12 Acoustic Assessment

12.1 Introduction

12.1.1 This chapter of the EIAR considers the likely significant acoustic effects associated with the construction, operation and decommissioning of the proposed Hill of Fare Wind Farm (hereafter referred to as the Proposed Development) on residents of nearby properties. The specific objectives of the chapter are to:

- Describe the current baseline;
- Describe the assessment methodology and significance criteria used in completing the impact assessment;
- Describe the potential effects, including direct, indirect and cumulative effects;
- Describe the mitigation measures to address the likely significant effects; and
- Assess the residual effects remaining following the implementation of mitigation measures.

12.1.2 This assessment has been undertaken by RES, with at least one in-house Member of the Institute of Acoustics involved in its production. RES has undertaken acoustic impact assessments for every single one of its UK wind farm development applications since 2000. RES has also carried out noise assessments and reported to several local planning authorities on operational wind energy projects, including taking measurements on newly constructed wind farms to ensure compliance with planning conditions.

12.1.3 The chapter author is Peter Brooks, a Member of the Institute of Acoustics with 13 years of working experience in acoustics, as well as a postgraduate and undergraduate education in acoustics. The chapter reviewer is Jeremy Bass, a Member of the Institute of Acoustics with over 30 years of experience in wind farm development and acoustic assessments.

12.1.4 Additionally, RES has been project co-ordinator for several Joule[1] projects, leading European research into wind turbine noise, was involved in producing the guideline 'The Assessment and Rating of Noise from Wind Farms'[2] for the DTI in 1996, acted as peer reviewer for the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'[3], and contributed to the RenewableUK work on Amplitude Modulation[4]. Selected publications include:

- 'Wind Turbine Measurements for Noise Source Identification', ETSU W/13/003914/00.REP, 1999, Dr P Dunbabin, RES et al;
- 'A Critical Appraisal of Wind Farm Noise Propagation', ETSU W/13/00385/REP, 2000 Dr J Bass, RES;
- 'Aerodynamic Noise Reduction for Variable Speed Turbines', ETSU/W/45/00504/REP, 2000, Dr P Dunbabin, RES;
- 'Fundamental research in amplitude modulation - a project by RenewableUK', Dr J Bass et al, Fourth International Meeting on Wind Turbine Noise, Rome, April 2011;
- 'Investigation of the 'Den Brook' Amplitude Modulation methodology for wind turbine noise', Dr J Bass, Acoustics Bulletin Vol 36 No 6 November/December 2011;
- 'How does noise influence the design of a wind farm?', Dr M Cassidy, Fifth International Conference on Wind Turbine Noise, Denver, 2013;
- 'Propagation of Noise from Wind Farms According to the Good Practice Guide', A Birchby, Sixth International Conference on Wind Turbine Noise, Glasgow, 2015; and
- 'A Method for Rating Amplitude Modulation in Wind Turbine Noise', Institute of Acoustics Noise Working Group, August 2016.

12.1.5 The chapter is supported by:

- Figure 12.1 – Predicted Sound Footprint;
- Technical Appendix 12.1 - Assessment of Energy Storage Facility;
- Technical Appendix 12.2 – Issues Scoped Out of Wind Farm Acoustic Assessment;
- Technical Appendix 12.3 – Calculating Standardised Wind Speed;
- Technical Appendix 12.4 – Background Noise Survey Photos;
- Technical Appendix 12.5 – Instrumentation Records;
- Technical Appendix 12.6 – Charts;

[1] DGXII European Commission funded projects in the field of Research and Technological Development in non-nuclear energy

[2] 'The Assessment and Rating of Noise from Wind Farms', The Working Group on Noise from Wind Turbines, ETSU Report for the DTI, ETSU-R-97, September 1996. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/49869/ETSU_Full_copy__Searchable_.pdf

[3] 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise', Institute of Acoustics, May 2013. Available at: https://www.ioa.org.uk/publications/wind-turbine-noise

[4] 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effects', RenewableUK, December 2013. Available at: http://usir.salford.ac.uk/id/eprint/33475/

- Technical Appendix 12.7 – Suggested Planning Conditions; and
- Glossary.

12.1.6 Figures and Technical Appendices are referenced in the text where relevant.

12.2 Legislation, Policy and Guidance

Construction Noise

12.2.1 In the web based Scottish Government technical advice on construction noise assessment in 'Appendix 1: Legislative Background, Technical Standards and Codes of Practice'[5] it is stated that:

"...under Environmental Impact Assessments and for planning purposes i.e., not in regard to the Control of Pollution Act 1974, the 2009 version of BS 5228 is applicable."

12.2.2 Given that BS 5228-1:2009 'Code of practice for noise and vibration control on construction and open sites - Part 1: Noise'[6] is identified as being the appropriate source of guidance on appropriate methods for minimising noise from construction activities, it is adopted herein.

12.2.3 The Control of Pollution Act 1974 provides information on the need for ensuring that the best practicable means are employed to minimise noise[7].

12.2.4 BS 5228-2:2009 'Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration'[8], provides a method for predicting vibration levels which has been adopted in this assessment.

12.2.5 BS 6472-2:2008 'Guide to evaluation of human exposure to vibration in buildings - Part 2: Blast-induced vibration'[9] has been used to set criteria for satisfactory magnitudes of vibration at nearby residential properties to ensure compliance with respect to human response.

Operational Noise

12.2.6 In the context of other sources of environmental noise, the noise levels produced by turbines are generally low and have greater dependence upon wind speed. The combination of these two factors implies that a degree of masking would often be provided by background noise.

12.2.7 As described by Scottish Government Planning Advice for Onshore Wind Turbines[10]:

"Technically, there are two quite distinct types of noise sources within a wind turbine - the mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise produced by the passage of the blades through the air. There has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design."

12.2.8 Within Scotland, noise is defined within the planning context by 'Planning Advice Note 1/2011: Planning and Noise'[11]. This Planning Advice Note provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. The Planning Advice Note 1/2011 states that:

"Good acoustical design and siting of turbines is essential to minimise the potential to generate noise."

12.2.9 Planning Advice Note 1/2011 refers to the use of the Department of Trade and Industry's 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97), noting that further guidance is provided in the web-based planning advice on renewable technologies for onshore turbines[5]. In relation to noise from wind farms the web-based renewables advice states:

"The Report, 'The Assessment and Rating of Noise from Wind Farms' describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available."

12.2.10 It is therefore considered that the use of ETSU-R-97, as criteria for assessment of wind farm noise, fulfils the requirements of Planning Advice Note 1/2011.

[5] 'Assessment of noise: technical advice note', Scottish Government, March 2011. Available at: http://www.gov.scot/publications/technical-advice-note-assessment-noise/

[6] 'Code of Practice for Noise and vibration control on construction and open sites - Part 1: Noise', British Standards Institution, BS 5228-1:2009

[7] 'Control of Pollution Act', published by Her Majesty's Stationary Office, July 1974. Available at: https://www.legislation.gov.uk/ukpga/1974/40

[8] 'Code of Practice for Noise and vibration control on construction and open sites - Part 2: Vibration', British Standards Institution, BS 5228-2:2009

[9] 'Guide to evaluation of human exposure to vibration in buildings. Blast-induced vibration', British Standards Institution, BS 6472-2:2008

[10] 'Onshore wind turbines: planning advice', Scottish Government, May 2014. Available at: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/

[11] 'Planning Advice Note 1/2011: Planning and Noise', Scottish Government, March 2011. Available at: https://www.gov.scot/publications/planning-advice-note-1-2011-planning-noise/

12.2.11 The methodology described in ETSU-R-97 was developed by a working group comprised of a cross-section of interested persons including, amongst others, environmental health officers, wind farm operators and independent acoustic experts.

12.2.12 ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the environmental impact of the wind farm against the national and global benefits that arise through the development of renewable energy resources. The principle of balancing development needs against protection of amenity may be considered common to any type of noise control guidance.

12.2.13 The basic aim of ETSU-R-97, in arriving at the recommendations contained within the report, is the intention to provide:

"Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities."

12.2.14 An article published in the Institute of Acoustics (IoA) Bulletin Vol. 34 No. 2, March/April 2009[12], recommends a methodology for addressing issues not made explicit by, or outside the scope of, ETSU-R-97, such as in relation to wind shear or noise propagation modelling. Whilst this article does not represent formal legislation or guidance it was authored by a group of independent acousticians experienced in wind farm noise issues who have undertaken work on behalf of wind farm developers, local planning authorities and third parties and as such is a good indicator of best practice techniques. The assessment presented herein adopts the recommendations made within this article.

12.2.15 A Good Practice Guide (GPG) to the application of ETSU-R-97 for the assessment and rating of turbine noise[3], issued by the Institute of Acoustics in May 2013 and endorsed by the Northern Ireland Executive, along with the governments in England, Scotland and Wales, provides guidance on all aspects of the use of ETSU-R-97 and reaffirms the recommendations of the Acoustics Bulletin article with regard to propagation modelling and wind shear. The assessment presented herein adopts the recommendations of the IoA GPG.

12.2.16 Supplementary guidance notes were published by the IoA in July and September 2014, and these provide further details on specific areas of the IoA GPG[13]. The assessment presented herein adopts the recommendations made within these supplementary guidance notes.

12.2.17 ETSU-R-97 has been applied at the vast majority of wind farms currently operating in the UK and provides a robust basis for assessing the noise impact of a wind farm when used in accordance with the IoA GPG. It is the only relevant guidance referenced in Scottish Planning Policy (SPP) (2014) for rating and assessing operational wind farm noise. In advance of SPP being superseded by National Planning Framework 4 (NPF4), the Scottish Government issued a policy statement in December 2022[14] which states that "*ETSU-R-97 should continue to be followed by applicants and used to assess and rate noise from wind energy developments*". The Onshore Wind Policy Statement (2022) states on paragraph 3.7.1 that "(ETSU-R-97) *provides the framework for the measurement of wind turbine noise, and all applicants are required to follow the framework and use it to assess and rate noise from wind energy developments*". Based on planning policy and guidance, as outlined above, a wind farm which can operate within noise limits derived according to ETSU-R-97 shall be considered acceptable. This approach has been agreed with Aberdeenshire Council.

12.3 Consultation

12.3.1 Details of the consultation undertaken are outlined in **Table 12.1**.

[12] 'Prediction and Assessment of Wind Turbine Noise', Bowdler et al, Acoustics Bulletin Vol 34 No 2 March/April 2009

[13] 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise - Supplementary Guidance Notes', Institute of Acoustics, July & September 2014. Available at https://www.ioa.org.uk/publications/wind-turbine-noise

[14] 'Onshore wind: policy statement 2022', Scottish Government, 21 December 2022. https://www.gov.scot/publications/onshore-wind-policy-statement-2022/

Table 12.1: Acoustic Assessment Consultation

Consultees	Date of Consultation	Nature and Purpose of Consultation
Energy Consents Unit	09/8/2022	"Planned acoustic assessment at the proposed Hill of Fare wind farm" (reference 04542-4049626-01) included as Appendix 8.1 of the scoping report (ECU reference ECU00004592 and included as **Technical Appendix 4.1**). This report details the proposed assessment methodology along with the background noise survey locations.
Energy Consents Unit	07/9/2022	Scoping report response received from Environmental Health Officer (EHO) (refer to **Technical Appendix 4.2**). Noise predictions should be carried out using octave band data. General agreement with proposed background noise monitoring locations. The Council would base noise limits on predicted noise levels (rounded up plus 1 dB). For existing turbine developments that have been granted full ETSU-R-97 limits, it should be assumed that the development is operating at these full limits for a cumulative assessment. It is advised that further contact is made with the Council prior to carrying out the background noise survey to agree finer details.
Aberdeenshire Council	23/11/2022	Confirmation from RES that noise predictions will be carried out using octave band data. Further clarification sought on the rationale for defining the noise limits. Confirmation sought on other existing turbines to be included in a cumulative assessment. Invitation given for an EHO to attend the equipment installation of the background noise survey.
Aberdeenshire Council	24/11/2022	Response from EHO. Details given on rationale for defining the noise limits. Confirmation given of other existing turbines to be included in a cumulative assessment. It may be possible for an EHO to attend the equipment installation of the background noise survey, pending detailed itinerary. Subsequent conversation on itinerary for the background noise survey.
Aberdeenshire Council	14/12/2022	Update provided on the itinerary for the background noise survey.
Aberdeenshire Council	9/1/2023	Update provided on the itinerary for the background noise survey.
Aberdeenshire Council	8/2/2023	Update provided on the itinerary for the background noise survey.
Aberdeenshire Council	8/2/2023	Dates confirmed to begin background noise survey. Subsequent discussion on itinerary for the background noise survey.
Aberdeenshire Council	14/2/2023	EHO unable to attend the equipment installation of the background noise survey. Agreed that equipment installation will take place as planned.
Aberdeenshire Council	25/4/2023	"Background Noise Survey Locations for the Acoustic Assessment of the Proposed Hill of Fare Wind Farm" report (dated 18/4/23) sent to the EHO detailing the background noise survey locations where equipment has been installed. Advice sought on assessment methodology for cumulative turbine operational noise and noise associated with the battery energy storage system (BESS).
Aberdeenshire Council	9/5/2023	EHO suggests to submit proposed assessment methodology regarding cumulative turbine operational noise and noise associated with the energy storage system for consideration. No response given regarding "Background Noise Survey Locations for the Acoustic Assessment of the Proposed Hill of Fare Wind Farm" report (dated 18/4/23).
Aberdeenshire Council	26/5/2023	Requested information from the council on cumulative wind farm sites
Aberdeenshire Council	14/7/2023	Requested information from the council on cumulative wind farm sites
Aberdeenshire Council	14/7/2023	Some information received from the council on cumulative wind farm sites
Aberdeenshire Council	10/8/2023	Requested information from the council on cumulative wind farm sites
Aberdeenshire Council	24/8/2023	Requested information from the council on cumulative wind farm sites

12.4 Methodology

Scope of Assessment

12.4.1 Noise can have an effect on the environment and on the quality of life enjoyed by individuals and communities. The effect of noise, both in the construction and operational phase, is therefore a material consideration in the determination of planning applications.

Construction Noise

12.4.2 The sources of construction noise, which are temporary, would vary both in location and duration as the different elements of the Proposed Development are constructed and would arise primarily through the operation of large items of plant. Noise would also arise due to the temporary increase in construction traffic near the Proposed Development. This level would also depend on the particular construction phase of the Proposed Development. Refer to **Chapter 2: Project Description**, which provides proposed activities during each phase of construction.

12.4.3 Noise due to construction activities and construction traffic is scoped into the assessment. The acoustic impact assessment of construction noise from the Proposed Development presented here is based on the applicant's experience of constructing wind farms and calculated for the operation of the primary large items of construction equipment. Additionally, consideration is given to the increased noise levels due to increased traffic flows during the construction phase to and from the Site.

