comparable to other roadwork activity and will quickly diminish as work progresses along the route. The short-term and transient nature of such works, combined with the absence of any particularly loud, unusual or impactful activities, will ensure that any noise and vibration effects which may be experienced are not likely to be significant or, in the case of vibration, be of a magnitude such that could result in cosmetic or structural damage.

Furthermore, construction traffic passing to and from the site will also represent a likely source of noise experienced at surrounding properties. Traffic flow data, as reported in **Chapter 14** (Material Assets), has been used to confirm the likely type and number of vehicles using the nearby roads for cases with and without construction traffic.

An average daily number of 70 no. construction HGV movements (i.e. 35 no. trips⁴) is predicted over the course of the construction phase. This equates to a noise level of 45dB $L_{Aeq, 12 \text{ hour}}$, at a distance of 15m away, which is considered a typical distance for the nearest dwellings to the construction traffic route. A level of 45dB is below the daytime threshold value for BS 5228-1 Category A and, as such, no significant effect is assessed as likely to occur. The greatest increase in HGV movements is predicted to occur during turbine foundation concrete pours (10 no. days) and is predicted to generate a maximum of 150 no. HGV movements (i.e. 75 no. trips). This equates a noise level of 48dB $L_{Aeq, 12 \text{ hour}}$, at a distance of 15m away, which is also below the daytime threshold value for BS 5228-1 Category A and, as such, no significant effect is assessed as likely to occur.

Table 12.17 lists the key construction activities and the predicted noise level associated with the installation of the underground electricity line at set distances back for these works.

Construction Activity	Sound Power Level, dB L_{WA}	On time % of day	Predicted noise level, dB L_{Aeq} at distance				
			15 m	40 m	60 m	80 m	100 m
Dust suppression	104	10	62	54	50	47	45
Breaking road surfaces	111	25	73	64	61	58	56
Rolling and compacting	105	50	70	62	58	55	53
Trenching	98	50	63	55	51	48	46
Cutting concrete	114	10	72	64	60	57	55
Tipping fill	107	10	65	57	53	50	48
Compaction	108	10	66	58	54	51	49

Table 12.17: Predicted Electricity Line Construction Noise Levels

The noise levels presented in **Table 12.17** may only occur for short periods of time at a very limited number of dwellings. Whilst it is noted that some dwellings are situated c. 15m from the route of the electricity line and may be exposed to the predicted noise levels shown in the 15m column of **Table 12.17**, this would only be for the day that such works are at this closest distance. The nature of the construction work associated with the installation of the electricity line will be comparable to other roadwork activity and will quickly diminish as work progresses along the route. The short-term and transient nature of such works, combined with the absence of any particularly loud, unusual or impactful activities, will ensure that any noise and vibration effects which may be experienced are not likely to be significant or, in the case of vibration, be of a magnitude such that could result in cosmetic or structural damage.

12.5.3 OPERATION PHASE

Table 12.18 presents the noise levels from the operation of the wind turbines within the

⁴ A 'trip' comprises an 'inward movement' to the site and an 'outward movement' from the site.

project at NSRs. The assessment of these noise levels for each NSR is detailed in **Table 12.19** and **Table 12.20** for the daytime and night-time periods respectively and **Graph 12.13** to **Graph 12.42 (Annex 12.4)** for each NSR. A negative exceedance indicates that the turbine immission level is below the appropriate limit. The predictions assume downwind propagation at all NSRs which represents a highly conservative approach as noise immission levels will be the highest in this scenario. In practice, NSRs will not be downwind of all turbines at any given time and the actual noise levels will be lower than those presented in **Table 12.18**.

All wind farm noise immission levels are presented in terms of the $L_{A90,T}$ noise indicator in accordance with the recommendations of the IOA GPG, obtained by subtracting 2dB(A) from the calculated $L_{Aeq,T}$ noise levels based on the turbine sound power levels presented in **Table 12.9** and **Table 12.10**.

NSR ID	Wind Turbine Noise (project only), dB L_{A90} , at Standardised wind speed, m/s								
	4	5	6	7	8	9	10	11	12
NSR01	25.7	29.5	32.5	33.8	33.9	33.9	33.9	33.9	34.6
NSR02	28.0	31.8	34.8	36.1	36.2	36.2	36.2	36.2	36.9
NSR03	25.4	29.6	32.6	33.5	33.5	33.5	33.5	33.5	34.5
NSR04	28.3	33.0	36.3	36.7	36.8	36.8	36.8	36.8	37.5
NSR05	28.4	33.1	36.4	36.8	36.9	36.9	36.9	36.9	37.6
NSR06	28.6	33.3	36.6	37.0	37.1	37.1	37.1	37.1	37.8
NSR07	29.6	34.3	37.5	37.9	37.9	37.9	37.9	37.9	38.8
NSR08	32.2	36.9	39.9	39.6	39.7	39.8	39.8	39.8	41.4
NSR09	29.5	34.3	37.5	37.4	37.4	37.5	37.5	37.5	38.8
NSR10	28.9	33.6	37.0	36.9	36.9	36.9	36.9	36.9	38.1
NSR11	28.6	33.4	36.8	36.8	36.9	36.9	36.9	36.9	37.8
NSR12	25.5	30.3	33.8	34.1	34.1	34.1	34.1	34.1	34.7
NSR13	28.4	33.2	36.8	37.2	37.2	37.2	37.2	37.2	37.7
NSR14	23.5	28.2	31.7	31.6	31.6	31.6	31.6	31.6	32.7
NSR15	24.8	29.6	33.1	32.9	33.0	33.0	33.0	33.0	34.1
NSR16	25.8	30.5	34.1	33.9	33.9	34.0	34.0	34.0	35.0
NSR17	26.5	31.2	34.7	34.2	34.3	34.3	34.3	34.3	35.7
NSR18	24.3	28.9	32.0	30.9	31.0	31.1	31.1	31.1	33.5
NSR19	28.4	33.1	36.2	34.6	34.8	34.9	34.9	34.9	37.6
NSR20	29.1	33.7	36.8	35.2	35.4	35.4	35.4	35.4	38.3
NSR21	31.0	35.7	38.6	36.9	37.1	37.2	37.2	37.2	40.2
NSR22	31.7	36.3	39.2	37.5	37.7	37.7	37.7	37.7	40.9
NSR23	30.5	34.9	37.1	36.5	36.7	36.7	36.7	36.7	39.6
NSR24	25.6	29.7	32.4	32.2	32.3	32.3	32.3	32.3	34.7
NSR25	24.5	28.7	31.3	30.9	31.0	31.0	31.0	31.0	33.5
NSR26	23.7	27.8	30.8	30.3	30.4	30.5	30.5	30.5	32.7
NSR27	23.8	27.9	30.9	30.7	30.7	30.8	30.8	30.8	32.9
NSR28	21.5	25.3	28.3	28.7	28.8	28.8	28.8	28.8	30.4
NSR29	23.2	27.0	30.0	30.7	30.7	30.7	30.7	30.7	32.1
NSR30	23.8	27.5	30.6	31.7	31.7	31.8	31.8	31.8	32.7

