11. Noise and Vibration

Contents

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11. Noise and Vibration

11.1 Abstract

11.1.1 This chapter considers the potential noise and vibration effects that could arise as a result of the Proposed Development during the construction, operational and decommissioning phases. This chapter (and its associated figure and appendices) is not intended to be read as a stand-alone assessment; it should be read as part of this EIA Report and in particular reference should be made to the Project Description in Chapter 3.

11.1.2 Should the Proposed Development not be consented, the "do-nothing scenario" will apply to the current baseline environment, in that the Applicant will construct the Consented Development. The Consented Development was environmentally assessed and consented in 2015 and the assessment is reported within the Sandy Knowe Wind Farm Environmental Statement (2015).

11.1.3 This chapter is necessarily technical in nature and contains terminology relating to noise and vibration. A glossary of acoustical terms is given in Appendix 11.1, which can be found in Volume 3 of the EIA Report.

11.1.4 The following considerations have been covered in this chapter:

- the existing noise climate at a representative number of local noise-sensitive receptors within the locality of the Proposed Development;
- the construction and decommissioning process associated with the Proposed Development and the effect this may have on local receptors; and
- the potential effects that the Proposed Development may have on the local noise climate once operational.

11.1.5 The construction, operational and decommissioning noise and vibration effects that have been considered are:

- potential construction noise effects on noise-sensitive receptors in the vicinity of the site, including construction traffic;
- potential construction vibration effects on vibration-sensitive receptors in the vicinity of the site;
- the potential cumulative effect of noise associated with the Proposed Development operating simultaneously with other nearby existing and approved wind farm developments, and those for which a valid application has been made (see paragraph 11.2.4), on noise sensitive receptors; and
- the potential effects of noise generated by any proposed fixed (i.e. non-turbine) plant on local noise-sensitive receptors.

11.1.6 Following the implementation of mitigation measures the Proposed Development would have no significant residual noise effects, with the exception of short term effects of moderate significance during construction. In addition, the Proposed Development can meet the conditioned noise limits of the Consented Development.

11.1.7 The EIA Regulations, at Schedule 4, require the EIA Report to provide a

"description of the likely significant effects of the development on the environment resulting from, inter alia:

… (e) the cumulation of effects with other existing and/or approved development, taking into account any existing environmental problems relating to areas of particular environmental importance likely to be affected or the use of natural resources;"

11.1.8 In this regard, the Proposed Development would be indiscernible from the Consented Development.

11.2 Legislation, Policy and Guidelines

Legislative Framework

11.2.1 For a development of this nature, there is no specific all-encompassing legislation relating to the standards associated with noise emission/effects. Noise legislation, where it does exist, tends to be either EU-derived and focussed on specific items of noise-emitting plant or on more general nuisance, such as that addressed by the provisions of the Environmental Protection Act 1990.

11.2.2 In lieu of any specific legislation, assessing the effect of such a development during the construction, operational and decommissioning phases must draw on information from a variety of sources. Therefore, this assessment makes reference to a number of British Standards, official planning advice notes and national guidance.

Planning policy

11.2.3 Chapter 5 of the EIA Report sets out the planning policy framework that is relevant to the EIA. The policies set out therein include those from the Dumfries and Galloway Council (DGC) Local Development Plan (September 2014), the DGC Local Development Plan Supplementary Guidance, Part 1 Wind Energy: *Development management considerations* (March 2015), those relevant aspects of Scottish Planning Policy (SPP), Planning Advice Notes and other relevant guidance. Of relevance to the noise assessment presented within this chapter are the following policies / guidance:

- national policy:
  - Scottish Planning Policy (SPP) (particularly paragraph 188); and
  - Scotland's Third National Planning Framework (NPF 3).
- local policy:
  - Local Development Plan policy OP 1: *Development Considerations*;
  - Local Development Plan policy IN 2: *Wind Energy;*
  - Local Development Plan Supplementary Guidance, Part 1 Wind Energy Development: *Development management considerations* section D;
  - Local Development Plan Supplementary Guidance, Part 1 Wind Energy Development: *Development management considerations* section F; and
  - Local Development Plan Supplementary Guidance, Part 1 Wind Energy Development: *Development management considerations* section O.