12.4.4 Blasting is anticipated to be required in order to extract material from the proposed borrow pits. Vibration and air overpressure due to blasting could therefore arise at periods during construction. An assessment of the level of vibration at nearby properties due to blasting to release material from the proposed borrow pits is therefore scoped in. Air overpressure due to blasting cannot be reliably predicted so this is scoped out of the assessment although steps to limit any resulting impact through appropriate blast design shall be adopted as detailed in **section 12.7.6.**

12.4.5 To assess the potential impacts of construction noise from the Proposed Development the following steps have been taken:

- Baseline noise criteria are established from the appropriate guidance BS 5228-1:2009;
- Noise levels due to on-site construction activities are predicted at nearby residential properties in accordance with the BS 5228-1:2009 standard;
- Predicted noise levels due to construction traffic at the same residential properties are made using the BS 5228-1:2009 standard;
- The cumulative noise level due to on-site construction activities and construction traffic is compared with the threshold values specified by the ABC Method of BS 5228-1:2009. Significant effects would be identified if the predicted construction noise levels exceed the threshold values. The effects would not be deemed significant if the predicted construction noise levels are less than the threshold values; and
- Predictions of the level of vibration due to blasting are made using BS 5228-2:2009 and the significance evaluated based on whether the criteria specified by BS 6472-2:2008 are met or exceeded.

Operational Noise

12.4.6 To ensure adequate assessment of the potential impacts of the operational noise from the Proposed Development the following steps have been taken, in accordance with relevant guidance detailed above:

- The baseline noise conditions at each of the nearest residential properties to the Proposed Development are established by way of representative background noise surveys;
- The noise levels at the nearest residential properties from the operation of the Proposed Development are predicted using a sound propagation model considering: the locations of the turbines; the intervening terrain; and the likely noise emission characteristics of the turbines;
- The acoustic assessment criteria are derived appropriately; and
- The evaluation of the acoustic impact is undertaken by comparing the predicted noise levels with the assessment criteria. Significant effects would be identified if the predicted noise levels exceed limits derived in accordance with ETSU-R-97. Significant effects would not be expected should the predicted noise levels be less than or equal to the ETSU-R-97 limit.

12.4.7 Aerodynamic and mechanical noise are scoped into the operational noise assessment. The main focus of the assessment of operational noise presented here is based on the most relevant type of noise emission for modern turbines: aerodynamic noise, which is broadband in nature. Mechanical noise, which can be tonal in nature, is also considered albeit less relevant to modern turbines whose improved design has led to significant reductions in mechanical noise. Implicitly incorporated within this assessment is the normal character of the noise associated with turbines (commonly referred to as 'blade swish') and consideration of a range of noise frequencies, including low frequencies.

12.4.8 An acoustic assessment considering the operation of the proposed battery energy storage system (BESS), is also scoped in and can be found in **Technical Appendix 12.1**.

12.4.9 Low frequency content of the noise from the Proposed Development shall be considered through the use of octave band specific noise emission and propagation modelling, however it is considered that specific and targeted assessment on low frequency content of noise emissions from the Proposed Development is unjustified. Details for scoping out low frequency noise from the operational noise assessment, as well as infrasound, sleep disturbance, vibration, amplitude modulation and wind turbine syndrome can be found in **Technical Appendix 12.2**.

12.4.10 A summary of the findings of a comprehensive study into turbine noise and associated health effects can be found in **Technical Appendix 12.2**.

Decommissioning Noise

12.4.11 Whilst noise would also arise during decommissioning of the Proposed Development (through turbine deconstruction and breaking of the exposed part of the concrete bases) this is not discussed separately as noise levels resulting from it are expected to be lower than those during construction due to the number and type of activities involved. The impact of decommissioning can therefore be considered in light of the conclusions of the construction noise assessment.

Baseline Characterisation

12.4.12 Similar to other assessments of noise impacts (most notably BS 4142[15], which ETSU-R-97 identifies as forming the basis of its recommendations), the ETSU-R-97 methodology requires the comparison of predicted noise levels due to turbine emissions (which vary with hub height wind speed) with noise limits based upon the noise levels already existing under those same conditions (i.e. the baseline conditions).

12.4.13 Since background noise levels depend upon wind speed, as indeed do turbine noise emissions, it is important when making reference measurements to put them in that context. Thus, the assessment of background noise levels requires the measurement of not only noise levels, but concurrent wind conditions, covering a representative range of wind speeds. These wind measurements are made at the site rather than at the residential properties, since it is this wind speed that would subsequently govern the Proposed Development's noise generation. Often the residential properties themselves will be sheltered from the wind and may consequently have relatively low background noise levels.

12.4.14 To establish the baseline conditions, sound level meters and associated apparatus are set up to record the required acoustic information at a selection of the nearest residential properties geographically spread around the Proposed Development and which are likely to be representative of other residential properties in the locale.

12.4.15 Wind speed and direction are recorded as 10-minute averages for the same period as for the noise measurements and are synchronised with the acoustic data to allow correlations to be established. The wind speed that is adopted for use is the same wind speed as that which drives the turbine noise levels.

12.4.16 The adoption of this wind speed was recommended within the article published in the IoA Bulletin and the subsequent IoA GPG. The methodology used to calculate standardised 10 m height wind speed is described in **Technical Appendix 12.3**.

12.4.17 Prior to establishing the baseline conditions the acoustic data is filtered as follows:

- For each background noise measurement location, the measured noise data is divided into two sets, as specified by ETSU-R-97 and shown in **Table 12.2:**

Table 12.2: Definition of Time-of-Day Periods

Time of Day	Definition (Local Time)
Quiet daytime	08:00 - 23:00 every day 13:00 - 18:00 Saturday 07:00 - 18:00 Sunday
Night-time	23:00 - 07:00 every day

- Rainfall affected data is systematically removed from the acoustic data set. To facilitate this, rainfall data has been provided by the Met Office from weather radar measurements to identify potentially affected noise data.
- Periods of measured background noise data thought to be affected by extraneous, i.e., non-typical, noise sources are identified and removed from the data set. Whilst some 'extraneous' data may actually be real, it tends to bias any trend lines upwards so its removal is adopted as a conservative measure.
- In practice this means close inspection of the measured background noise levels, comparison with concurrent data measured at nearby locations and consideration of both directional and temporal variation.

Modelling Noise Propagation

12.4.18 Whilst there are several sound propagation models available, the ISO 9613 Part 2 model has been used[16], this being identified as most appropriate for use in such rural sites[17]. The specific interpretation of the ISO 9613 Part 2 propagation methodology recommended in the aforementioned IoA Bulletin and the subsequent IoA GPG has been employed.

12.4.19 To make noise predictions it is assumed that:

- The turbines radiate noise at the power specified in this report;
- Each turbine can be modelled as a point source at hub-height; and
- Each residential property is assigned a reference height to simulate the presence of an observer.

[15] 'Method for Rating Industrial Noise affecting Mixed Residential and Industrial Areas', British Standards Institution, BS 4142:1990

[16] 'Acoustics - Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation', International Organisation for Standardisation, ISO 9613-2:1996

[17] 'A Critical Appraisal of Wind Farm Noise Propagation', ETSU Report W/13/00385/REP, January 2000

12.4.20 The sound propagation model takes account of attenuation due to geometric spreading and atmospheric absorption. The assumed temperature and relative humidity are 10 ˚C and 70 % respectively, as recommended in the IoA Bulletin and IoA GPG. Ground effects are also taken into account by the propagation model with a ground factor of 0.5 and a receiver height of 4 m used as recommended in the IoA Bulletin and IoA GPG.

12.4.21 The barrier attenuations predicted by ISO 9613 Part 2 have been shown to be significantly greater than those measured in practice under downwind conditions[17]. Therefore, barrier attenuation according to the ISO 9613 Part 2 method has been discounted. In lieu of this, where there is no direct line of sight between the residential property in question and any part of the turbine, 2 dB(A) attenuation has been assumed as recommended in the IoA Bulletin and the IoA GPG.

12.4.22 Additionally, verification studies have also shown that ISO 9613 Part 2 tends to slightly underestimate noise levels at nearby dwellings in certain exceptional cases, notably in a valley type environment where the ground drops off between source and receiver. In these instances, an addition of 3 dB(A) has been applied to the resulting overall A-weighted noise level as recommended by the IoA GPG.

12.4.23 To generate the ground cross sections between each turbine and each dwelling necessary for reliable propagation modelling, ground contours at 5 m intervals for the area of interest have been generated from 50 m grid resolution digital terrain data.

12.4.24 The predicted noise levels are calculated as L_{Aeq} noise levels and changed to the L_{A90} descriptor (to allow comparisons to be made) by subtraction of 2 dB(A), as specified by ETSU-R-97.

12.4.25 It has been shown by measurement-based verification studies that the ISO 9613 Part 2 model tends to slightly overestimate noise levels at nearby dwellings[17]. Examples of additional conservative assumptions modelled are:

- Properties are assumed to be downwind of all noise sources simultaneously and at all times. In reality, this is not the case and additional attenuation would be expected when a property is upwind or crosswind of the proposed turbines;
- Although, in reality, the ground is predominantly porous (acoustically absorptive) it has been modelled as ‘mixed’, i.e., a combination of hard and porous, corresponding to a ground absorption coefficient of 0.5 as recommended by the IoA Bulletin and IoA GPG;
- Receiver heights are modelled at 4 m above local ground level, which equates roughly to first floor window level, as recommended by the IoA Bulletin and IoA GPG. This results in a predicted noise level up to 2 dB(A) higher than at the typical human ear height of 1.2 m – 1.8 m;
- Trees and other non-terrain shielding effects have not been considered;
- An allowance for measurement uncertainty has been included in the sound power levels for the presented candidate turbine.

Operational Noise Impact Criteria

12.4.26 Noise is measured in decibels (dB) which is a measure of the sound pressure level, i.e., the magnitude of the pressure variations in the air. Measurements of environmental noise are usually made in dB(A) which includes a correction for the sensitivity of the human ear at different frequencies.

12.4.27 ETSU-R-97 seeks to protect the internal and external amenity of wind farm neighbours by defining acceptable limits for operational noise from turbines. The test applied to operational noise is whether or not the noise levels produced by the combined operation of the turbines comply with the noise limits derived in accordance with ETSU-R-97 at nearby residential properties.

12.4.28 Whilst ETSU-R-97 presents a comprehensive and detailed assessment methodology for wind farm noise, it also provides a simplified methodology: “if the noise is limited to an $L_{A90,10min}$ of 35 dB(A) up to wind speeds of 10 m/s at 10 m height, then these conditions alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary.”.

12.4.29 In the detailed methodology, ETSU-R-97 states that different limits should be applied during daytime and night-time periods. The daytime limits, derived from the background noise levels measured during quiet daytime periods, are intended to preserve outdoor amenity, while the night-time limits are intended to prevent sleep disturbance. The general principle is that the noise limits should be based on existing background noise levels, except for very low background noise levels, in which case a fixed limit may be applied. The suggested limits are given in **Table 12.3** below, where L_B is the background $L_{A90,10min}$ and is a function of wind speed. During daytime periods and at low background noise levels, a lower fixed limit of 35–40 dB(A) is applicable. The exact value is dependent upon a number of factors: the number of nearby dwellings, the effect of the noise limits on energy produced, and the duration and level of exposure.

Table 12.3: Permissible Noise Level Criteria ($L_{A90,10mins}$ dB)

Time of Day	Definition
Quiet daytime	35-40 dB(A) for L_B less than or equal to 30-35 dB(A) L_B + 5 dB, for L_B greater than 30-35 dB(A)
Night-time	43 dB(A) for L_B less than or equal to 38 dB(A) L_B + 5 dB, for L_B greater than 38 dB(A)

12.4.30 Note that a higher noise level is permissible during the night than during the day as it is assumed that residents would be indoors. The night-time criterion is derived from sleep disturbance criterion referred to in ETSU-R-97, with an allowance of 10 dB(A) for attenuation through an open window.

12.4.31 The wind speeds at which the acoustic impact is considered are less than or equal to 12 m/s at a height of 10 m and are likely to be the acoustically critical wind speeds. Above these wind speeds, as stated in ETSU-R-97, reliable measurements of background and turbine noise are difficult to make. However, if a wind farm meets the noise criteria at the wind speeds presented, it is most unlikely that it would cause any greater loss of amenity at higher wind speeds due to increasing background noise levels masking wind farm generated noise.

12.4.32 It is important to note that, since reactions to noise are subjective, it is not possible to guarantee that a given development would not result in any adverse comment with regard to noise as the response to any given noise will vary from person to person. Consequently, standards and guidance that relate to environmental noise are typically presented in terms of criteria that would be expected to be considered acceptable by the majority of the population.

12.5 Baseline

Construction Noise

12.5.1 For the on-site construction noise assessment, Annex E of BS 5228-1:2009 provides guidance on setting environmental noise targets. Several methods of assessing the significance of noise levels are presented in Annex E and the most applicable to the construction of the Proposed Development is the ABC method. The ABC method sets threshold noise levels for specific periods based on the ambient noise levels.

Operational Noise

12.5.2 The Proposed Development is located on the Hill of Fare, approximately 6 km[18] north of Banchory, Aberdeenshire. The surrounding area is predominantly rural in nature and used for forestry, grazing sheep and cattle, with the A980 main road to the south. The general acoustic character is typical of a rural environment with sound from traffic, farm machinery, sheep, cattle, birds, foliage and the occasional overhead aircraft.

12.5.3 Background noise measurements were undertaken at four residential property locations (Strath Farmhouse, Blairhead, Upper Tillenhilt and Craigshannoch Cottage) based on the initial turbine layout and in accordance with ETSU-R-97 and the IoA GPG. The four locations are detailed in **Table 12.4** and illustrated in **Figure 12.1**.

Table 12.4: Background Noise Survey Details

Survey Location (House Name)	House ID	Measurement Period		
		Start	End	Duration (days)
Strath Farmhouse	H70	21/2/2023	2/5/2023	71
Blairhead	H87	20/2/2023	2/5/2023	72
Upper Tillenhilt	H138	20/2/2023	2/5/2023	72
Craigshannoch Cottage	H139	21/2/2023	3/5/2023	72

12.5.4 The background noise monitoring equipment was housed in weather-proof enclosures and powered by lead-acid batteries. The microphones were placed at a height of approximately 1.2 - 1.5 m above ground and equipped with all-weather wind shields which also provide an element of water resistance.

12.5.5 The proprietary wind shields used are designed to reduce the effects of wind-generated noise at the microphone and accord with the recommendations of the IoA GPG in that they are the appropriate size and, in combination with the microphone, are certified by the manufacturer as meeting Type 1 / Class 1 precision standards.