Table 12.18: Wind Turbine Noise - Project Only

NSR ID	Limit Exceedance (project only), dB LA90, at Standardised wind speed, m/s								
	4	5	6	7	8	9	10	11	12
NSR01	-14.3	-10.5	-7.5	-11.2	-11.1	-11.1	-13.8	-17.5	-20.2
NSR02	-12.0	-13.2	-10.2	-8.9	-8.8	-10.1	-13.6	-17.4	-20.8
NSR03	-14.6	-15.4	-12.4	-11.5	-11.5	-12.8	-16.2	-20.1	-23.3
NSR04	-11.7	-7.0	-3.7	-8.3	-8.2	-8.2	-8.2	-9.6	-12.0
NSR05	-11.6	-6.9	-3.6	-8.2	-8.1	-8.1	-8.1	-9.5	-11.9
NSR06	-11.4	-6.7	-3.4	-8.0	-7.9	-7.9	-7.9	-9.3	-11.7
NSR07	-10.4	-5.7	-2.5	-7.1	-7.1	-7.1	-7.1	-8.5	-10.7
NSR08	-12.8	-8.1	-5.1	-5.4	-5.3	-5.2	-5.2	-6.6	-8.1
NSR09	-10.5	-5.7	-2.5	-7.6	-7.6	-7.5	-7.5	-8.4	-10.0
NSR10	-11.1	-6.4	-3.0	-8.1	-8.1	-8.1	-8.1	-8.9	-10.7
NSR11	-11.4	-6.6	-3.2	-8.2	-8.1	-8.1	-8.1	-9.0	-11.0
NSR12	-14.5	-9.7	-6.2	-10.9	-10.9	-10.9	-10.9	-11.7	-14.1
NSR13	-11.6	-6.8	-3.2	-7.8	-7.8	-7.8	-7.8	-8.6	-11.1
NSR14	-16.5	-11.8	-8.3	-13.4	-13.4	-13.4	-13.4	-14.2	-16.1
NSR15	-15.2	-10.4	-6.9	-12.1	-12.0	-12.0	-12.0	-12.9	-14.7
NSR16	-14.2	-9.5	-5.9	-11.1	-11.1	-11.0	-11.0	-11.9	-13.8
NSR17	-13.5	-8.8	-5.3	-10.8	-10.7	-10.7	-10.7	-11.6	-13.1
NSR18	-15.7	-16.1	-13.0	-14.1	-14.0	-13.9	-13.9	-16.2	-17.0
NSR19	-11.6	-11.9	-8.8	-10.4	-10.2	-10.1	-10.1	-12.4	-12.8
NSR20	-10.9	-11.3	-8.2	-9.8	-9.6	-9.6	-9.6	-11.9	-12.2
NSR21	-9.0	-9.3	-6.4	-8.1	-7.9	-7.8	-7.8	-10.1	-10.2
NSR22	-8.3	-8.7	-5.8	-7.5	-7.3	-7.3	-7.3	-9.6	-9.5
NSR23	-9.5	-10.1	-7.9	-8.5	-8.3	-8.3	-8.3	-10.6	-10.8
NSR24	-14.4	-15.3	-12.6	-12.8	-12.7	-12.7	-12.7	-15.0	-15.8
NSR25	-15.5	-16.3	-13.7	-14.1	-14.0	-14.0	-14.0	-16.3	-16.9
NSR26	-16.3	-17.2	-14.2	-14.7	-14.6	-14.5	-14.5	-16.9	-17.7
NSR27	-16.2	-17.1	-14.1	-14.3	-14.3	-14.2	-14.2	-16.5	-17.6
NSR28	-18.5	-19.7	-16.7	-16.3	-16.2	-16.2	-16.2	-18.5	-20.0
NSR29	-16.8	-18.0	-15.0	-14.3	-14.3	-14.3	-14.3	-16.6	-18.3
NSR30	-16.2	-12.5	-9.4	-13.3	-13.3	-13.2	-15.9	-19.6	-22.1

Table 12.19: Daytime Margin Between Limit and Turbine Immission - Project Only

NSR ID	Limit Exceedance (project only), dB LA90, at Standardised wind speed, m/s								
	4	5	6	7	8	9	10	11	12
NSR01	-17.3	-13.5	-10.5	-9.2	-9.1	-9.1	-12.4	-16.8	-20.7
NSR02	-15.0	-11.2	-8.2	-6.9	-6.8	-9.0	-11.8	-14.2	-15.2
NSR03	-17.6	-13.4	-10.4	-9.5	-9.5	-11.7	-14.5	-16.9	-17.7
NSR04	-14.7	-10.0	-6.7	-6.3	-6.2	-6.2	-6.2	-6.8	-9.0
NSR05	-14.6	-9.9	-6.6	-6.2	-6.1	-6.1	-6.1	-6.7	-8.9
NSR06	-14.4	-9.7	-6.4	-6.0	-5.9	-5.9	-5.9	-6.5	-8.7
NSR07	-13.4	-8.7	-5.5	-5.1	-5.1	-5.1	-5.1	-5.6	-7.7