Planning Guidance

Planning Advice Note (PAN) 1/2011: 'Planning and Noise'

11.2.4 Published in March 2011, this document provides advice on the role of the planning system in helping to prevent and limit adverse effects of noise (Scottish Government, 2011a). Information and advice on noise assessment methods are provided in the accompanying Technical Advice Note (TAN): *Assessment of Noise*. Included within the PAN document and the accompanying TAN are details of the legislation, technical standards and codes of practice for specific noise issues.

11.2.5 With regards to noise from wind turbines, paragraph 29 of PAN 1/2011 states the following:

> "*There are two sources of noise from wind turbines – the mechanical noise from the turbines and the aerodynamic noise from the blades. Mechanical noise is related to engineering design. Aerodynamic noise varies with rotor design and wind speed, and is generally greatest at low speeds. Good acoustical design and siting of turbines is essential to minimise the potential to generate noise. Web based planning advice on renewable technologies for onshore wind turbines provides advice on 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) published by the former Department of Trade and Industry (DTI) and the findings of the Salford University report into Aerodynamic Modulation of Wind Turbine Noise.*"

11.2.6 With regards to appropriate assessment methods, the '*web-based planning advice*' referred to in PAN 1/2011 is contained in an online document entitled '*Onshore wind turbines*', published by the Scottish Government (updated December 2013). This document is summarised in the corresponding section below, and also refers to the use of ETSU-R-97.

11.2.7 The accompanying TAN to PAN 1/2011 also refers to ETSU-R-97, including a summary of the associated assessment approach (Scottish Government, 2011b). The ETSU-R-97 assessment guidance is summarised in paragraphs 11.2.13 to 11.2.25 below. The TAN points out that the ETSU-R-97 report presents a consensus view of a group of experts, who between them have a breadth and depth of experience in assessing and controlling the environmental impact of noise from wind farms.

11.2.8 With regards to the assessment and control of noise and vibration from construction sites the use of BS 5228: 2009 (Parts 1 and 2) is discussed. These parts of BS 5228 have been superseded by BS 5228-1:2009+A1:2014: *Code of practice for noise and vibration control on construction and open sites. Noise* and BS 5228-2:2009+A1:2014: *Code of practice for noise and vibration control on construction and open sites. Vibration*. These standards are summarised in paragraphs 11.2.36 to 11.2.42.

11.2.9 Of relevance to the assessment of development generated road traffic noise, it is stated that a change of 3 dB(A) is the minimum perceptible under normal conditions, and that a change of 10 dB(A) corresponds roughly to a halving or doubling of the loudness of a sound.

11.2.10 Neither PAN 1/2011 nor the associated TAN provide specific guidance on the assessment of noise from fixed plant, but the TAN includes an example assessment scenario for '*New noisy development (incl. commercial and recreation) affecting a noise sensitive building*', which is based on BS4142:1997: *Method for rating industrial noise affecting mixed residential and industrial areas*. This British Standard has recently been replaced with BS4142:2014: *Methods for rating and assessing industrial and commercial sound.*

11.2.11 In summary, national planning policy on assessment of operational noise impacts from wind farms stipulates the use of the ETSU-R-97 assessment method and application of the IOA GPG, whilst construction noise and vibration should be assessed with reference to BS 5228. These guidance documents, and others relevant to the assessment of possible noise and vibration impacts generated by the Proposed Development, are summarised below.