12.5.6 Noise levels were monitored continuously, and summary statistics stored every 10 minutes in the internal memory of each sound level meter. The relevant statistic measured is the $L_{A90,10min}$ (The A-weighted sound pressure level exceeded for 90% of the 10-minute interval).

[18] This distance is given to the approximate centre point of the site boundary.

12.5.7 The sound level meters were placed suitably away from reflecting walls and vegetation. Photos of the equipment, in situ, may be seen in **Technical Appendix 12.4.** The equipment was field calibrated before, during and after the survey period and the maximum drift detected was 0.3 dB, which is within the required range recommended in the IoA GPG. All instrumentation has been subject to laboratory calibration traceable to national standards within the last 12 months, in accordance with the recommendations of the IoA GPG. Details are provided in **Technical Appendix 12.5**.

12.5.8 Chart 12.6.1 (see **Technical Appendix 12.6** for all charts) shows the measured wind rose over the background noise survey period, as measured by a LiDAR located on Site.

12.5.9 A LiDAR (Light Detection and Ranging) is a remote sensing device that measures conditions in the atmosphere by using pulses from a LASER by applying the principle of the Doppler Effect, detecting the movement of air in the atmospheric boundary layer to measure wind speed and direction. LiDAR provides measurements at several heights, and this enables wind speed data to be obtained that describe the wind profile across a range of heights.

12.5.10 LIDAR has been successfully tested, by independent third parties using suitable test sites, against conventional anemometry[19,20]. From the technical reports, these tests have demonstrated that, over a range of relevant heights, the accuracy of the LIDAR is comparable to that of the conventional anemometry.

12.5.11 For illustrative purposes, **Chart 12.6.2** shows the measured wind rose over an extended period (28/07/22 – 31/05/23) by the remote sensing device located on Site. As previously discussed, the noise prediction model employed is likely to overestimate the real noise immission levels for locations not downwind of the turbines. **Chart 12.6.2** therefore may aid the reader as to the likelihood of over-estimation due to this factor.

12.5.12 The noise data has been cross-referenced with rainfall data provided by the Met Office from weather radar measurements to identify potentially affected noise data. Any noise data identified as having been affected by rainfall has been removed from the analysis as shown in **Charts 12.6.3** to **12.6.8**.

12.5.13 All data measured at Upper Tillenhilt (H138) has been excluded from analysis and therefore appropriate background noise levels have not been derived for this survey location from the measurement data. This is because it was not possible to accurately account for the contribution to the measured levels from two existing small turbines, which are located approximately 1 km east of the measurement location.

12.5.14 Short-term periods of increased noise levels considered to be atypical have been removed from the datasets. The excluded data is shown in **Charts 12.6.3** to **12.6.8**.

12.5.15 Periods of raised noise levels were removed from the night-time datasets at Craigshannoch Cottage due to the dawn chorus which may not be present to the same extent at other times of year.

12.5.16 Directional filtering of the data measured at H70 (Strath Farmhouse) was undertaken by excluding data from analysis where the wind direction was 90 - 270 degrees. This excludes data from the analysis where traffic noise from the A980 main road to the south may have been a significant contributor to the background noise environment.

12.5.17 **Charts 12.6.3** to **12.6.5** show $L_{A90,10min}$ correlated against wind speed for quiet daytime periods at each survey location. In each case, a third order 'best fit' line has been fitted to the data and the noise limits added. The equation of the regression polynomial has been provided in the charts.

12.5.18 **Charts 12.6.6** to **12.6.8** show $L_{A90,10min}$ correlated against the wind speed for night-time periods at each survey location. In each case, a third order 'best fit' line has been fitted to the data and the noise limits added. The equation of the regression polynomial has been provided in the charts.

12.5.19 **Table 12.5** and **Table 12.6** detail the $L_{A90,10min}$ background noise levels calculated from the derived 'best fit' lines, as described above. They are provided as sound pressure levels in dB(A) referenced to 20 micro Pascals (see Glossary for further details).

Table 12.5: Quiet Daytime Background Noise Levels ($L_{A90,10min}$ dB)

[19] "Evaluation of WINDCUBE", Albers et al, Deutsche WindGuard Consulting GmbH, Report PP 08007, 16 March 2008

[20] "Verification test for three WindCubeTM WLS7 LiDARs at the Høvsøre test site", Gottschall et al, DTU Report Risø-R-1732, May 2010

Survey Location	Standardised 10 m Height Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Strath Farmhouse	28.8	28.8	28.8	28.8	28.8	29.0	29.6	30.5	31.7	33.3	33.3	33.3
Blairhead	22.5	23.7	24.7	25.6	26.4	27.1	27.9	28.8	29.7	30.7	30.7	30.7
Craigshannoch Cottage	28.3	28.3	28.3	28.4	28.6	29.1	30.0	31.2	33.0	35.3	35.3	35.3

Table 12.6: Night-time Background Noise Levels ($L_{A90,10min}$ dB)

Survey Location	Standardised 10m Height Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Strath Farmhouse	26.8	26.8	26.8	26.8	27.0	27.4	28.1	29.0	30.1	31.4	31.4	31.4
Blairhead	24.1	24.1	24.1	24.2	24.5	25.1	26.1	27.4	29.2	31.4	31.4	31.4
Craigshannoch Cottage	23.7	23.7	23.7	23.7	24.2	25.1	26.6	28.4	30.6	33.0	33.0	33.0

Future Baseline

12.5.20 The baseline conditions would not be expected to change under the "do nothing" scenario i.e. in the event that the Proposed Development does not go ahead.

12.6 Assessment of Potential Effects

Construction Effects

Construction Noise Assessment

12.6.1 Primary activities creating noise during the construction period are: the construction of the turbine bases; the erection of the turbines; the excavation of trenches for cables; the working of borrow pits; and the construction of associated hard standings, access tracks and construction compounds. Noise from vehicles on local roads and access tracks would also arise due to the delivery of turbine components and construction materials, notably aggregates, concrete and steel reinforcement.

12.6.2 It should be noted that the exact methodology and timing of construction activities cannot be predicted at this time, this assessment is therefore based on assumptions representing a worst-case approach.

Construction Noise Predictions

12.6.3 The plant assumed for each construction activity is shown in **Table 12.7**. The number of items indicates how many of each plant are required for the specified activity, and the duration of activity is a percentage of a given 12-hour day period needed for that plant to operate. Overall sound power levels are based upon the data in Annex C of BS 5228-1:2009.

Table 12.7: Construction Phases and Sound Power Levels

Activities	Plant	Sound Power (L_{WA} dB)	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA} dB)
Construction Compound	Tracked excavator	113	2	100	119
	Dump truck	113	2	100	
	Tipper lorry	107	2	50	
	Vibratory roller	102	1	75	
	Lorry	108	1	75	
Construct Site Tracks	Tracked excavator	113	3	100	122
	Dump truck	113	2	75	
	Tipper lorry	107	4	50	
	Dozer	109	1	100	
	Vibratory roller	102	1	75	
	Excavator mounted rock breaker	121	1	50	
Construct Control Building and Substation/BESS compound	Tracked excavator	113	1	100	117
	Concrete mixer truck	108	2	50	
	Lorry	108	1	50	
	Telescopic Handler	99	1	100	
	Piling rig	117	1	50	
Construct Crane Hardstands	Tracked excavator	113	3	100	120
	Dump truck	113	2	100	
	Tipper lorry	107	4	50	
	Vibratory roller	102	1	50	
Construct Turbine Foundations	Tracked excavator	113	2	75	123
	Dump truck	113	2	75	
	Concrete mixer truck	108	4	50	
	Mobile telescopic crane	110	1	50	
	Concrete pump	106	2	50	
	Water pump	93	1	100	
	Hand-held pneumatic breaker	111	1	75	
	Compressor	103	3	50	
	Piling rig	117	1	100	
	Poker vibrator	106	3	50	
	Excavator mounted rock breaker	121	1	50	

Activities	Plant	Sound Power (L_{WA} dB)	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA} dB)
Excavate and Lay Site Cables	Tracked excavator	113	2	100	122
	Dump truck	113	2	75	
	Tractor (Towing Equipment)	108	1	75	
	Tractor (Towing Trailer)	107	1	75	
	Vibratory plate	108	1	50	
	Excavator mounted rock breaker	121	1	50	
Erect Turbine	Mobile telescopic crane	110	2	75	119
	Lorry	108	1	75	
	Diesel generator	102	1	100	
	Torque guns	111	4	100	
Reinstate Crane Bases	Tracked excavator	113	1	75	115
	Dump truck	113	1	75	
Reinstate Road Verges	Tracked excavator	113	1	75	115
	Dump truck	113	1	75	
Forestry Felling Along Site Tracks	Saw	104	1	100	116
	Harvester	108	2	100	
Borrow Pits	Excavator mounted rock breaker	121	1	100	126
	Dump truck	113	2	75	
	Dozer	109	1	100	
	Tracked semi-mobile crusher	124	1	100	
	Tracked excavator	113	1	100	
Construct New Water Crossing	Tracked Excavator	113	1	100	120
	Dump Truck	113	1	100	
	Tipper lorry	107	4	50	
	Dozer	109	1	75	
	Vibratory Roller	102	1	75	
	Telescopic Handler	99	1	100	
	Piling Rig	117	1	50	
	Concrete Pump	106	1	50	
	Concrete mixer truck	108	3	50	
	Poker vibrator	106	2	50	
	Water pump	93	2	100	
Construct Batching Plant	Tracked excavator	113	1	67	116
	Dump truck	113	1	67	
	Tipper lorry	107	1	67	
	Vibratory roller	102	1	67	
	Lorry	108	1	67	
	Mobile telescopic crane	110	1	67	
Operational Batching Plant	Concrete Batching Plant	111	1	67	109

12.6.4 Predictions of construction noise levels have been carried out using the methods prescribed in Annex F of BS 5228-1:2009[21]. The worst-case scenario, where each construction activity takes place at the nearest proposed location to the residential property being assessed, is considered. The locations of the construction activities are taken from the infrastructure drawing. The results of these predictions, made at ten representative residential properties (as detailed in **Table 12.12**), are shown in **Table 12.8.**

12.6.5 In all cases average noise levels over the construction period would be lower as the worst case is presented for when the construction activities are closest to the residential property.

Table 12.8: Predicted Sound Pressure Levels due to Construction Noise (L_{Aeq} dB)

Activity	H136	H134	H124	H122	H113	H88	H51	H65	H253	H138
Construction Compound	43.1	39.5	48.9	54.7	68.6	39.1	35.7	33.8	32.7	34.2
Construct Site Tracks	46.4	48.2	72.1	68.5	74.5	40.7	46.3	47.6	47.2	44.6
Construct Control Building and Substation/BESS compound	37.1	33.7	31.7	30.6	30.4	35.1	36.7	33.8	31.4	31.9
Construct Crane Hardstands	44.3	40.2	36.8	35.3	34.8	38.2	43.7	44.3	45.4	42.4
Construct Turbine Foundations	47.2	43.1	39.7	38.2	37.7	41.1	46.6	47.2	48.3	45.3

[21] A 50% mixed ground attenuation has been used throughout to conservatively account for the arable nature of ground conditions in the vicinity of the Proposed Development

Excavate and Lay Site Cables	45.6	47.4	71.3	67.7	73.7	39.9	45.5	46.8	46.4	43.8
Erect Turbine	42.6	38.5	35.1	33.6	33.1	36.5	42.0	42.6	43.7	40.7
Reinstate Crane Bases	38.6	34.5	31.1	29.6	29.1	32.5	38.0	38.6	39.7	36.7
Reinstate Road Verges	27.6	34.6	43.9	50.1	66.6	34.2	24.4	22.6	21.5	22.6
Forestry Felling Along Site Tracks	39.9	41.7	65.6	62.0	68.0	34.2	39.8	41.1	40.7	38.1
Borrow Pits	49.8	50.2	66.8	64.0	58.1	46.2	44.4	46.9	50.8	46.7
Construct New Water Crossing	34.8	44.5	69.5	53.0	48.5	39.7	30.3	28.5	27.6	28.9
Construct Batching Plant	29.4	36.9	47.9	56.2	56.4	35.6	26.0	24.2	23.1	24.3
Operational Batching Plant	22.5	30.0	41.0	49.3	49.5	28.7	19.1	17.3	16.2	17.4

Construction Traffic

12.6.6 Due to the delivery of construction material and wind farm components, vehicle movements either into or away from the Proposed Development shall increase levels of traffic flow on public roads in the area. HGV traffic regularly accessing the site is shown in **Chapter 11: Traffic & Transport Assessment** and is assumed to be characterised by a sound power level of 113 dB(A) as a worst case. It is estimated that a total of 74 HGV movements per day would be required during the most intense period of construction activity although this would only be the case for a maximum of one month when site track construction and turbine foundation construction occurs simultaneously.

12.6.7 HGV construction traffic noise has been quantified using the method described in BS 5228:2009 Part 1. Calculated using the distances from residential properties to the centre of the closest relevant carriageway where construction traffic would be, the noise levels predicted are presented in **Table 12.9**. The maximum sound pressure level due to traffic flows during the most intensive period of activity is predicted to be 52.3 dB L_{Aeq}. The property where this occurs, H113 (South Newfield), is adjacent to the delivery route at the site entrance and, as such, corresponds to the worst case.

Table 12.9: Traffic Noise Predictions by Activity (L_{Aeq} dB)

House ID	Total Traffic Noise
H136	39.8
H134	40.6
H124	51.2
H122	49.6
H113	52.3
H88	37.3
H51	39.7
H65	40.3
H253	40.1
H138	39.0

12.6.8 The increase in noise level due to the presence of construction traffic on the B977 road south of Echt has been quantified using the methodology set out in CRTN[22]. The maximum predicted increase in daytime average traffic noise level, during the most intense period of construction, is 1.1 dB(A). Given that a 3 dB(A) change is commonly regarded as the smallest subjectively perceptible difference in noise level, the predicted short-term change in traffic noise levels are considered **negligible** and **not significant**.

General Construction Noise in Conjunction with Traffic Noise

12.6.9 Worst case construction noise levels may arise when work on the following activities occurs simultaneously: Construction Compound, Construct Site Tracks, Construct Control Building, Substation/BESS compound, Construct Crane Hardstands, Construct Turbine Foundations, Forestry Felling Along Site Tracks, Borrow Pits, Construct New Water Crossing, and Operational Batching Plant. Therefore, cumulative predictions of these construction activities and the additional noise contribution from construction traffic have been calculated and are shown in **Table 12.10**.

12.6.10 It should be noted that the predictions exclude the screening effects of local topography, therefore actual levels of noise experienced at nearby residential properties could be lower.