NSR08	-12.8	-8.1	-5.1	-5.4	-5.3	-5.2	-5.2	-5.2	-5.1
NSR09	-13.5	-8.7	-5.5	-5.6	-5.6	-5.5	-5.5	-5.5	-6.9
NSR10	-14.1	-9.4	-6.0	-6.1	-6.1	-6.1	-6.1	-6.1	-7.6
NSR11	-14.4	-9.6	-6.2	-6.2	-6.1	-6.1	-6.1	-6.1	-7.8
NSR12	-17.5	-12.7	-9.2	-8.9	-8.9	-8.9	-8.9	-8.9	-10.9
NSR13	-14.6	-9.8	-6.2	-5.8	-5.8	-5.8	-5.8	-5.8	-8.0
NSR14	-19.5	-14.8	-11.3	-11.4	-11.4	-11.4	-11.4	-11.4	-13.0
NSR15	-18.2	-13.4	-9.9	-10.1	-10.0	-10.0	-10.0	-10.0	-11.6
NSR16	-17.2	-12.5	-8.9	-9.1	-9.1	-9.0	-9.0	-9.0	-10.6
NSR17	-16.5	-11.8	-8.3	-8.8	-8.7	-8.7	-8.7	-8.7	-10.0
NSR18	-18.7	-14.1	-11.0	-12.1	-12.0	-11.9	-11.9	-11.9	-12.8
NSR19	-14.6	-9.9	-6.8	-8.4	-8.2	-8.1	-8.1	-8.1	-8.7
NSR20	-13.9	-9.3	-6.2	-7.8	-7.6	-7.6	-7.6	-7.6	-8.0
NSR21	-12.0	-7.3	-4.4	-6.1	-5.9	-5.8	-5.8	-5.8	-6.1
NSR22	-11.3	-6.7	-3.8	-5.5	-5.3	-5.3	-5.3	-5.3	-5.4
NSR23	-12.5	-8.1	-5.9	-6.5	-6.3	-6.3	-6.3	-6.3	-6.7
NSR24	-17.4	-13.3	-10.6	-10.8	-10.7	-10.7	-10.7	-10.7	-11.7
NSR25	-18.5	-14.3	-11.7	-12.1	-12.0	-12.0	-12.0	-12.0	-12.8
NSR26	-19.3	-15.2	-12.2	-12.7	-12.6	-12.5	-12.5	-12.5	-13.6
NSR27	-19.2	-15.1	-12.1	-12.3	-12.3	-12.2	-12.2	-12.2	-13.5
NSR28	-21.5	-17.7	-14.7	-14.3	-14.2	-14.2	-14.2	-14.2	-15.9
NSR29	-19.8	-16.0	-13.0	-12.3	-12.3	-12.3	-12.3	-12.3	-14.2
NSR30	-19.2	-15.5	-12.4	-11.3	-11.3	-11.2	-14.5	-19.0	-22.6

Table 12.20: Night-time Margin Between Limit and Turbine Immission - Project Only

The results of the assessment detailed in **Table 12.19** and **Table 12.20** and **Annex 12.4** confirm that the predicted wind farm noise immission levels for the project do not exceed the daytime or night-time noise limits derived in accordance with the 2006 Guidelines under all wind speeds and at all locations. Accordingly, no significant effects are predicted or assessed as likely during the operation of the wind turbines.

In addition to operational noise from the turbines, the electricity substation will typically be operational continuously and, therefore, the predicted noise level at the nearest NSR has been assessed.

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

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

recommended that a minimum distance of 5m is maintained between 110kV substations and the land boundary of any noise sensitive property."

The electricity substation will have comparable noise emissions to the 110kV unit discussed above. Given the distance between the substation and the nearest NSR (c. 280m from NSR08), noise from the operation of the substation is not assessed as likely to be audible at the nearest NSR.

It is therefore assessed that noise emissions from the operation of the electricity substation will be negligible, and are not likely to be significant.

12.5.4 DECOMMISSIONING PHASE

Upon decommissioning of the project, the wind turbines will be disassembled and all above ground components will be dismantled and removed off-site. It is proposed that turbine foundations will generally remain in place; however, the foundation will be broken up to a depth of 1m and will be covered with soil and allowed to revegetate. These activities will be undertaken during daytime hours, and noise will be of a lesser impact than for construction. As construction noise effects are likely to be not significant, decommissioning phase noise effects are also likely to be not significant.

Site access tracks could be in use for purposes other than the operation of the project at the time of decommissioning and, therefore, it may be more appropriate to leave the site access tracks in situ for future use. If the tracks are not required in the future for any other useful purpose, they will be removed. This would involve removing hard core material and the underlying geotextile. Soil may be spread across the affected area as required. If the access tracks are removed, the noise effect is expected to be less than that during the construction stage and therefore also likely to be not significant.

It is proposed that underground electrical and communications cables and underground electricity line will not be dug up and removed; instead, the cabling will be removed from its ducting at joint bays while the ducting will remain in-situ thus avoiding substantial construction-type activities. The works associated with the removal of the underground cables and electricity line will have an imperceptible impact.

Therefore, decommissioning phase noise effects are likely to be not significant.

12.5.5 CUMULATIVE EFFECTS

Having regard to the characteristic of the project and the other existing, permitted and proposed developments listed at **Chapter 1**, no cumulative construction effects are expected.

Table 12.21 presents the cumulative noise levels from the operation of the project (wind turbines) together with those at the Largan Hill Wind Farm. The assessment of these noise levels for each NSR is detailed in **Table 12.22** and **Table 12.23** for the daytime and night-time respectively and **Graph 12.13** to **Graph 12.42 (Annex 12.4)** for each NSR. A negative exceedance indicates that the turbine immission level is below the appropriate limit. The predictions assume downwind propagation which represents a highly-conservative approach as noise immission levels will be the highest in this scenario. In practice, NSRs will not be downwind of all turbines at any given time and the actual noise levels will be lower than those presented in **Table 12.21**.