Table 12.10: Predicted Noise Levels Due to Combined Traffic and Construction Activities (L_{Aeq} dB)

House ID	Construction Plant Noise	Traffic Noise	Combined Noise
H136	54.1	39.8	54.1
H134	54.1	40.6	54.1
H124	75.3	51.2	75.3
H122	70.7	49.6	70.7
H113	76.3	52.3	76.3
H88	49.9	37.3	49.9
H51	52.0	39.7	52.0

[22] Calculation of Road Traffic Noise (CRTN), HMSO Department of Transport, 1988.

House ID	Construction Plant Noise	Traffic Noise	Combined Noise
H65	53.1	40.3	53.1
H253	54.6	40.1	54.6
H138	51.4	39.0	51.4

Assessment of Construction Noise

12.6.11 In accordance with the ABC method of Annex E of BS 5228-1:2009, due to the relatively low levels of ambient noise in the vicinity of the Proposed Development, a Category A assessment is appropriate. This category sets significant effect threshold L_{Aeq} criteria of: 65 dB(A) during weekdays (07:00-19:00) and Saturdays (07:00-13:00); 55 dB(A) for evenings (19:00-23:00), Saturdays (13:00-23:00) and Sundays (07:00-23;00); and 45 dB(A) for night-time (23:00-07:00) periods.

12.6.12 Construction activities and Heavy Goods Vehicle (HGV) deliveries would be limited to 07:00-19:00 Monday to Saturday, except during construction of the turbine foundations and turbine erection or during periods of emergency work, so an assessment against the 65dB(A) and 55dB(A) criteria has been undertaken.

12.6.13 **Table 12.10** shows that predicted noise levels from the combined effect of increased traffic flows and activities associated with the peak of construction activities are below the 65 dB(A) weekday (07:00-19:00) and Saturday (07:00-13:00) threshold specified by BS 5228-1:2009 at seven of the assessed residential properties.

12.6.14 Peak construction noise levels are predicted to exceed the 65 dB(A) threshold for weekdays (07:00-19:00) and Saturday (07:00-13:00) at three of the assessed properties.

12.6.15 Peak construction noise levels are predicted to exceed the 55 dB(A) threshold for evenings (19:00-23:00) and Saturday afternoons (13:00-23:00) at three of the assessed properties although, of the times when this criterion applies, construction is only scheduled to take place on Saturday afternoons (13:00-19:00) and not during the evenings (19:00-23:00), with the exception of the construction of the turbine foundations and turbine erection or periods of emergency work.

12.6.16 An assessment against the night-time threshold has not been undertaken as construction work is not scheduled to take place during the night with the exception of the construction of the turbine foundations and turbine erection or periods of emergency work. Predicted noise levels of greater than 45 dB(A) due to construction of the turbine foundations and turbine erection as detailed in **Table 12.8** imply that this activity should be avoided at night unless absolutely necessary.

12.6.17 The predictions made represent the worst-case combination of most intensive traffic activity with simultaneous construction activity at the nearest possible locations to each residential property and are therefore highly conservative.

Assessment of Vibration due to Blasting

12.6.18 BS 5228-2:2009 provides guidance on the assessment of vibration due to blasting. A scaled distance graph is shown in Figure E.1 in Annex E of BS 5228-2:2009 which provides an indication of likely vibration magnitudes at various distances. This figure can be used to determine the level of vibration which would not be expected to be exceeded in 95% of blasts for a given distance and charge size.

12.6.19 BS 6472-2:2008 details the maximum satisfactory magnitudes for vibration measured on a firm surface outside buildings with respect to human response. For up to three blast vibration events per day the generally accepted maximum satisfactory magnitude at residential premises during daytime periods (08:00-18:00 Monday to Friday and 08:00-13:00 on Saturdays) is a peak particle velocity (ppv) of 6.0 to 10.0 mms^{-1}. In practice, the lower satisfactory magnitude should be used with the higher magnitude being justified on a case-by-case basis.

12.6.20 For a charge size of 200 kg the estimated vibration magnitude is 6.0 mms^{-1} at the nearest residential property to the eastern most borrow pit near the site entrance, H124 (Hillbrae Cottage), which is approximately 282 m away from the eastern most borrow pit. This suggests that the probability of adverse comment is low according to the criteria outlined in BS 6472-2:2008. No significant effects would therefore be anticipated by using a maximum charge size of 200 kg at the eastern most borrow pit.

12.6.21 For a charge size of 1000 kg the estimated vibration magnitude is 4.0 mms^{-1} at the nearest residential property to the other five borrow pits (excluding the eastern most borrow pit near the site entrance), H253 (Braeside), which is approximately 1447 m away, albeit this is a derelict unoccupied building. This suggests that the probability of adverse comment is low according to the criteria outlined in BS 6472-2:2008. No significant effects would therefore be anticipated by using a maximum charge size of 1000 kg at all other borrow pits (excluding the eastern most borrow pit near the site entrance for which a maximum charge size of 200 kg would be used).

Potential Operational Effects

Noise Propagation Modelling

12.6.22 The locations of the proposed turbines are provided in **Table 12.11** and shown in **Figure 12.1**. All coordinates are according to Ordnance Survey of Great Britain, 1936 (EPSG code 27700).

Table 12.11: Locations of Proposed Turbines

Turbine ID	Coordinates		Turbine ID	Coordinates	
	X (m)	Y (m)		X (m)	Y (m)
T1	368524	803990	T9	368075	801743
T2	367938	803584	T10	368623	801831
T3	367494	803236	T11	368481	802506
T4	366981	803057	T12	368796	802950
T5	366953	802515	T13	369001	803453
T6	367415	802232	T14	369387	803064
T7	367917	802895	T15	369915	803201
T8	367930	802400	T16	370404	803434

12.6.23 The locations of the nearest residential properties to the turbines have been determined by inspection of relevant maps and through site visits. More residential properties may have been identified but have not been considered critical to this acoustic assessment or may be adequately represented by another residential property. The locations considered are listed in **Table 12.12** and are also shown in **Figure 12.1**.

12.6.24 The distances from each residential property to the nearest turbine are given in **Table 12.12**. Coordinates are according to Ordnance Survey of Great Britain, 1936 (EPSG code 27700). It can be seen that the minimum house-to-turbine separation is 1344 m to H253 (Braeside), albeit this is a derelict unoccupied building. All other properties have minimum 1500 m turbine separation. There are no properties being occupied by a financial beneficiary of the Proposed Development.

Table 12.12: Locations of Assessment Properties and Distances to Nearest Proposed Turbine

House ID	Property Name	Coordinates		Distance (m)	Nearest Turbine
		X (m)	Y (m)		
H1	East Mill Cottage	369387	798953	2978	T10
H2	West Mill Cottage	369380	798956	2973	T10
H3	Damhead	369146	799049	2830	T10
H4	Foresters Cottage	369654	799054	2962	T10
H5	2 Smithy Cottages	370007	799119	3045	T10
H6	1 Smithy Cottages	369996	799124	3035	T10
H7	Newton Farm House	370504	799206	3229	T10
H8	Schoolhouse	370079	799210	2998	T10
H9	Brae House	368237	799234	2514	T9
H10	Flat 4	370104	799238	2986	T10
H11	Flat 3	370104	799238	2986	T10
H12	Flat 1	370104	799238	2986	T10
H13	Flat 2	370104	799238	2986	T10
H14	Cairniewhin	371196	799341	3581	T10
H15	Gardeners Cottage	369720	799450	2622	T10
H16	Brockton Cottages	368405	799463	2303	T9
H17	1 Cluny Crichton Cottages	368476	799496	2282	T9
H18	Raemoir House	369493	799497	2491	T10
H19	Flat	369486	799502	2484	T10
H20	Green Cottage	370496	799550	2952	T10
H21	Corriecraig	367863	799645	2108	T9
H22	Home Farm Cottage	369967	799648	2564	T10
H23	Raemoir Home Farm	369968	799648	2564	T10
H24	Craignarb House	367834	799649	2107	T9
H25	Viewbank House	367821	799652	2106	T9

House ID	Property Name	Coordinates		Distance (m)	Nearest Turbine
		X (m)	Y (m)		
H26	New Craignarb	367771	799668	2097	T9
H27	The Stables	369930	799670	2526	T10
H28	The Kennels	368917	799693	2158	T10
H29	Kennerty Cottage	367349	799727	2142	T9
H30	Green Farm	370277	799761	2650	T10
H31	2 Cluny Crichton Cottages	368386	799766	2001	T9
H32	Kennerty Farm	367363	799876	1998	T9
H33	Alexander Farms Ltd	368519	799912	1884	T9
H34	Quarry Cottage	370076	800024	2319	T10
H35	Coorie Doon	370657	800096	2674	T10
H36	2 Craigton Cottages	371345	800101	3225	T10
H37	1 Craigton Cottages	371352	800104	3230	T10
H38	8 Craigton Cottages	371430	800105	3295	T10
H39	7 Craigton Cottages	371425	800109	3290	T10
H40	Myreside House	370700	800109	2698	T10
H41	9 Craigton Cottages	371433	800110	3295	T10
H42	6 Craigton Cottages	371430	800112	3292	T10
H43	West Craigton	371376	800115	3244	T10
H44	3 Craigton Cottages	371347	800116	3219	T10
H45	4 Craigton Cottages	371345	800119	3216	T10
H46	5 Craigton Cottages	371340	800124	3209	T10
H47	Myreside Farm	370726	800127	2707	T10
H48	Greenburn	366655	800141	2140	T9
H49	Turadh	370665	800141	2650	T10
H50	Greenburn Schoolhouse	366429	800175	2273	T9
H51	Burnhead Farm	368821	800245	1598	T10
H52	Fare View Raemoir	371615	800317	3344	T16
H53	Tillyfaud	365657	800336	2536	T5
H54	Moss-Side	365819	800346	2448	T5
H55	Pinetrees	365361	800369	2672	T5
H56	Struan	365388	800371	2655	T5
H57	Birchbank	365488	800371	2597	T5
H58	Hattonburn Farmhouse	372020	800442	3400	T16
H59	Easter Leabank	366824	800458	1793	T9
H60	Hattonburn Cottage	371941	800470	3339	T16
H61	Easter Leabank Cottage	366796	800477	1799	T9
H62	Hattonburn Lodge	371935	800486	3322	T16
H63	Pine View Campfield	365273	800491	2631	T5
H64	White Lodge	365235	800499	2649	T5
H65	Corfeidly	367165	800550	1500	T9
H66	Leabank Farmhouse	366399	800551	1964	T6
H67	Craigton Farmhouse	371657	800569	3127	T16
H68	Craigton Steading	371672	800620	3086	T16
H69	Broomhillock Croft	372423	800731	3374	T16
H70	Strath Farmhouse	366653	800785	1635	T6
H71	Hattonburn Croft	372223	800794	3206	T16
H72	Wester Campfield	365297	800807	2379	T5
H73	Kilduthie Farm	372908	800841	3604	T16
H74	Berwick Cottage	365109	800858	2480	T5
H75	Campfield House	366050	800887	1862	T5
H76	Campfield Cottage	366077	800932	1810	T5
H77	1 Kilduthie Cottage	372944	801000	3518	T16
H78	2 Kilduthie Cottage	372954	801002	3523	T16
H79	Birklands	372937	801148	3412	T16
H80	St. Duthac Cottage	372756	801156	3274	T16
H81	Ferretfold	365051	801198	2314	T5
H82	Birks Lodge	372859	801225	3302	T16
H83	Wester Mains	365635	801243	1832	T5
H84	Wickerinn Farm	373580	801296	3828	T16
H85	Wickerinn Farmhouse	373566	801550	3680	T16
H86	Wickerinn Steading	373574	801569	3678	T16
H87	Blairhead	365580	801777	1559	T5
H88	Birkwood	372721	801858	2802	T16
H89	Cormoir	365392	802206	1592	T5

House ID	Property Name	Coordinates		Distance (m)	Nearest Turbine
		X (m)	Y (m)		
H90	Pitcullen	364790	802448	2165	T5
H91	Birks Of Cullerlie Cottage	373997	802463	3721	T16
H92	Tillyorn	375306	802484	4993	T16
H93	Ceva Freight Ltd	374581	802493	4281	T16
H94	Unit 4	374663	802502	4360	T16
H95	Birks Farm	374255	802540	3953	T16
H96	Halliburton Birchmoss	374428	802551	4119	T16
H97	Unit 11	375079	802583	4751	T16
H98	Shed 16	374992	802634	4657	T16
H99	Hydrafit	374819	802647	4484	T16
H100	Rigcool	374820	802650	4485	T16
H101	Sheds 14 & 15	374818	802653	4482	T16
H102	Legasea Ltd	374818	802653	4482	T16
H103	Fugro	374820	802654	4484	T16
H104	Mcintosh Plant Hire (Aberdeen) Ltd	374820	802657	4483	T16
H105	Cosyneuk	374276	802673	3946	T16
H106	1 Thistleycrook Steading	364469	802817	2503	T5
H107	East Woodside	374101	802871	3739	T16
H108	Nether Woodside	374616	802879	4248	T16
H109	Cullerlie Farm Museum	374616	802879	4248	T16
H110	Meikle Maldron	364890	802950	2094	T4
H111	Wester Tillyshogle Croft	374073	803280	3672	T16
H112	Wester Tillyshogle Farm	374660	803486	4255	T16
H113	South Newfield	374374	803585	3972	T16
H114	Banks Of Finnercy	375035	803617	4634	T16
H115	The Byre	375379	803778	4986	T16
H116	The Mill	375402	803790	5010	T16
H117	The Farmhouse	375364	803791	4973	T16
H118	The Stables	375424	803803	5033	T16
H119	Milton Of Finnercy	375638	803924	5256	T16
H120	Newfield	374603	803954	4231	T16
H121	Finnercy Cottage	375322	804053	4956	T16
H122	Wellwood	374130	804059	3778	T16
H123	Cowiehillock Cottage	375256	804076	4894	T16
H124	Hillbrae Cottage	373585	804129	3256	T16
H125	South Finnercy	375050	804199	4708	T16
H126	Hillbrae Farm	373834	804262	3528	T16
H127	Cowiehillock Farm	374934	804323	4616	T16
H128	Cowiehillock Bothy	374961	804340	4646	T16
H129	Landerberry Cottage	374677	804397	4380	T16
H130	West Landerberry	374226	804432	3950	T16
H131	Mains Of Landerberry Farm	374387	804464	4114	T16
H132	Sandyhillock	373523	804538	3308	T16
H133	Tillenturk	365579	804699	2159	T4
H134	Woodside	372301	804715	2288	T16
H135	Tillenturk Boarding Kennels	365602	804739	2175	T4
H136	Dove Cottage	369792	804804	1501	T16
H137	Craigshannoch Lodge	369788	804844	1526	T1
H138	Upper Tillenhilt	366620	804845	1824	T4
H139	Craigshannoch Cottage	369837	804920	1591	T16
H140	Tilloch Farm	373224	804979	3215	T16
H141	Tilloch Cottage	373347	805007	3337	T16
H142	Craigshannoch Farm	369853	805038	1693	T1
H143	Mill Of Echt Farmhouse	373774	805098	3758	T16
H144	Mill Of Echt Cottage	373852	805104	3831	T16
H145	South Kirkton Farm	374081	805106	4039	T16
H146	Mill Of Echt	373768	805121	3763	T16
H147	Mid Tillenhilt	366780	805128	1930	T2
H148	Hillside	367149	805160	1762	T2
H149	2 Kirkton Cottages	373975	805184	3976	T16
H150	3 Kirkton Cottages	373979	805189	3982	T16
H151	1 Kirkton Cottages	373973	805196	3980	T16
H152	6 Kirkton Cottages	373966	805204	3977	T16
H153	Midmar Castle	370463	805255	1822	T16
H154	7 Kirkton Cottages	373950	805264	3990	T16