NSR ID	Wind Turbine Noise (Cumulative), dB LA90, at Standardised wind speed, m/s								
	4	5	6	7	8	9	10	11	12
NSR01	26.6	30.6	33.2	34.3	34.4	34.5	34.5	34.6	35.3
NSR02	28.6	32.6	35.3	36.5	36.6	36.6	36.7	36.7	37.4
NSR03	26.3	30.6	33.2	34.0	34.1	34.1	34.2	34.2	35.1
NSR04	28.9	33.6	36.6	37.1	37.1	37.2	37.2	37.2	37.9
NSR05	29.0	33.7	36.7	37.2	37.2	37.3	37.3	37.3	38.0
NSR06	29.2	33.9	36.9	37.3	37.4	37.4	37.5	37.5	38.2
NSR07	30.2	34.9	37.8	38.2	38.3	38.3	38.3	38.4	39.2
NSR08	32.5	37.3	40.1	39.9	40.0	40.0	40.1	40.1	41.7
NSR09	30.0	34.7	37.7	37.6	37.7	37.8	37.8	37.8	39.1
NSR10	29.3	34.0	37.2	37.1	37.2	37.2	37.3	37.3	38.4
NSR11	29.0	33.7	37.0	37.0	37.1	37.1	37.2	37.2	38.1
NSR12	25.9	30.6	34.0	34.3	34.3	34.4	34.4	34.4	35.0
NSR13	28.6	33.4	37.0	37.3	37.4	37.4	37.4	37.4	37.8
NSR14	24.1	28.9	32.0	31.9	32.0	32.1	32.1	32.1	33.2
NSR15	25.4	30.2	33.4	33.2	33.3	33.4	33.4	33.4	34.5
NSR16	26.4	31.1	34.4	34.2	34.3	34.4	34.4	34.4	35.4
NSR17	27.3	32.0	35.1	34.7	34.8	34.9	34.9	35.0	36.2
NSR18	26.3	30.9	33.2	32.5	32.7	32.9	33.0	33.1	34.9
NSR19	31.5	36.2	38.2	37.4	37.7	37.9	38.0	38.3	39.9
NSR20	32.1	36.8	38.7	37.9	38.2	38.4	38.6	38.8	40.5
NSR21	33.8	38.5	40.4	39.5	39.8	40.0	40.1	40.3	42.2
NSR22	33.7	38.4	40.4	39.3	39.6	39.8	39.9	40.1	42.3
NSR23	36.0	40.7	41.7	41.7	42.0	42.3	42.5	42.8	44.0
NSR24	36.5	41.2	41.8	42.1	42.4	42.8	43.1	43.4	44.0
NSR25	33.9	38.7	39.3	39.5	39.9	40.3	40.5	40.9	41.5
NSR26	33.3	38.0	38.8	38.9	39.3	39.7	39.9	40.3	40.9
NSR27	33.3	38.0	38.8	39.0	39.3	39.7	40.0	40.3	40.9
NSR28	28.1	32.7	33.7	34.0	34.3	34.6	34.8	35.1	35.9
NSR29	27.8	32.3	33.6	34.1	34.4	34.6	34.8	35.0	35.8
NSR30	25.8	30.0	32.1	33.0	33.1	33.2	33.3	33.4	34.2

Table 12.21: Wind Turbine Noise - Cumulative

NSR ID	Limit Exceedance (Cumulative), dB LA90, at Standardised wind speed, m/s								
	4	5	6	7	8	9	10	11	12
NSR01	-13.4	-9.4	-6.8	-10.7	-10.6	-10.5	-13.1	-16.8	-19.6
NSR02	-11.4	-12.4	-9.7	-8.5	-8.4	-9.7	-13.1	-16.9	-20.4
NSR03	-13.7	-14.4	-11.8	-11.0	-10.9	-12.2	-15.6	-19.4	-22.7
NSR04	-11.1	-6.4	-3.4	-7.9	-7.9	-7.8	-7.8	-9.1	-11.6
NSR05	-11.0	-6.3	-3.3	-7.8	-7.8	-7.7	-7.7	-9.0	-11.5
NSR06	-10.8	-6.1	-3.1	-7.7	-7.6	-7.6	-7.5	-8.9	-11.3
NSR07	-9.8	-5.1	-2.2	-6.8	-6.7	-6.7	-6.7	-8.0	-10.3
NSR08	-12.5	-7.7	-4.9	-5.1	-5.0	-5.0	-4.9	-6.3	-7.9