House ID	Property Name	Coordinates		Distance (m)	Nearest Turbine
		X (m)	Y (m)		
H155	Peace Coaches	371272	805265	2026	T16
H156	5 Kirkton Cottages	373980	805281	4024	T16
H157	4 Kirkton Cottages	373958	805283	4006	T16
H158	J D Peace & Co	371293	805292	2060	T16
H159	Farepark	371295	805293	2061	T16
H160	The Manse	373893	805340	3975	T16
H161	The Old Mill	371289	805346	2107	T16
H162	Glenecht	373933	805360	4020	T16
H163	Midmar Cottage	370265	805384	1955	T16
H164	Sunhoney Cottage	371650	805424	2348	T16
H165	Asylum Interactive Ltd	371283	805426	2177	T16
H166	Mill Of Hole House	371290	805428	2182	T16
H167	Rosedale	371629	805431	2343	T16
H168	Manor House	370284	805435	2005	T16
H169	Corrieburn	371604	805448	2344	T16
H170	Forest Products Ltd	371291	805473	2223	T16
H171	Mill Of Hole Bothy	371312	805484	2242	T16
H172	Sunhoney Farm	371746	805527	2486	T16
H173	Greentree Croft	372860	805537	3233	T16
H174	29 Barmekin Park	373762	805544	3966	T16
H175	6 Fareview Cottages	373902	805547	4086	T16
H176	2 Barmekin Park	373865	805549	4056	T16
H177	1 Barmekin Park	373872	805552	4063	T16
H178	17 Barmekin Park	373820	805552	4019	T16
H179	3 Barmekin Park	373858	805552	4051	T16
H180	5 Fareview Cottages	373901	805553	4088	T16
H181	4 Barmekin Park	373852	805554	4047	T16
H182	28 Barmekin Park	373763	805557	3973	T16
H183	18 Barmekin Park	373794	805559	4001	T16
H184	16 Barmekin Park	373821	805564	4026	T16
H185	27 Barmekin Park	373763	805564	3977	T16
H186	5 Barmekin Park	373845	805565	4047	T16
H187	19 Barmekin Park	373798	805568	4009	T16
H188	4 Fareview Cottages	373892	805570	4090	T16
H189	26 Barmekin Park	373764	805572	3982	T16
H190	15 Barmekin Park	373812	805573	4023	T16
H191	6 Barmekin Park	373850	805575	4057	T16
H192	3 Fareview Cottages	373890	805577	4091	T16
H193	14 Barmekin Park	373814	805580	4029	T16
H194	Barnyards	373418	805581	3700	T16
H195	7 Barmekin Park	373860	805581	4068	T16
H196	25 Barmekin Park	373760	805586	3986	T16
H197	13 Barmekin Park	373813	805592	4034	T16
H198	24 Barmekin Park	373762	805594	3992	T16
H199	8 Barmekin Park	373860	805594	4075	T16
H200	2 Fareview Cottages	373887	805595	4099	T16
H201	Greentree Lodge	372915	805597	3314	T16
H202	1 Fareview Cottages	373884	805603	4100	T16
H203	22 Barmekin Park	373780	805604	4012	T16
H204	9 Barmekin Park	373853	805604	4074	T16
H205	20 Barmekin Park	373796	805604	4026	T16
H206	12 Barmekin Park	373824	805604	4050	T16
H207	11 Barmekin Park	373830	805604	4055	T16
H208	23 Barmekin Park	373772	805605	4006	T16
H209	21 Barmekin Park	373789	805605	4020	T16
H210	10 Barmekin Park	373843	805605	4066	T16
H211	Struan	373846	805628	4081	T16
H212	3 Orchard Grove	373768	805635	4020	T16
H213	2 Orchard Grove	373789	805637	4038	T16
H214	1 Orchard Grove	373815	805643	4063	T16
H215	Old School House	373878	805648	4119	T16
H216	West Mains	372596	805663	3126	T16
H217	Kirkton Station House	373745	805668	4019	T16
H218	The Midmar Inn	370583	805671	2244	T16

House ID	Property Name	Coordinates		Distance (m)	Nearest Turbine
		X (m)	Y (m)		
H219	The House	370583	805671	2244	T16
H220	Fare-Lea	373787	805672	4056	T16
H221	Briar Cottage	370487	805673	2241	T16
H222	Eilan Reach	373769	805673	4041	T16
H223	Birchlea	373809	805674	4075	T16
H224	Toll House	373344	805678	3698	T16
H225	Gormack House	370604	805692	2267	T16
H226	Upper Lurg	369387	805741	1952	T1
H227	Lurg Lodge	369438	805744	1978	T1
H228	Windward	367553	805754	2013	T1
H229	Itsashed	367532	805803	2067	T1
H230	Auchmore Steading	367525	805852	2113	T1
H231	Auchmore	367469	805865	2152	T1
H232	Auchmore Steading Caravan	367503	805880	2148	T1
H233	Beinn Alvinn	369148	805937	2045	T1
H234	Brae Cottage	369022	806000	2071	T1
H235	Braes O Mar	369018	806056	2125	T1
H236	St. Aidens	369869	806065	2473	T1
H237	The Braes	369023	806107	2175	T1
H238	Mill O Brae	369056	806139	2214	T1
H239	Lurg House	369737	806148	2476	T1
H240	Middle Lurg	369575	806150	2402	T1
H241	The Caravan	367856	806153	2264	T1
H242	The Lurg	369616	806163	2433	T1
H243	Skybrae	367891	806185	2285	T1
H244	Miller Plant Ltd	369680	806187	2483	T1
H245	North Lurg	369666	806228	2513	T1
H246	Treehouse Cafe	369648	806271	2543	T1
H247	Wester Tulloch	367979	806330	2403	T1
H248	Easter Tulloch	368534	806331	2341	T1
H249	Tulloch View	368055	806378	2434	T1
H250	Sunnyleigh	369392	806420	2580	T1
H251	Roadside Croft	369372	806423	2577	T1
H252	Roadside Cottage	369343	806423	2568	T1
H253	Braeside	365645	802906	1344	T4
H254	Burnhead Cottage	368995	800110	1761	T10

12.6.25 Although not finalised, the candidate turbine type used for the purposes of the acoustic assessment of the Proposed Development is the Siemens Gamesa SG 6.6-155 6.6 MW machine. This report uses the acoustic data from the manufacturer's performance specification for this machine for all analysis[23]. A 2 dB(A) allowance for uncertainty has therefore been added to the warranted levels as a conservative measure as recommended by the IoA GPG. Details used in this analysis are as follows:

- A hub height of 122.5 m, representing the height of the turbines at 200 m tip heights,
- A rotor diameter of 155 m;
- Sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) and including the 2 dB(A) value for uncertainty as shown in **Table 12.13**;
- Octave band sound power level data, at the maximum wind speed where it is available, including the 2 dB(A) value for uncertainty as shown in **Table 12.14**; and
- Tonal emission characteristics such that no clearly audible tones are present at any wind speed.

Table 12.13: A-Weighted Sound Power Levels (dB(A) re 1 pW) at Standardised 10 m Height Wind Speeds for the Siemens Gamesa SG 6.6-155 6.6 MW Turbine

23 'Acoustic Emission for SG 6.6-155, Rev. 0_AM0', Siemens Gamesa Renewable Energy S.A., Document ID: D2311677_006, 2022-11-08

Standardised 10 m Height Wind Speed, v_{10} (ms^{-1})	L_{WA} (122.5 m Hub Height)
1	95.2
2	95.2
3	95.2
4	100.4
5	105.2
6	107.0
7	107.0
8	107.0
9	107.0
10	107.0
11	107.0
12	107.0

Table 12.14: Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at Standardised 10 m Height Wind Speeds for the Siemens Gamesa SG 6.6-155 6.6 MW Turbine

Octave Band (Hz)	L_{WA} (8 ms^{-1})
63	88.1
125	94.3
250	99.3
500	99.6
1000	101.3
2000	100.9
4000	95.0
8000	78.1
OVERALL	107.0

Predictions of Noise Levels at Residential Properties

12.6.26 **Table 12.15** shows the predicted noise immission levels at the nearest properties at each wind speed considered, calculated from the operation of the Proposed Development. The property with the highest predicted noise immission level of 36.1 dB(A) is H136 (Dove Cottage).

12.6.27 **Figure 12.1** shows an isobel (i.e., noise contour) plot for the Proposed Development at a Standardised 10 m height wind speed of 8 ms^{-1}. Such plots are useful for evaluating the noise 'footprint' of a given development.

Table 12.15: Predicted Noise Levels At Nearby Residential Properties ($L_{A90,10mins}$ dB)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H1	15.9	15.9	15.9	21.1	25.9	27.7	27.7	27.7	27.7	27.7	27.7	27.7
H2	15.9	15.9	15.9	21.1	25.9	27.7	27.7	27.7	27.7	27.7	27.7	27.7
H3	16.4	16.4	16.4	21.6	26.4	28.2	28.2	28.2	28.2	28.2	28.2	28.2
H4	15.3	15.3	15.3	20.5	25.3	27.1	27.1	27.1	27.1	27.1	27.1	27.1
H5	14.6	14.6	14.6	19.8	24.6	26.4	26.4	26.4	26.4	26.4	26.4	26.4
H6	14.7	14.7	14.7	19.9	24.7	26.5	26.5	26.5	26.5	26.5	26.5	26.5
H7	13.9	13.9	13.9	19.1	23.9	25.7	25.7	25.7	25.7	25.7	25.7	25.7
H8	14.5	14.5	14.5	19.7	24.5	26.3	26.3	26.3	26.3	26.3	26.3	26.3
H9	17.6	17.6	17.6	22.8	27.6	29.4	29.4	29.4	29.4	29.4	29.4	29.4
H10	14.6	14.6	14.6	19.8	24.6	26.4	26.4	26.4	26.4	26.4	26.4	26.4
H11	14.6	14.6	14.6	19.8	24.6	26.4	26.4	26.4	26.4	26.4	26.4	26.4
H12	14.6	14.6	14.6	19.8	24.6	26.4	26.4	26.4	26.4	26.4	26.4	26.4
H13	14.6	14.6	14.6	19.8	24.6	26.4	26.4	26.4	26.4	26.4	26.4	26.4
H14	14.1	14.1	14.1	19.3	24.1	25.9	25.9	25.9	25.9	25.9	25.9	25.9
H15	15.6	15.6	15.6	20.8	25.6	27.4	27.4	27.4	27.4	27.4	27.4	27.4
H16	17.9	17.9	17.9	23.1	27.9	29.7	29.7	29.7	29.7	29.7	29.7	29.7
H17	18.0	18.0	18.0	23.2	28.0	29.8	29.8	29.8	29.8	29.8	29.8	29.8
H18	16.1	16.1	16.1	21.3	26.1	27.9	27.9	27.9	27.9	27.9	27.9	27.9
H19	16.1	16.1	16.1	21.3	26.1	27.9	27.9	27.9	27.9	27.9	27.9	27.9
H20	14.7	14.7	14.7	19.9	24.7	26.5	26.5	26.5	26.5	26.5	26.5	26.5
H21	18.0	18.0	18.0	23.2	28.0	29.8	29.8	29.8	29.8	29.8	29.8	29.8
H22	15.6	15.6	15.6	20.8	25.6	27.4	27.4	27.4	27.4	27.4	27.4	27.4
H23	15.6	15.6	15.6	20.8	25.6	27.4	27.4	27.4	27.4	27.4	27.4	27.4
H24	18.0	18.0	18.0	23.2	28.0	29.8	29.8	29.8	29.8	29.8	29.8	29.8
H25	18.1	18.1	18.1	23.3	28.1	29.9	29.9	29.9	29.9	29.9	29.9	29.9
H26	18.1	18.1	18.1	23.3	28.1	29.9	29.9	29.9	29.9	29.9	29.9	29.9
H27	15.7	15.7	15.7	20.9	25.7	27.5	27.5	27.5	27.5	27.5	27.5	27.5
H28	18.4	18.4	18.4	23.6	28.4	30.2	30.2	30.2	30.2	30.2	30.2	30.2
H29	18.6	18.6	18.6	23.8	28.6	30.4	30.4	30.4	30.4	30.4	30.4	30.4
H30	15.5	15.5	15.5	20.7	25.5	27.3	27.3	27.3	27.3	27.3	27.3	27.3
H31	18.5	18.5	18.5	23.7	28.5	30.3	30.3	30.3	30.3	30.3	30.3	30.3
H32	18.5	18.5	18.5	23.7	28.5	30.3	30.3	30.3	30.3	30.3	30.3	30.3
H33	19.2	19.2	19.2	24.4	29.2	31.0	31.0	31.0	31.0	31.0	31.0	31.0

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H34	16.6	16.6	16.6	21.8	26.6	28.4	28.4	28.4	28.4	28.4	28.4	28.4
H35	15.3	15.3	15.3	20.5	25.3	27.1	27.1	27.1	27.1	27.1	27.1	27.1
H36	14.3	14.3	14.3	19.5	24.3	26.1	26.1	26.1	26.1	26.1	26.1	26.1
H37	14.5	14.5	14.5	19.7	24.5	26.3	26.3	26.3	26.3	26.3	26.3	26.3
H38	14.4	14.4	14.4	19.6	24.4	26.2	26.2	26.2	26.2	26.2	26.2	26.2
H39	14.4	14.4	14.4	19.6	24.4	26.2	26.2	26.2	26.2	26.2	26.2	26.2
H40	15.0	15.0	15.0	20.2	25.0	26.8	26.8	26.8	26.8	26.8	26.8	26.8
H41	14.4	14.4	14.4	19.6	24.4	26.2	26.2	26.2	26.2	26.2	26.2	26.2
H42	14.4	14.4	14.4	19.6	24.4	26.2	26.2	26.2	26.2	26.2	26.2	26.2
H43	14.4	14.4	14.4	19.6	24.4	26.2	26.2	26.2	26.2	26.2	26.2	26.2
H44	14.5	14.5	14.5	19.7	24.5	26.3	26.3	26.3	26.3	26.3	26.3	26.3
H45	14.4	14.4	14.4	19.6	24.4	26.2	26.2	26.2	26.2	26.2	26.2	26.2
H46	14.4	14.4	14.4	19.6	24.4	26.2	26.2	26.2	26.2	26.2	26.2	26.2
H47	15.0	15.0	15.0	20.2	25.0	26.8	26.8	26.8	26.8	26.8	26.8	26.8
H48	18.3	18.3	18.3	23.5	28.3	30.1	30.1	30.1	30.1	30.1	30.1	30.1
H49	15.2	15.2	15.2	20.4	25.2	27.0	27.0	27.0	27.0	27.0	27.0	27.0
H50	17.9	17.9	17.9	23.1	27.9	29.7	29.7	29.7	29.7	29.7	29.7	29.7
H51	20.5	20.5	20.5	25.7	30.5	32.3	32.3	32.3	32.3	32.3	32.3	32.3
H52	14.6	14.6	14.6	19.8	24.6	26.4	26.4	26.4	26.4	26.4	26.4	26.4
H53	16.5	16.5	16.5	21.7	26.5	28.3	28.3	28.3	28.3	28.3	28.3	28.3
H54	16.8	16.8	16.8	22.0	26.8	28.6	28.6	28.6	28.6	28.6	28.6	28.6
H55	15.8	15.8	15.8	21.0	25.8	27.6	27.6	27.6	27.6	27.6	27.6	27.6
H56	15.9	15.9	15.9	21.1	25.9	27.7	27.7	27.7	27.7	27.7	27.7	27.7
H57	16.2	16.2	16.2	21.4	26.2	28.0	28.0	28.0	28.0	28.0	28.0	28.0
H58	14.8	14.8	14.8	20.0	24.8	26.6	26.6	26.6	26.6	26.6	26.6	26.6
H59	20.0	20.0	20.0	25.2	30.0	31.8	31.8	31.8	31.8	31.8	31.8	31.8
H60	15.0	15.0	15.0	20.2	25.0	26.8	26.8	26.8	26.8	26.8	26.8	26.8
H61	20.1	20.1	20.1	25.3	30.1	31.9	31.9	31.9	31.9	31.9	31.9	31.9
H62	15.0	15.0	15.0	20.2	25.0	26.8	26.8	26.8	26.8	26.8	26.8	26.8
H63	16.0	16.0	16.0	21.2	26.0	27.8	27.8	27.8	27.8	27.8	27.8	27.8
H64	15.9	15.9	15.9	21.1	25.9	27.7	27.7	27.7	27.7	27.7	27.7	27.7
H65	21.3	21.3	21.3	26.5	31.3	33.1	33.1	33.1	33.1	33.1	33.1	33.1
H66	18.9	18.9	18.9	24.1	28.9	30.7	30.7	30.7	30.7	30.7	30.7	30.7
H67	15.3	15.3	15.3	20.5	25.3	27.1	27.1	27.1	27.1	27.1	27.1	27.1
H68	15.4	15.4	15.4	20.6	25.4	27.2	27.2	27.2	27.2	27.2	27.2	27.2

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H69	14.1	14.1	14.1	19.3	24.1	25.9	25.9	25.9	25.9	25.9	25.9	25.9
H70	20.9	20.9	20.9	26.1	30.9	32.7	32.7	32.7	32.7	32.7	32.7	32.7
H71	14.8	14.8	14.8	20.0	24.8	26.6	26.6	26.6	26.6	26.6	26.6	26.6
H72	18.0	18.0	18.0	23.2	28.0	29.8	29.8	29.8	29.8	29.8	29.8	29.8
H73	13.9	13.9	13.9	19.1	23.9	25.7	25.7	25.7	25.7	25.7	25.7	25.7
H74	17.5	17.5	17.5	22.7	27.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3
H75	19.0	19.0	19.0	24.2	29.0	30.8	30.8	30.8	30.8	30.8	30.8	30.8
H76	18.2	18.2	18.2	23.4	28.2	30.0	30.0	30.0	30.0	30.0	30.0	30.0
H77	13.2	13.2	13.2	18.4	23.2	25.0	25.0	25.0	25.0	25.0	25.0	25.0
H78	13.2	13.2	13.2	18.4	23.2	25.0	25.0	25.0	25.0	25.0	25.0	25.0
H79	13.4	13.4	13.4	18.6	23.4	25.2	25.2	25.2	25.2	25.2	25.2	25.2
H80	13.6	13.6	13.6	18.8	23.6	25.4	25.4	25.4	25.4	25.4	25.4	25.4
H81	18.1	18.1	18.1	23.3	28.1	29.9	29.9	29.9	29.9	29.9	29.9	29.9
H82	13.7	13.7	13.7	18.9	23.7	25.5	25.5	25.5	25.5	25.5	25.5	25.5
H83	18.6	18.6	18.6	23.8	28.6	30.4	30.4	30.4	30.4	30.4	30.4	30.4
H84	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H85	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H86	11.7	11.7	11.7	16.9	21.7	23.5	23.5	23.5	23.5	23.5	23.5	23.5
H87	21.9	21.9	21.9	27.1	31.9	33.7	33.7	33.7	33.7	33.7	33.7	33.7
H88	14.5	14.5	14.5	19.7	24.5	26.3	26.3	26.3	26.3	26.3	26.3	26.3
H89	21.1	21.1	21.1	26.3	31.1	32.9	32.9	32.9	32.9	32.9	32.9	32.9
H90	18.3	18.3	18.3	23.5	28.3	30.1	30.1	30.1	30.1	30.1	30.1	30.1
H91	10.9	10.9	10.9	16.1	20.9	22.7	22.7	22.7	22.7	22.7	22.7	22.7
H92	8.7	8.7	8.7	13.9	18.7	20.5	20.5	20.5	20.5	20.5	20.5	20.5
H93	9.8	9.8	9.8	15.0	19.8	21.6	21.6	21.6	21.6	21.6	21.6	21.6
H94	9.6	9.6	9.6	14.8	19.6	21.4	21.4	21.4	21.4	21.4	21.4	21.4
H95	10.2	10.2	10.2	15.4	20.2	22.0	22.0	22.0	22.0	22.0	22.0	22.0
H96	10.1	10.1	10.1	15.3	20.1	21.9	21.9	21.9	21.9	21.9	21.9	21.9
H97	8.8	8.8	8.8	14.0	18.8	20.6	20.6	20.6	20.6	20.6	20.6	20.6
H98	9.0	9.0	9.0	14.2	19.0	20.8	20.8	20.8	20.8	20.8	20.8	20.8
H99	9.2	9.2	9.2	14.4	19.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0
H100	9.2	9.2	9.2	14.4	19.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0
H101	9.2	9.2	9.2	14.4	19.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0
H102	9.2	9.2	9.2	14.4	19.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0
H103	9.2	9.2	9.2	14.4	19.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H104	9.2	9.2	9.2	14.4	19.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0
H105	10.1	10.1	10.1	15.3	20.1	21.9	21.9	21.9	21.9	21.9	21.9	21.9
H106	17.9	17.9	17.9	23.1	27.9	29.7	29.7	29.7	29.7	29.7	29.7	29.7
H107	10.2	10.2	10.2	15.4	20.2	22.0	22.0	22.0	22.0	22.0	22.0	22.0
H108	9.0	9.0	9.0	14.2	19.0	20.8	20.8	20.8	20.8	20.8	20.8	20.8
H109	9.0	9.0	9.0	14.2	19.0	20.8	20.8	20.8	20.8	20.8	20.8	20.8
H110	18.8	18.8	18.8	24.0	28.8	30.6	30.6	30.6	30.6	30.6	30.6	30.6
H111	9.9	9.9	9.9	15.1	19.9	21.7	21.7	21.7	21.7	21.7	21.7	21.7
H112	8.6	8.6	8.6	13.8	18.6	20.4	20.4	20.4	20.4	20.4	20.4	20.4
H113	9.1	9.1	9.1	14.3	19.1	20.9	20.9	20.9	20.9	20.9	20.9	20.9
H114	8.6	8.6	8.6	13.8	18.6	20.4	20.4	20.4	20.4	20.4	20.4	20.4
H115	8.0	8.0	8.0	13.2	18.0	19.8	19.8	19.8	19.8	19.8	19.8	19.8
H116	8.0	8.0	8.0	13.2	18.0	19.8	19.8	19.8	19.8	19.8	19.8	19.8
H117	8.1	8.1	8.1	13.3	18.1	19.9	19.9	19.9	19.9	19.9	19.9	19.9
H118	7.9	7.9	7.9	13.1	17.9	19.7	19.7	19.7	19.7	19.7	19.7	19.7
H119	7.9	7.9	7.9	13.1	17.9	19.7	19.7	19.7	19.7	19.7	19.7	19.7
H120	9.6	9.6	9.6	14.8	19.6	21.4	21.4	21.4	21.4	21.4	21.4	21.4
H121	8.5	8.5	8.5	13.7	18.5	20.3	20.3	20.3	20.3	20.3	20.3	20.3
H122	9.5	9.5	9.5	14.7	19.5	21.3	21.3	21.3	21.3	21.3	21.3	21.3
H123	8.6	8.6	8.6	13.8	18.6	20.4	20.4	20.4	20.4	20.4	20.4	20.4
H124	11.0	11.0	11.0	16.2	21.0	22.8	22.8	22.8	22.8	22.8	22.8	22.8
H125	8.9	8.9	8.9	14.1	18.9	20.7	20.7	20.7	20.7	20.7	20.7	20.7
H126	10.6	10.6	10.6	15.8	20.6	22.4	22.4	22.4	22.4	22.4	22.4	22.4
H127	9.4	9.4	9.4	14.6	19.4	21.2	21.2	21.2	21.2	21.2	21.2	21.2
H128	9.3	9.3	9.3	14.5	19.3	21.1	21.1	21.1	21.1	21.1	21.1	21.1
H129	9.6	9.6	9.6	14.8	19.6	21.4	21.4	21.4	21.4	21.4	21.4	21.4
H130	10.2	10.2	10.2	15.4	20.2	22.0	22.0	22.0	22.0	22.0	22.0	22.0
H131	10.1	10.1	10.1	15.3	20.1	21.9	21.9	21.9	21.9	21.9	21.9	21.9
H132	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H133	18.0	18.0	18.0	23.2	28.0	29.8	29.8	29.8	29.8	29.8	29.8	29.8
H134	14.5	14.5	14.5	19.7	24.5	26.3	26.3	26.3	26.3	26.3	26.3	26.3
H135	18.0	18.0	18.0	23.2	28.0	29.8	29.8	29.8	29.8	29.8	29.8	29.8
H136	24.3	24.3	24.3	29.5	34.3	36.1	36.1	36.1	36.1	36.1	36.1	36.1
H137	24.2	24.2	24.2	29.4	34.2	36.0	36.0	36.0	36.0	36.0	36.0	36.0

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H138	20.8	20.8	20.8	26.0	30.8	32.6	32.6	32.6	32.6	32.6	32.6	32.6
H139	23.7	23.7	23.7	28.9	33.7	35.5	35.5	35.5	35.5	35.5	35.5	35.5
H140	12.3	12.3	12.3	17.5	22.3	24.1	24.1	24.1	24.1	24.1	24.1	24.1
H141	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H142	23.3	23.3	23.3	28.5	33.3	35.1	35.1	35.1	35.1	35.1	35.1	35.1
H143	11.6	11.6	11.6	16.8	21.6	23.4	23.4	23.4	23.4	23.4	23.4	23.4
H144	11.3	11.3	11.3	16.5	21.3	23.1	23.1	23.1	23.1	23.1	23.1	23.1
H145	10.9	10.9	10.9	16.1	20.9	22.7	22.7	22.7	22.7	22.7	22.7	22.7
H146	11.6	11.6	11.6	16.8	21.6	23.4	23.4	23.4	23.4	23.4	23.4	23.4
H147	20.5	20.5	20.5	25.7	30.5	32.3	32.3	32.3	32.3	32.3	32.3	32.3
H148	20.3	20.3	20.3	25.5	30.3	32.1	32.1	32.1	32.1	32.1	32.1	32.1
H149	11.3	11.3	11.3	16.5	21.3	23.1	23.1	23.1	23.1	23.1	23.1	23.1
H150	11.3	11.3	11.3	16.5	21.3	23.1	23.1	23.1	23.1	23.1	23.1	23.1
H151	11.3	11.3	11.3	16.5	21.3	23.1	23.1	23.1	23.1	23.1	23.1	23.1
H152	11.3	11.3	11.3	16.5	21.3	23.1	23.1	23.1	23.1	23.1	23.1	23.1
H153	20.8	20.8	20.8	26.0	30.8	32.6	32.6	32.6	32.6	32.6	32.6	32.6
H154	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H155	17.5	17.5	17.5	22.7	27.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3
H156	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H157	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H158	17.3	17.3	17.3	22.5	27.3	29.1	29.1	29.1	29.1	29.1	29.1	29.1
H159	17.3	17.3	17.3	22.5	27.3	29.1	29.1	29.1	29.1	29.1	29.1	29.1
H160	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H161	17.2	17.2	17.2	22.4	27.2	29.0	29.0	29.0	29.0	29.0	29.0	29.0
H162	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H163	21.0	21.0	21.0	26.2	31.0	32.8	32.8	32.8	32.8	32.8	32.8	32.8
H164	16.6	16.6	16.6	21.8	26.6	28.4	28.4	28.4	28.4	28.4	28.4	28.4
H165	17.1	17.1	17.1	22.3	27.1	28.9	28.9	28.9	28.9	28.9	28.9	28.9
H166	17.1	17.1	17.1	22.3	27.1	28.9	28.9	28.9	28.9	28.9	28.9	28.9
H167	16.7	16.7	16.7	21.9	26.7	28.5	28.5	28.5	28.5	28.5	28.5	28.5
H168	20.7	20.7	20.7	25.9	30.7	32.5	32.5	32.5	32.5	32.5	32.5	32.5
H169	16.7	16.7	16.7	21.9	26.7	28.5	28.5	28.5	28.5	28.5	28.5	28.5
H170	17.0	17.0	17.0	22.2	27.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8
H171	16.9	16.9	16.9	22.1	26.9	28.7	28.7	28.7	28.7	28.7	28.7	28.7