NSR09	-10.0	-5.3	-2.3	-7.4	-7.3	-7.2	-7.2	-8.1	-9.7
NSR10	-10.7	-6.0	-2.8	-7.9	-7.8	-7.8	-7.7	-8.6	-10.4
NSR11	-11.0	-6.3	-3.0	-8.0	-7.9	-7.9	-7.8	-8.7	-10.7
NSR12	-14.1	-9.4	-6.0	-10.7	-10.7	-10.6	-10.6	-11.5	-13.8
NSR13	-11.4	-6.6	-3.0	-7.7	-7.6	-7.6	-7.6	-8.5	-11.0
NSR14	-15.9	-11.1	-8.0	-13.1	-13.0	-12.9	-12.9	-13.8	-15.6
NSR15	-14.6	-9.8	-6.6	-11.8	-11.7	-11.6	-11.6	-12.4	-14.3
NSR16	-13.6	-8.9	-5.6	-10.8	-10.7	-10.6	-10.6	-11.5	-13.4
NSR17	-12.7	-8.0	-4.9	-10.3	-10.2	-10.1	-10.1	-10.9	-12.6
NSR18	-13.7	-14.1	-11.8	-12.5	-12.3	-12.1	-12.0	-14.2	-15.5
NSR19	-8.5	-8.8	-6.8	-7.6	-7.3	-7.1	-7.0	-9.1	-10.5
NSR20	-7.9	-8.2	-6.3	-7.1	-6.8	-6.6	-6.4	-8.5	-9.9
NSR21	-6.2	-6.5	-4.6	-5.5	-5.2	-5.0	-4.9	-7.0	-8.2
NSR22	-6.3	-6.6	-4.6	-5.7	-5.4	-5.2	-5.1	-7.2	-8.1
NSR23	-4.0	-4.3	-3.3	-3.3	-3.0	-2.7	-2.5	-4.5	-6.4
NSR24	-3.5	-3.8	-3.2	-2.9	-2.6	-2.2	-1.9	-3.9	-6.4
NSR25	-6.1	-6.3	-5.7	-5.5	-5.1	-4.7	-4.5	-6.4	-8.9
NSR26	-6.7	-7.0	-6.2	-6.1	-5.7	-5.3	-5.1	-7.0	-9.5
NSR27	-6.7	-7.0	-6.2	-6.0	-5.7	-5.3	-5.0	-7.0	-9.5
NSR28	-11.9	-12.3	-11.3	-11.0	-10.7	-10.4	-10.2	-12.2	-14.6
NSR29	-12.2	-12.7	-11.4	-10.9	-10.6	-10.4	-10.2	-12.3	-14.6
NSR30	-14.2	-10.0	-7.9	-12.0	-11.9	-11.8	-14.3	-17.9	-20.6

Table 12.22: Daytime Margin Between Limit and Turbine Immission - Cumulative

NSR ID	Limit Exceedance (Cumulative), dB LA90, at Standardised wind speed, m/s								
	4	5	6	7	8	9	10	11	12
NSR01	-16.4	-12.4	-9.8	-8.7	-8.6	-8.5	-11.7	-16.1	-20.0
NSR02	-14.4	-10.4	-7.7	-6.5	-6.4	-8.6	-11.4	-13.7	-14.7
NSR03	-16.7	-12.4	-9.8	-9.0	-8.9	-11.1	-13.9	-16.2	-17.1
NSR04	-14.1	-9.4	-6.4	-5.9	-5.9	-5.8	-5.8	-6.3	-8.6
NSR05	-14.0	-9.3	-6.3	-5.8	-5.8	-5.7	-5.7	-6.2	-8.5
NSR06	-13.8	-9.1	-6.1	-5.7	-5.6	-5.6	-5.5	-6.0	-8.3
NSR07	-12.8	-8.1	-5.2	-4.8	-4.7	-4.7	-4.7	-5.2	-7.3
NSR08	-12.5	-7.7	-4.9	-5.1	-5.0	-5.0	-4.9	-4.9	-4.8
NSR09	-13.0	-8.3	-5.3	-5.4	-5.3	-5.2	-5.2	-5.2	-6.6
NSR10	-13.7	-9.0	-5.8	-5.9	-5.8	-5.8	-5.7	-5.7	-7.3
NSR11	-14.0	-9.3	-6.0	-6.0	-5.9	-5.9	-5.8	-5.8	-7.6
NSR12	-17.1	-12.4	-9.0	-8.7	-8.7	-8.6	-8.6	-8.6	-10.7
NSR13	-14.4	-9.6	-6.0	-5.7	-5.6	-5.6	-5.6	-5.6	-7.9
NSR14	-18.9	-14.1	-11.0	-11.1	-11.0	-10.9	-10.9	-10.9	-12.5
NSR15	-17.6	-12.8	-9.6	-9.8	-9.7	-9.6	-9.6	-9.6	-11.2
NSR16	-16.6	-11.9	-8.6	-8.8	-8.7	-8.6	-8.6	-8.6	-10.2
NSR17	-15.7	-11.0	-7.9	-8.3	-8.2	-8.1	-8.1	-8.0	-9.4
NSR18	-16.7	-12.1	-9.8	-10.5	-10.3	-10.1	-10.0	-9.9	-11.4

NSR19	-11.5	-6.8	-4.8	-5.6	-5.3	-5.1	-5.0	-4.7	-6.4
NSR20	-10.9	-6.2	-4.3	-5.1	-4.8	-4.6	-4.4	-4.2	-5.8
NSR21	-9.2	-4.5	-2.6	-3.5	-3.2	-3.0	-2.9	-2.7	-4.1
NSR22	-9.3	-4.6	-2.6	-3.7	-3.4	-3.2	-3.1	-2.9	-4.0
NSR23	-7.0	-2.3	-1.3	-1.3	-1.0	-0.7	-0.5	-0.2	-2.3
NSR24	-6.5	-1.8	-1.2	-0.9	-0.6	-0.2	0.1	0.4	-2.3
NSR25	-9.1	-4.3	-3.7	-3.5	-3.1	-2.7	-2.5	-2.1	-4.8
NSR26	-9.7	-5.0	-4.2	-4.1	-3.7	-3.3	-3.1	-2.7	-5.4
NSR27	-9.7	-5.0	-4.2	-4.0	-3.7	-3.3	-3.0	-2.7	-5.4
NSR28	-14.9	-10.3	-9.3	-9.0	-8.7	-8.4	-8.2	-7.9	-10.5
NSR29	-15.2	-10.7	-9.4	-8.9	-8.6	-8.4	-8.2	-8.0	-10.5
NSR30	-17.2	-13.0	-10.9	-10.0	-9.9	-9.8	-12.9	-17.3	-21.1

Table 12.23: Night-time Margin Between Limit and Turbine Immission - Cumulative

The results of the cumulative operational assessment shown in **Table 12.22**, **Table 12.23** and **Annex 12.4** highlight a small exceedance of the night-time limit (up to 0.4dB) at NSR24 at wind speeds of 10m/s and 11m/s. The assessment of the night-time period for this receptor is considered in further detail below in **Table 12.24**.

Detail	Noise Level, dB L _{A90} , at Standardised wind speed, m/s								
	4	5	6	7	8	9	10	11	12
Largan Hill Wind Farm	36.1	40.9	41.3	41.6	42.0	42.4	42.7	43.1	43.5
Project	25.6	29.7	32.4	32.2	32.3	32.3	32.3	32.3	34.7
Cumulative	36.5	41.2	41.8	42.1	42.4	42.8	43.1	43.4	44.0
Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3
Night-time margin	-6.5	-1.8	-1.2	-0.9	-0.6	-0.2	0.1	0.4	-2.3

Table 12.24: Wind Turbine Operational Noise Detailed Night-time Assessment – NSR24

The small cumulative exceedance at 10m/s and 11m/s can be seen from **Table 12.24** to be as a result of Largan Hill Wind Farm, which is predicted to slightly exceed the night-time TNAC on its own at 11m/s. It is therefore not possible to be cumulatively below the limit at this location, based on the parameters used in the calculation. **Table 12.24** also shows that wind turbine noise from the project is more than 10dB lower than that of the Largan Hill Wind Farm and the night-time TNAC at NSR24 at 10m/s and 11m/s. As discussed above in **Section 12.3.1**, the introduction of new noise source that is at least 10dB lower than an existing source is not considered to significantly contribute to the overall level of noise, even though a slight change is shown when considered to 1 no. decimal place. The human ear begins to perceive a difference in noise level when a sound is increased by 3dB, under laboratory conditions. Therefore, it would not be possible to perceive an increase in wind turbine noise at NSR24 with the introduction of the project. This is further discussed in the UK DfESNZ guidance document, where it is stated that “if the contribution from other wind turbine developments is equal to, or above, the TNAC, the SSNL would usually be set at 10dB below the TNAC”.

Whilst there is 1 no. receptor that exceeds the TNAC under cumulative conditions, it is only at 2 no. wind speeds during the night-time period and is primarily as a result of the Largan Hill Wind Farm rather than the project. In such cases, the best practice

guidance is to set limits for the project to be 10dB lower than the TNAC, which in this case would equal 33dB L_{A90} . It can be seen in **Table 12.18** that wind turbine noise from the project does not exceed this value at NSR24 for all windspeeds up to and including 11m/s. At all other locations, the predicted cumulative wind farm noise immission levels do not exceed the daytime or night-time TNAC derived in accordance with the 2006 Guidelines. Accordingly, it is assessed that no significant cumulative effects are likely to be experienced at any NSR as a result of the introduction of the project.

12.6 MITIGATION & MONITORING MEASURES

12.6.1 CONSTRUCTION PHASE

Construction activities will be completed in accordance with the provisions, where relevant, of BS 5228-1 which offers detailed guidance on the control of noise & vibration from demolition and construction activities. The relevant practices to be adopted during construction shall include:-

- Limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- Establishing channels of communication between the contractor/developer, the Planning Authority and residents;
- Appointing a site representative responsible for matters relating to noise and vibration;
- Monitoring typical levels of noise and vibration during critical periods and at sensitive locations; and,
- Keeping site access tracks even to mitigate the potential for noise and vibration from HGVs.

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

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

12.6.1.1 Noise

The various contractors involved in the construction phase will be obliged, under contract, to take specific noise abatement measures and comply with the recommendations of BS 5228-1. The following list of measures will be implemented, as relevant, to ensure compliance with the relevant construction noise criteria:-

- No plant or machinery will be permitted to cause a public nuisance due to noise;
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract;

- Compressors will be attenuated models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers;
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use;
- Any plant, such as generators or pumps, which may be required to operate outside of general construction hours will be surrounded by an acoustic enclosure or portable screen;
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits detailed in **Table 12.1** using methods outlined in BS 5228-1; and,
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations, including the delivery of construction materials, shall be restricted to between 07:00hrs and 19:00hrs Monday to Friday and between 07:00hrs and 13:00hrs on Saturdays, with no operations on Sundays or public holidays. However, to ensure that optimal use is made of good weather periods, at occasional critical periods within the construction programme (i.e. concrete pours, turbine component deliveries and turbine erection) or in the event of an emergency; activities may be necessary outside out of these hours.

The following measures will be implemented, where necessary, to control and mitigate noise emissions associated with blasting operations and the processing of quarried stone:-

- Notification of nearby residents before blasting starts (e.g. 24-hour written notification);
- Carry out blasting using a series of trial blasts, each with progressively increasing charges. Larger charge weights are only to be used if the trial blast shows acceptable levels of air overpressure;
- If air overpressure from blasting is too high a reduction in the amount of primer cord used, together with the adequate burial of any that is above the ground can greatly reduce;
- Where NSRs are situated close to the blast site and air over pressure levels are cause for complaint, blasting shall be postponed during weather conditions whereby the NSRs are down wind of the blast;
- The firing of blasts at similar times of the day to reduce the 'startle' effect.
- Fit suitably designed muffler or sound reduction equipment to the rock breaking tool to reduce noise without impairing machine efficiency;
- Ensure all air lines are sealed;
- Use a dampened bit to eliminate a 'ringing' sound;
- Erect an acoustic screen between compressors or generators and NSRs. When possible, line of sight between top of machine and NSR will be obscured; and,
- Enclose the breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation.

12.6.1.2 Vibration

The level of vibration from construction activities shall be limited to the values set out in **Table 12.2**. It should be noted that these limits are not absolute but provide guidance as to magnitudes of vibration that are very unlikely to cause cosmetic damage. Magnitudes of vibration slightly greater than those in the table are normally unlikely to cause cosmetic damage, but construction work creating such magnitudes should proceed with caution. Where there is existing damage, these limits may need to be reduced by up to 50%.

Given the substantial distances between locations where notable levels of vibration may take place (e.g. at turbine locations or extensive use of vibration rollers in access track construction) and the nearest NSRs, no likely significant effect will be experienced. Therefore, no specific mitigation measures are proposed in respect of vibration.