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H172	16.4	16.4	16.4	21.6	26.4	28.2	28.2	28.2	28.2	28.2	28.2	28.2
H173	13.4	13.4	13.4	18.6	23.4	25.2	25.2	25.2	25.2	25.2	25.2	25.2
H174	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H175	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H176	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H177	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H178	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H179	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H180	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H181	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H182	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H183	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H184	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H185	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H186	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H187	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H188	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H189	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H190	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H191	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H192	11.8	11.8	11.8	17.0	21.8	23.6	23.6	23.6	23.6	23.6	23.6	23.6
H193	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H194	12.4	12.4	12.4	17.6	22.4	24.2	24.2	24.2	24.2	24.2	24.2	24.2
H195	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H196	12.3	12.3	12.3	17.5	22.3	24.1	24.1	24.1	24.1	24.1	24.1	24.1
H197	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H198	12.3	12.3	12.3	17.5	22.3	24.1	24.1	24.1	24.1	24.1	24.1	24.1
H199	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H200	11.9	11.9	11.9	17.1	21.9	23.7	23.7	23.7	23.7	23.7	23.7	23.7
H201	13.4	13.4	13.4	18.6	23.4	25.2	25.2	25.2	25.2	25.2	25.2	25.2
H202	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H203	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H204	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H205	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H206	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H207	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H208	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H209	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H210	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H211	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H212	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H213	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H214	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H215	12.0	12.0	12.0	17.2	22.0	23.8	23.8	23.8	23.8	23.8	23.8	23.8
H216	14.2	14.2	14.2	19.4	24.2	26.0	26.0	26.0	26.0	26.0	26.0	26.0
H217	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H218	19.5	19.5	19.5	24.7	29.5	31.3	31.3	31.3	31.3	31.3	31.3	31.3
H219	19.5	19.5	19.5	24.7	29.5	31.3	31.3	31.3	31.3	31.3	31.3	31.3
H220	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H221	19.6	19.6	19.6	24.8	29.6	31.4	31.4	31.4	31.4	31.4	31.4	31.4
H222	12.2	12.2	12.2	17.4	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
H223	12.1	12.1	12.1	17.3	22.1	23.9	23.9	23.9	23.9	23.9	23.9	23.9
H224	12.7	12.7	12.7	17.9	22.7	24.5	24.5	24.5	24.5	24.5	24.5	24.5
H225	19.3	19.3	19.3	24.5	29.3	31.1	31.1	31.1	31.1	31.1	31.1	31.1
H226	19.3	19.3	19.3	24.5	29.3	31.1	31.1	31.1	31.1	31.1	31.1	31.1
H227	19.4	19.4	19.4	24.6	29.4	31.2	31.2	31.2	31.2	31.2	31.2	31.2
H228	18.4	18.4	18.4	23.6	28.4	30.2	30.2	30.2	30.2	30.2	30.2	30.2
H229	18.3	18.3	18.3	23.5	28.3	30.1	30.1	30.1	30.1	30.1	30.1	30.1
H230	18.2	18.2	18.2	23.4	28.2	30.0	30.0	30.0	30.0	30.0	30.0	30.0
H231	18.4	18.4	18.4	23.6	28.4	30.2	30.2	30.2	30.2	30.2	30.2	30.2
H232	18.4	18.4	18.4	23.6	28.4	30.2	30.2	30.2	30.2	30.2	30.2	30.2
H233	18.6	18.6	18.6	23.8	28.6	30.4	30.4	30.4	30.4	30.4	30.4	30.4
H234	17.9	17.9	17.9	23.1	27.9	29.7	29.7	29.7	29.7	29.7	29.7	29.7
H235	17.5	17.5	17.5	22.7	27.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3
H236	17.2	17.2	17.2	22.4	27.2	29.0	29.0	29.0	29.0	29.0	29.0	29.0
H237	17.5	17.5	17.5	22.7	27.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3
H238	17.3	17.3	17.3	22.5	27.3	29.1	29.1	29.1	29.1	29.1	29.1	29.1
H239	17.6	17.6	17.6	22.8	27.6	29.4	29.4	29.4	29.4	29.4	29.4	29.4
H240	17.7	17.7	17.7	22.9	27.7	29.5	29.5	29.5	29.5	29.5	29.5	29.5
H241	17.2	17.2	17.2	22.4	27.2	29.0	29.0	29.0	29.0	29.0	29.0	29.0

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H242	17.6	17.6	17.6	22.8	27.6	29.4	29.4	29.4	29.4	29.4	29.4	29.4
H243	17.0	17.0	17.0	22.2	27.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8
H244	17.5	17.5	17.5	22.7	27.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3
H245	17.4	17.4	17.4	22.6	27.4	29.2	29.2	29.2	29.2	29.2	29.2	29.2
H246	17.2	17.2	17.2	22.4	27.2	29.0	29.0	29.0	29.0	29.0	29.0	29.0
H247	16.5	16.5	16.5	21.7	26.5	28.3	28.3	28.3	28.3	28.3	28.3	28.3
H248	16.9	16.9	16.9	22.1	26.9	28.7	28.7	28.7	28.7	28.7	28.7	28.7
H249	16.4	16.4	16.4	21.6	26.4	28.2	28.2	28.2	28.2	28.2	28.2	28.2
H250	16.8	16.8	16.8	22.0	26.8	28.6	28.6	28.6	28.6	28.6	28.6	28.6
H251	16.8	16.8	16.8	22.0	26.8	28.6	28.6	28.6	28.6	28.6	28.6	28.6
H252	16.8	16.8	16.8	22.0	26.8	28.6	28.6	28.6	28.6	28.6	28.6	28.6
H253	22.0	22.0	22.0	27.2	32.0	33.8	33.8	33.8	33.8	33.8	33.8	33.8
H254	19.5	19.5	19.5	24.7	29.5	31.3	31.3	31.3	31.3	31.3	31.3	31.3

12.6.28 Noise levels at 250 of the 254 nearest residential properties are below 35 dB(A), indicating that the noise immission levels would be regarded as acceptable and the resident's amenity as receiving 'sufficient protection' without further assessment requiring to be undertaken.

12.6.29 There are 4 properties that have predicted noise levels greater than this simplified noise criteria as indicated in **Table 12.15**. Therefore the 'full' acoustic assessment need only be considered at these properties, which are H136, H137, H139 and H142.

Acoustic Acceptance Criteria

12.6.30 As stated previously, during daytime periods and at low background noise levels, a lower fixed limit of 35-40 dB(A) is applicable with the exact value dependent upon a number of factors: the number of noise affected residential properties; the potential impact on the power output of the Proposed Development and the likely duration and level of exposure. Through consideration of these factors, RES have adopted a 37.5 dB(A) daytime lower fixed limit for all properties. The justification being:

- Number of noise affected residential properties: 4 of the considered residential properties are predicted to experience noise levels of greater than 35 dB(A) and within the lower fixed limit of 35-40 dB(A). This is a small number of properties relative to the number within the study area and in relation to the scale of the Proposed Development, suggesting a limit towards the middle of the range would be appropriate;
- Potential impact on the power output of the Proposed Development: The rated power would be approximately 106 MW should the turbine type considered in the acoustic assessment be installed, which is large in comparison with other wind farm developments in Scotland, suggesting that a lower limit towards the middle, or upper end, of the range would be appropriate. A lower limit towards the lower end of the range would limit the power output of the Proposed Development; and
- The likely duration and level of exposure: The amount of time that noise levels of greater than 35 dB(A) are predicted is limited to periods of sufficiently high wind speed. Noise levels would also be reduced when properties are not located downwind of the turbines. Again, this does not suggest a high impact such that a lower limit in the middle of the range would be appropriate.

12.6.31 A 43 dB(A) lower limit has been adopted at night for all properties in accordance with ETSU-R-97. The resulting criteria are shown in **Table 12.16**.

Table 12.16: Permissible Noise Level Criteria ($L_{A90,10mins}$ dB)

Time of Day	Permissible Noise Level
Daytime	37.5 dB(A) for L_B less than or equal to 32.5 dB(A) L_B + 5 dB, for L_B greater than 32.5 dB(A)
Night-time	43 dB(A) for L_B less than or equal to 38 dB(A) L_B + 5 dB, for L_B greater than 38 dB(A)

Calculation of Acceptable Noise Limits from Baseline Conditions

12.6.32 The 'best-fit' lines of **Technical Appendix 12.6 Charts 12.6.3 – 12.6.8** have been used to calculate the acceptable noise limits at the background noise measurement locations in line with the permissible noise level criteria set out in **Table 12.16**. **Table 12.17** shows the proposed daytime noise limits and **Table 12.18** the night-time noise limits.

Table 12.17: Daytime Noise Limits ($L_{A90,10mins}$ dB)

Survey Location	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Strath Farmhouse	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.3	38.3	38.3
Blairhead	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5
Craigshannoch Cottage	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.0	40.3	40.3	40.3

Table 12.18: Night-time Noise Limits ($L_{A90,10mins}$ dB)

Survey Location	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Strath Farmhouse	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Blairhead	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Craigshannoch Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

12.6.33 The recommendations of ETSU-R-97 state that where there are groups of properties that are likely to have a similar background noise environment, it is appropriate to use data from one representative location as the basis for assessment at the other properties. The survey location inferred to be representative for each property are shown in **Table 12.19**. For all other properties which are not shown in **Table 12.19**, the proposed daytime noise limits are 37.5 dB $L_{A90,10mins}$ and the night-time noise limits are 43.0 dB $L_{A90,10mins}$ for standardised 10 m wind speeds up to and including 12 ms^{-1}.

12.6.34 The specific choice of the noise survey location chosen has been made considering the distance to the nearest survey location and the likelihood of experiencing a broadly similar acoustic environment.

Table 12.19: Representative Background Noise Survey Locations

House ID	Property Name	Survey Location
H65	Corfeidly	Strath Farmhouse
H70	Strath Farmhouse	Strath Farmhouse
H87	Blairhead	Blairhead
H89	Cormoir	Blairhead
H136	Dove Cottage	Craigshannoch Cottage
H137	Craigshannoch Lodge	Craigshannoch Cottage
H139	Craigshannoch Cottage	Craigshannoch Cottage
H142	Craigshannoch Farm	Craigshannoch Cottage
H253	Braeside	Blairhead

Acoustic Assessment

12.6.35 **Table 12.20** shows a comparison of the predicted noise levels (L_p) with the proposed daytime noise limits ('Limit') for each residential property where the full assessment procedure is being applied. The predicted noise levels at 1 ms^{-1} and 2 ms^{-1} have been assumed as equal to 3 ms^{-1} as a conservative measure as noise levels at these wind speeds would typically be less. The term ΔL is used to denote the difference between the predicted noise level and the noise limit. A negative value indicates that the predicted noise level is within the limit. **Table 12.21** shows a comparison with the night-time noise limits.

12.6.36 Noise levels at all locations are within the daytime noise limits at all wind speeds considered with a minimum margin of -1.4 dB(A). Noise levels at all locations are within the night-time noise limits at all wind speeds considered with a minimum margin of -6.9 dB(A).

Table 12.20: Comparison of Predicted Noise Levels and Daytime Noise Limits ($L_{A90,10mins}$ dB)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})																																			
	1			2			3			4			5			6			7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H136	24.3	37.5	-13.2	24.3	37.5	-13.2	24.3	37.5	-13.2	29.5	37.5	-8.0	34.3	37.5	-3.2	36.1	37.5	-1.4	36.1	37.5	-1.4	36.1	37.5	-1.4	36.1	38.0	-1.9	36.1	40.3	-4.2	36.1	40.3	-4.2	36.1	40.3	-4.2
H137	24.2	37.5	-13.3	24.2	37.5	-13.3	24.2	37.5	-13.3	29.4	37.5	-8.1	34.2	37.5	-3.3	36.0	37.5	-1.5	36.0	37.5	-1.5	36.0	37.5	-1.5	36.0	38.0	-2.0	36.0	40.3	-4.3	36.0	40.3	-4.3	36.0	40.3	-4.3
H139	23.7	37.5	-13.8	23.7	37.5	-13.8	23.7	37.5	-13.8	28.9	37.5	-8.6	33.7	37.5	-3.8	35.5	37.5	-2.0	35.5	37.5	-2.0	35.5	37.5	-2.0	35.5	38.0	-2.5	35.5	40.3	-4.8	35.5	40.3	-4.8	35.5	40.3	-4.8
H142	23.3	37.5	-14.2	23.3	37.5	-14.2	23.3	37.5	-14.2	28.5	37.5	-9.0	33.3	37.5	-4.2	35.1	37.5	-2.4	35.1	37.5	-2.4	35.1	37.5	-2.4	35.1	38.0	-2.9	35.1	40.3	-5.2	35.1	40.3	-5.2	35.1	40.3	-5.2

Table 12.21: Comparison of Predicted Noise Levels and night-time Noise Limits ($L_{A90,10mins}$ dB)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})																																			
	1			2			3			4			5			6			7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H136	24.3	43.0	-18.7	24.3	43.0	-18.7	24.3	43.0	-18.7	29.5	43.0	-13.5	34.3	43.0	-8.7	36.1	43.0	-6.9	36.1	43.0	-6.9	36.1	43.0	-6.9	36.1	43.0	-6.9	36.1	43.0	-6.9	36.1	43.0	-6.9	36.1	43.0	-6.9
H137	24.2	43.0	-18.8	24.2	43.0	-18.8	24.2	43.0	-18.8	29.4	43.0	-13.6	34.2	43.0	-8.8	36.0	43.0	-7.0	36.0	43.0	-7.0	36.0	43.0	-7.0	36.0	43.0	-7.0	36.0	43.0	-7.0	36.0	43.0	-7.0	36.0	43.0	-7.0
H139	23.7	43.0	-19.3	23.7	43.0	-19.3	23.7	43.0	-19.3	28.9	43.0	-14.1	33.7	43.0	-9.3	35.5	43.0	-7.5	35.5	43.0	-7.5	35.5	43.0	-7.5	35.5	43.0	-7.5	35.5	43.0	-7.5	35.5	43.0	-7.5	35.5	43.0	-7.5
H142	23.3	43.0	-19.7	23.3	43.0	-19.7	23.3	43.0	-19.7	28.5	43.0	-14.5	33.3	43.0	-9.7	35.1	43.0	-7.9	35.1	43.0	-7.9	35.1	43.0	-7.9	35.1	43.0	-7.9	35.1	43.0	-7.9	35.1	43.0	-7.9	35.1	43.0	-7.9

The term L_p is used to denote the predicted noise level due to the operation of the Proposed Development.

The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit.

12.7 Mitigation

Construction Noise

12.7.1 For all activities, measures will be taken to reduce noise levels with due regard to practicality and cost as per the concept of 'best practicable means' as defined in Section 72 of the Control of Pollution Act 1974.

12.7.2 BS 5228-1:2009 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local authority is recommended along with steps to inform residents of intended activity. Non-acoustic factors, which influence the overall level of complaints such as mud on roads and dust generation, would also be controlled through construction practices adopted on-site.

12.7.3 Furthermore, the following noise mitigation options will be implemented where appropriate:

- Consideration will be given to noise emissions when selecting plant and equipment to be used on-site;
- All equipment will be maintained in good working order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable;
- Stationary noise sources will be sited as far away as reasonably possible from residential properties and where necessary and appropriate, acoustic barriers will be used to screen them; and
- The movement of vehicles to and from the Proposed Development will be controlled and employees instructed to ensure compliance with the noise control measures adopted.

12.7.4 Site operations will be limited to 07:00-19:00 Monday to Saturday except during the construction of the turbine foundations and turbine erection or periods of emergency work. Should it be considered necessary to reduce noise levels from the conservative predicted levels to adhere to the 65 dB(A) weekday (07:00-19:00) threshold and 55 dB(A) threshold for Saturday afternoons (13:00-19:00), the following mitigation measures will be considered:

- Reduce the number of construction activities occurring simultaneously;
- Restrict the distance of construction activity from nearby properties during these times; and
- Reduce construction traffic as appropriate.

12.7.5 There are many strategies to reduce construction noise by the limitation of activities that will result in predicted noise levels being lower than the specified threshold. Any such measures will be considered adequate and the mitigation adopted will not be limited to the measures proposed within this chapter.

12.7.6 With specific regard to borrow pit blasting, it is proposed that the following mitigation measures are implemented:

- Good practice on blasting, as recommended by Planning Advice Note (PAN) 50 'Controlling the environmental effects of surface mineral workings'[24] shall be followed;
- The vibration and air overpressure reduction methods outlined in Section 8.6.9.2 of BS 5228-2:2009 shall be adhered to where appropriate;
- Advance warning shall be given to nearby residents;
- Blasting will only occur between the hours of 08:00-18:00 on Mondays-Fridays or between the hours of 08:00-13:00 on Saturdays; and
- No more than three blasts per day will occur with a maximum charge size of 200 kg per blast at the eastern most borrow pit near the site entrance.
- No more than three blasts per day will occur with a maximum charge size of 1000 kg per blast for the other five borrow pits (excluding the eastern most borrow pit).

12.7.7 Depending upon the charge sizes required it may be prudent to perform trial blasts with smaller amounts of explosive and measure vibration magnitudes at various distances to more accurately determine how vibration propagates at the Proposed Development.

Operational Noise

12.7.8 One of the key constraints and considerations in designing the layout of the turbines was the minimisation of potential noise impacts at the nearest residential receptors. As such the turbine layout was designed to ensure that there is an adequate separation distance between any of the proposed turbines and the nearest residential property. Refer to **Chapter 3: Design Evolution and Alternatives** for further details of the design evolution.

12.7.9 Due to this consideration of the noise impacts in the design of the Proposed Development, by embedding mitigation measures in the turbine layout, when a conservative candidate machine is modelled this meets the noise limits derived in accordance with ETSU-R-97.

[24] 'Planning Advice Note 50: Controlling the environmental effects of surface mineral workings', Scottish Government, October 1996. Available at: https://www.gov.scot/publications/planning-advice-note-pan-50-controlling-environmental-effects-surface-mineral/

12.7.10 If planning permission is granted for the Proposed Development, planning conditions can be proposed to provide a degree of protection to nearby residents in the form of limits relating to noise level and tonality.

12.7.11 **Technical Appendix 12.7** contains a set of draft planning conditions relating to noise that RES considers appropriate.

12.8 Assessment of Residual Effects

Construction

12.8.1 Construction noise levels above the criteria noise level for weekdays (07:00-19:00) and Saturday daytimes (07:00-19:00) are predicted at a limited number of properties near the site entrance although this can be mitigated by controlling the activities that are allowed to take place as necessary, through a Construction and Environment Management Plan (CEMP) to be agreed with Aberdeenshire Council pre-construction. At all other locations predicted noise from the worst-case combination of increased traffic and site construction noise would not exceed relevant criteria and therefore no significant impacts are expected.

Operational

12.8.2 The acoustic assessment demonstrates that predicted noise levels at residential properties do not exceed the derived noise limits. This should not be interpreted to mean that wind farm operational noise would be inaudible (or masked by background noise) under all conditions, but that the levels of noise are acceptable under ETSU-R-97 and associated guidance.

12.9 Assessment of Cumulative Effects

Cumulative Construction Noise Assessment

12.9.1 Construction of other wind farms within a suitable distance for cumulative effects to occur will not be ongoing at the same time as the construction of the Proposed Development.

Cumulative Operational Noise Assessment

12.9.2 An assessment of the cumulative acoustic impact of the Proposed Development in conjunction with the existing four small turbines to the north-west of the Proposed Development has been undertaken in accordance with the guidance on wind farm noise assessment; ETSU-R-97 and the IoA GPG. No other wind farm sites are considered as they are far enough away that there is no cumulative impact i.e., the noise levels from other sites would be insignificant compared to those from the Proposed Development in combination with the existing four small turbines. The turbines to consider in a cumulative operational noise assessment have been agreed with Aberdeenshire Council.

12.9.3 ETSU-R-97 states:

12.9.4 “It is clearly unreasonable to suggest that, because a wind farm has been constructed in the vicinity in the past which resulted in increased noise levels at some properties, the residents of those properties are now able to tolerate higher noise levels still. The existing wind farm should not be considered as part of the prevailing background noise.” The existing four turbines are comprised of two sites each containing two turbines. These are located at:

- Auchmore, Midmar, Inverurie, AB51 7NL[25]
- Auchorie Farm, Midmar, Inverurie, AB51 7NL[26]

12.9.5 The residential properties considered in the cumulative assessment are those detailed in **Table 12.12**. The locations of the existing four turbines considered in the cumulative assessment are provided in **Table 12.22**.

Table 12.22: Locations of Existing Turbines

Turbine ID	Site	Coordinates	
		X (m)	Y (m)
A1	Auchmore	367445	805278
A2	Auchmore	367426	805424
AF1	Auchorie Farm	365970	806276
AF2	Auchorie Farm	365717	806437

Cumulative Assessment Methodology

[25] Planning application APP/2011/0216.

[26] Planning application APP/2011/3257

12.9.6 ETSU-R-97 recommends that the derived noise limits applicable at nearby residential properties shall relate to the cumulative effects of noise from all turbines that may affect a particular location.

12.9.7 The methodology is therefore to:

- Predict the level of noise resulting from the operation of the turbines being considered in the cumulative assessment without the Proposed Development;
- Identify appropriate overall ETSU-R-97 noise limits for each property;
- Subtract the predicted noise levels calculated in step 1 from the overall ETSU-R-97 limits identified in step 2. Such a calculation shall provide a maximum total noise limit at each house identified which the Proposed Development should not exceed; and
- Compare the predicted noise levels due to the Proposed Development to the limit calculated in step 3 to determine compliance with ETSU-R-97.

12.9.8 The methodology outlined above is in accordance with the appropriate guidance on cumulative wind farm noise assessment as described in ETSU-R-97 and the IoA GPG.

Predictions of Noise Levels at Residential Properties

12.9.9 Using information made available to the Applicant by Aberdeenshire Council, a simplified approach in predicting the noise levels at the residential properties from the existing turbines has been used, incorporating the assumption that both sites have the same planning condition relating to noise, which is that included in the decision notice for the turbines at Auchorie Farm[27]:

"At Wind Speeds not exceeding 10 m/s (referenced to a height of 10 m above ground level, at the location of one of the turbines, the Wind Turbine Noise Level, when measured at any dwelling, shall not exceed 35 dB $L_{A90,\ 10min}$"; and

"Wind Turbine Noise Level means the rated noise level due to the combined effect of all the wind turbines".

12.9.10 Therefore, the predicted noise levels at the residential properties from the existing turbines at standardised 10 m height wind speeds (at the location of one of the turbines) up to and including 10 m/s is taken to be 35 dB(A).

12.9.11 An exception is the property H148 (Hillside) which is financially involved in the Auchmore site and therefore has a conditioned noise limit of 40 dB(A). The predicted noise levels at H148 at standardised 10 m height wind speeds (at the location of one of the Auchmore site turbines) up to and including 10 m/s is taken to be 40 dB(A) due to the existing Auchmore turbines, which is significantly greater than the noise level at this property due to the Proposed Development. Therefore, H148 is scoped out of this cumulative assessment.

12.9.12 As a conservative assumption, the standardised 10 m height wind speed value is taken to be the same for all sites, i.e., the existing turbines and the Proposed Development.

Derived Acoustic Acceptance Criteria

12.9.13 Considering a minimum overall ETSU-R-97 noise limit of 37.5 dB(A) from **Table 12.16** and a predicted noise level of 35 dB(A) from the existing turbines at all residential properties, the noise limit remaining for the Proposed Development is 33.9 dB(A).

Cumulative Acoustic Assessment

12.9.14 Comparing the predicted noise levels from the Proposed Development in isolation as detailed in **Table 12.15** shows the noise level is below or equal to 33.9 dB(A) for all properties with the exception of H136, H137, H139 and H142.

12.9.15 When considering the distances from the existing four turbines to properties H136, H137, H139 and H142 the noise level at these properties due to the existing turbines will be significantly less than 35 dB(A), such that it would not be possible for the overall ETSU-R-97 noise limit of 37.5 dB(A) to be exceeded due to the contribution from the Proposed Development and the existing turbines.

12.9.16 Based on the above cumulative assessment, the overall ETSU-R-97 minimum noise limit of 37.5 dB(A) is predicted to be met due to the cumulative contributions from the Proposed Development and the existing four turbines.

12.10 Summary

12.10.1 The acoustic impact for the operation of the Proposed Development on nearby residential properties has been assessed in accordance with the guidance on wind farm noise as issued in the DTI publication 'The Assessment and Rating of Noise from Wind Farms', otherwise known as ETSU-R-97, and Institute of Acoustics Good Practice Guide (IoA GPG), as recommended for use by relevant planning policy.

[27] Aberdeenshire Council Local Review Body. Reference LRB113 G/APP/2011/3257. Review Decision Notice. 8 November 2012.

12.10.2 To establish baseline conditions, background noise surveys were carried out at nearby properties and the measured background noise levels used to determine appropriate noise limits, as specified by ETSU-R-97 and the IoA GPG.

12.10.3 Operational noise levels were predicted using the recommended noise propagation model. The predicted noise levels for the Proposed Development are within the derived noise limits at all considered wind speeds. The Proposed Development therefore complies with the relevant guidance on wind farm noise and the impact on the amenity of all nearby residential properties would be regarded as acceptable.

12.10.4 A construction noise assessment carried out in accordance with BS 5228-1:2009 "Noise control on construction and open sites - Part 1: Noise" found that construction noise levels are predicted to temporarily exceed construction noise criteria at a limited number of nearby properties although appropriate mitigation measures have been identified.

12.10.5 Vibration and air overpressure due to blasting are assessed to have no significant impact on nearby residents following mitigation measures described within the chapter.

12.10.6 The potential impact of the Proposed Development, along with the mitigation proposed and any residual impact, is summarised in **Table 12.23**.

Table 12.23: Summary of Potential Impacts, Mitigation and Residual Impacts

Potential Impact	Mitigation Proposed	Means of Implementation	Outcome/ Residual Impact
Construction			
Potential for noise and vibration to be created during general construction activities and by construction traffic	Due regard for 'best practicable means' (defined by Section 72 of the Control of Pollution Act 1974). A range of noise mitigation measures are proposed for the construction phase in accordance with measures outlined in BS 5228-1:2009. Site operations to be limited to 07:00-19:00 Monday to Saturday (except during the construction of the turbine foundations and turbine erection or periods of emergency work). Good practice on blasting shall be followed along with guidance on charge size, blast frequency and timing.	Noise mitigation measures would be implemented as part of the Construction and Environmental Management Plan which will be required to be agreed as a condition of consent.	Not significant
Operation			
Potential impact on residential amenity due to operational noise	Impact is deemed to be acceptable as the Proposed Development meets noise limits specified by relevant guidance both alone and in the cumulative scenario. No additional mitigation measures are required due to absence of identified significant effect.	Not applicable	Not significant
Decommissioning			
Potential noise from Proposed Development decommissioning activities	General best practice measures of reducing noise, employed during the construction phase, would be adopted as precaution.	A Decommissioning and Restoration Plan would be submitted for approval no later than twelve months prior to the final decommissioning of the Proposed Development.	Not significant

12.11 Glossary

Table 12.24: Glossary Terms

Word	Definition
A-weighting	A frequency-response function providing good correlation with the sensitivity of the human ear.
Broadband Noise	Noise which covers a wide range of frequencies (see Frequency).
Decibel dB(A)	The decibel (dB) is a logarithmic unit used in acoustics to quantify sound levels relative to a 0 dB reference (e.g. a sound pressure level of $2*10^{-5}$ Pa). The 'A' signifies A-weighting.
Equivalent Continuous Sound Level (L_{eq})	The equivalent continuous sound level is a notional steady noise level, which over a given time would provide the same energy as the intermittent noise.
Frequency	Refers to how quickly the air vibrates, or how close the sound waves are to each other and is measured in cycles per second, or Hertz (Hz). The lowest frequency audible to humans is 20 Hz and the highest is 20,000 Hz. The human ear is most sensitive to the 1 kHz, 2 kHz and 4 kHz octave bands and much less sensitive at lower audible frequencies.
Frequency Spectrum	Description of the sound pressure level of a source as a function of frequency.
Percentile Sound Level (L_{90})	Sound pressure level exceeded for 90% of the time for any given time interval. For example, $L_{(A)90,10min}$ means the A-weighted level that is exceeded for 90% of a ten-minute interval. This indicates the noise levels during quieter periods, or the background noise level. It represents the lower estimate of the prevailing noise level and is useful for excluding such effects as aircraft or dogs barking on background noise levels.
Noise Emission	The noise energy emitted by a source (e.g. a turbine).
Noise Immission	The sound pressure level detected at a given location (e.g. nearest dwelling).
Octave Band	Range of frequencies between one frequency ($f_0*2^{-1/2}$) and a second frequency ($f_0*2^{+1/2}$). The quoted centre frequency of the octave band is f_0.
Sound Power Level	Sound power level is the acoustic power radiated from a sound source and is independent of the surroundings. It is a logarithmic measure in comparison to a reference level (10^{-12} watts).
Sound Pressure Level	A logarithmic measure of the effective sound pressure of a sound relative to a reference value which is for minimum audible field conditions ($20*10^{-6}$ Pa).
Third Octave Band	The range of frequencies between one frequency ($f_0*2^{-1/6}$) and a second frequency equal to ($f_0*2^{+1/6}$). The quoted centre frequency of the third octave band is f_0.
Tonal Noise	A noise that contains a noticeable or discrete, continuous note and includes noises such as hums, hisses, screeches.