The transmission and magnitude of ground vibrations associated with blasting operations at borrow pits are subject to many complex influences including charge type and position, and importantly, the precise nature of the ground conditions (material composition, compaction, discontinuities) at the source, receiver, and at every point along all potential ground transmission paths. Clearly any estimation of such conditions is subject to considerable uncertainty, thus limiting the utility of predictive exercises. Mitigation of the impacts of these activities is best achieved through on site testing processes, with progressively increased charges, carried out in consultation with the Planning Authority.

12.6.2 OPERATION PHASE

12.6.2.1 Noise

An assessment of the operation phase noise levels, both specific to the project and in combination with the operational Largan Hill Wind Farm, has been undertaken in accordance with best practice guidelines and procedures. The findings of the assessment confirm that predicted operation phase noise levels from the project would be not significant. It is noted that this includes some small embedded mitigation measures in the form of noise reduced modes for the project turbines, as set out in **Annex 12.5**. Therefore, no further noise mitigation measures are required for the operation phase.

Wind turbine manufactures offer various noise reduced modes for their turbines, whereby the turbine can operate normally but would produce a lower level of noise at the expense of a corresponding reduction in energy generation. The assumed noise reduced modes considered for embedded mitigation will be confirmed by the manufacturer prior to installation. The final requirement for noise reduced modes will be required to meet the SSNL set out in **Table 12.25** and **Table 12.26** for the daytime and night-time respectively. The SSNL have been determined in accordance with the UK DfESNZ guidance document by logarithmically subtracting Largan Hill wind turbine noise immission levels from the overall TNAC presented in **Table 12.14** and **Table 12.15** for the daytime and night-time respectively.

NSR ID	Survey Proxy	Noise Limit, dB LA90, at Standardised wind speed, m/s								
		4	5	6	7	8	9	10	11	12
NSR01	NML1	39.9	39.9	39.9	45.0	45.0	45.0	47.6	51.3	54.8

NSR02	NML2	40.0	44.9	44.9	44.9	44.9	46.2	49.7	53.6	57.8
NSR03	NML2	40.0	45.0	45.0	45.0	45.0	46.3	49.7	53.6	57.8
NSR04	NML3	39.8	39.8	39.8	44.9	44.9	44.9	44.9	46.3	49.5
NSR05	NML3	39.8	39.8	39.8	44.9	44.9	44.9	44.9	46.3	49.5
NSR06	NML3	39.8	39.8	39.8	44.9	44.9	44.9	44.9	46.3	49.5
NSR07	NML3	39.8	39.8	39.8	44.9	44.9	44.9	44.9	46.3	49.5
NSR08	NML3	44.9	44.9	44.9	44.9	44.9	44.9	44.9	46.3	49.5
NSR09	NML4	39.9	39.9	39.9	44.9	44.9	44.9	44.9	45.8	48.8
NSR10	NML4	39.9	39.9	39.9	44.9	44.9	44.9	44.9	45.8	48.8
NSR11	NML4	39.9	39.9	39.9	45.0	45.0	45.0	45.0	45.8	48.8
NSR12	NML4	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.9	48.8
NSR13	NML4	39.9	39.9	39.9	45.0	45.0	45.0	45.0	45.9	48.8
NSR14	NML4	39.9	39.9	39.9	45.0	45.0	45.0	45.0	45.9	48.8
NSR15	NML4	39.9	39.9	39.9	45.0	45.0	45.0	45.0	45.9	48.8
NSR16	NML4	39.9	39.9	39.9	45.0	45.0	45.0	45.0	45.9	48.8
NSR17	NML4	39.9	39.9	39.9	44.9	44.9	44.9	44.9	45.8	48.8
NSR18	NML6	39.9	44.9	44.9	44.9	44.9	44.9	44.9	47.3	50.4
NSR19	NML6	39.7	44.5	44.5	44.5	44.5	44.5	44.5	47.0	50.3
NSR20	NML6	39.6	44.5	44.5	44.5	44.5	44.5	44.5	47.0	50.3
NSR21	NML6	39.5	44.2	44.2	44.2	44.2	44.2	44.2	46.8	50.2
NSR22	NML6	39.6	44.4	44.4	44.4	44.4	44.4	44.4	47.0	50.2
NSR23	NML6	38.5	42.7	42.7	42.7	42.7	42.7	42.7	46.0	49.8
NSR24	NML6	37.7	41.1	41.1	41.1	41.1	41.1	41.1	45.2	49.5
NSR25	NML6	38.9	43.3	43.3	43.3	43.3	43.3	43.3	46.3	49.9
NSR26	NML6	39.1	43.6	43.6	43.6	43.6	43.6	43.6	46.5	50.0
NSR27	NML6	39.1	43.6	43.6	43.6	43.6	43.6	43.6	46.5	50.0
NSR28	NML6	39.8	44.7	44.7	44.7	44.7	44.7	44.7	47.1	50.3
NSR29	NML6	39.8	44.7	44.7	44.7	44.7	44.7	44.7	47.2	50.3
NSR30	NML1	39.8	39.8	39.8	44.9	44.9	44.9	47.6	51.3	54.8

Table 12.25: Daytime SSNL at Various Wind Speeds

NSR ID	Survey Proxy	Noise Limit, dB LA90, at Standardised wind speed, m/s								
		4	5	6	7	8	9	10	11	12
NSR01	NML1	42.9	42.9	42.9	42.9	42.9	42.9	46.2	50.7	55.3
NSR02	NML2	42.9	42.9	42.9	42.9	42.9	45.1	48.0	50.4	52.1
NSR03	NML2	42.9	42.9	42.9	42.9	42.9	45.1	48.0	50.4	52.1
NSR04	NML3	42.9	42.9	42.9	42.9	42.9	42.9	42.9	43.4	46.4
NSR05	NML3	42.9	42.9	42.9	42.9	42.9	42.9	42.9	43.4	46.4
NSR06	NML3	42.9	42.9	42.9	42.9	42.9	42.9	42.9	43.4	46.4
NSR07	NML3	42.9	42.9	42.9	42.9	42.9	42.9	42.9	43.4	46.4
NSR08	NML3	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	46.4
NSR09	NML4	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	45.6
NSR10	NML4	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	45.6
NSR11	NML4	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	45.6

NSR ID	Survey Proxy	Noise Limit, dB LA90, at Standardised wind speed, m/s								
		4	5	6	7	8	9	10	11	12
NSR12	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR13	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR14	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR15	NML4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7
NSR16	NML4	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	45.7
NSR17	NML4	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	45.6
NSR18	NML6	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	46.2
NSR19	NML6	42.1	42.1	42.1	42.1	42.1	42.1	42.1	42.1	45.9
NSR20	NML6	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	45.8
NSR21	NML6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	45.6
NSR22	NML6	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	45.8
NSR23	NML6	37.4	37.4	37.4	37.4	37.4	37.4	37.4	37.4	44.3
NSR24	NML6	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	43.1
NSR25	NML6	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	44.9
NSR26	NML6	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	45.1
NSR27	NML6	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	45.1
NSR28	NML6	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	46.0
NSR29	NML6	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	46.1
NSR30	NML1	42.9	42.9	42.9	42.9	42.9	42.9	46.2	50.7	55.3

Table 12.26: Night-time SSNL at Various Wind Speeds

In the unlikely event that an issue with low frequency noise is associated with the project, an appropriate detailed investigation, by an independent acoustic consultant, shall be undertaken. Due consideration shall 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 Procedure for the assessment of low frequency noise complaints, Revision 1, December 2011.

In the unlikely event that a complaint is received which indicates potential tonal content associated with the perceived wind turbine noise, an independent acoustic consultant shall be employed to assess the level of tonality in accordance with paragraphs 3.15 to 3.17 of the DfESNZ guidance document. Where appropriate, a character correction shall be applied to the overall wind turbine noise to account for the audibility of the tone.

In the unlikely event that a complaint is received which indicates potential amplitude modulation (AM) associated with turbine operation, an independent acoustic consultant shall be employed to assess the level of AM in accordance with the methods outlined in the IOA Wind Turbine Noise Amplitude Modulation Working Group (AMWG) document *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (IOA, 2016) or subsequent revisions, and to implement suitable measures as necessary.

12.6.2.2 Vibration

The project is not assessed as likely to give rise to significant vibration effects during

the operation phase. There will be no requirement for impact machinery or significant numbers of HGV movements during this phase of the project. Vehicles accessing the project site will typically be LGVs and, where HGVs may be required, the volume of movements will be imperceptible. Accordingly, no mitigation measures are required.

12.6.3 DECOMMISSIONING PHASE

The mitigation measures to be implemented during the decommissioning of the project are the same as those proposed for the construction phase, with the exception of the measures discussed specifically for blasting and the processing of quarried rock. No blasting or processing of quarried rock will take place during the decommissioning phase.

12.6.4 MONITORING

12.6.4.1 Construction Phase

No specific monitoring of noise or vibration levels during the construction phase is proposed.

12.6.4.2 Operational Phase

It is proposed that, if planning permission is granted for the project, noise levels arising from the operation of the project are measured to demonstrate compliance with appropriate limits. Such monitoring shall be carried out in full accordance with ETSU-R-97 and shall include penalties for any tonal characteristics of the noise (if present).

A Planning-Stage Noise Monitoring Plan has been prepared and is enclosed at **Annex 12.6**. The acoustic consultant appointed to undertake the monitoring shall update the monitoring plan as may be required prior to the commencement of monitoring.

12.6.4.3 Decommissioning Phase

No monitoring of noise or vibration levels during the decommissioning phase is proposed.

12.7 RESIDUAL EFFECTS

This section outlines the likely residual noise and vibration effects associated with the project taking account of the mitigation measures.

12.7.1 DO NOTHING SCENARIO

If the project were not to proceed, the existing noise environment will remain unchanged.

12.7.2 CONSTRUCTION PHASE

During the construction phase, it is likely that some NSRs will experience an increase in noise levels arising from emissions from site traffic and construction activities. However, given that the construction phase of the development is temporary in nature and the distances between the main construction activities and nearby NSRs, it is assessed that the noise generated will not be excessively intrusive. Furthermore, the application of binding noise limits and defined construction hours, along with implementation of widely-recognised effective noise and vibration mitigation measures, will ensure that noise and vibration effects are unlikely to be significant. The residual effects are

assessed to be likely and not significant.

12.7.3 OPERATION PHASE

12.7.3.1 Noise

The assessment of operational wind turbine noise from the project, both in isolation and cumulatively with the Largan Hill Wind Farm, concludes that no significant effect is likely.

While noise levels will increase due to the project, and specifically the operation of the turbines, the predicted increase will not be significant, albeit new sources of noise will be introduced into the soundscape.

For all of NSRs assessed, the likely effect of the operational wind turbines is not significant.

12.7.3.2 Vibration

There is no expected source of vibration related with the operation phase of the project and therefore the residual vibration effect is assessed as not significant.

12.7.4 DECOMMISSIONING PHASE

During the decommissioning phase, noise effects will be similar to those of the construction phase and are assessed to be not significant.

12.8 SUMMARY

The construction noise assessment has determined that mitigation will not be required to reduce a significant effect but will be implemented as part of best practice for the control of noise. The associated residual levels are expected to be audible at various times throughout the construction programme, but remain within acceptable limits such that their temporary effects are not significant.

Operational noise from the project has been assessed in accordance with current best practice. It has been demonstrated that with embedded mitigation in the form of noise-reduced modes, there will be no significant effects. The assumed noise-reduced modes will be confirmed by the manufacturer prior to the installation of the wind turbines. Consequently, it is assessed that operation phase noise effects are not significant. Operational noise from the substation would also be not significant.

Decommissioning phase noise effects from the project have been assessed and confirmed to be not significant without the need for mitigation.

In summary, the noise and vibration effect of the project is likely to be not significant based on this assessment which has been carried out in accordance with current best practice.