Scottish Government Online Planning Advice for Renewable Energy Technologies: *Onshore Wind Turbines (12 December 2013)*

11.2.12 Superseding the former PAN 45: *Renewable energy*, this online resource states the following with respect to noise and vibration:

> *"The Report, "The Assessment and Rating of Noise from Wind Farms" (Final Report, Sept 1996, DTI), (ETSU-R-97) 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. This gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions.*
>
> *On April 6, 2011, a further report produced by Hayes McKenzie for DECC entitled "An Analysis of How Noise Impacts are Considered in the Determination of Wind Farm Planning Applications" suggested that best practice guidance is required to confirm and, where necessary, clarify and add to the way ETSU-R-97 should be implemented in practice. (A previous report in 2006 by the same authors concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by the wind turbines that were tested).*
>
> *The Salford University report into Aerodynamic Modulation of Wind Turbine Noise (last modified September 27, 2011) summarised the conclusions of the Hayes McKenzie report and investigated further complaints caused by amplitude modulation of aerodynamic noise (AM). Report findings were constrained by the low incidence of AM and the low numbers of people adversely affected in the UK.*
>
> *The Institute of Acoustics (IOA) has since published Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise The document provides significant support on technical issues to all users of the ETSU-R-97 method for rating and assessing wind turbine noise, and should be used by all IOA members and those undertaking assessments to ETSU-R-97. The Scottish Government accepts that the guide represents current industry good practice.*
>
> *Further research by AECOM entitled 'NANR 277 - Wind Farm Noise: Statutory Nuisance Complaints Methodology' is aimed at helping Local Authorities deal with wind farm noise complaints, using statutory nuisance powers.*
>
> *PAN on Planning and Noise provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. The associated Technical Advice Note provides guidance which may assist in the technical evaluation of noise assessment."*

Assessment Guidance

ETSU-R-97: *The Assessment and Rating of Noise from Windfarms*

11.2.13 As referenced for use in PAN/2011 and the online planning advice for renewable technologies: Onshore wind turbines, this document was written by a Noise Working Group including developers, noise consultants and environmental health officers, set up in 1995 by the Department of Trade and Industry through ETSU (the Energy Technology Support Unit).

11.2.14 This document presents a consensus view of the working group and was prepared to present a common approach to the assessment of noise from wind turbines. This document states that noise from wind turbines or wind farms should be assessed against site specific noise limits.

11.2.15 These limits are derived based on a series of acceptable lower limits, and based on an allowable exceedance above the prevailing background noise levels, including consideration to a variety of different prevailing wind speed conditions. The noise limits should be derived for external areas used for relaxation, or areas where a quiet noise environment is highly desirable. Separate limits are required for night-time and daytime periods. Night-time limits are derived drawing upon measured night-time background noise levels, whilst daytime limits are derived drawing upon the background noise levels arising during 'quiet daytime' periods.

11.2.16 Night-time is defined as the period between 23:00 and 07:00 hours, whilst quiet daytime periods are defined as 18:00 to 23:00 hours on all days, as well as 13:00 to 18:00 hours on Saturdays and Sundays, and 07:00 to 13:00 hours on Sundays.

11.2.17 For the daytime, the suggested limits are 5dB above the prevailing background noise level determined during quiet daytime periods, or 35 to 40 dB(A), whichever is the higher. The absolute criterion between the 35 to 40 dB(A) range is selected taking account of the site environs (e.g. number of local receptors), the energy generation capacity (e.g. number of kWh that can be generated) of the Proposed Development, and the associated duration and level of exposure.

11.2.18 During the night-time, the suggested limits are 5dB above the prevailing night-time background noise level or 43 dB(A), whichever is the higher. The absolute criterion for the night-time is higher than that for the daytime, as the derivation of this limit is based on preventing sleep disturbance within a building whereas for the daytime, limits are based on occupation of external spaces used for relaxation.

11.2.19 It is required that the prevailing background noise levels be determined in terms of the $L_{A90,10min}$ noise index for both quiet daytime and night-time periods, for wind conditions ranging from 2 ms^{-1} to 12 ms^{-1}.

11.2.20 The noise limits are calculated by undertaking a regression analysis of the $L_{A90,10min}$ noise levels and the prevailing average wind speed for the same 10 minute period, when measured or determined at 10m above ground at the location of the proposed turbines. The allowable limit is then defined at +5dB above the average noise level at each wind speed (as defined by the regression analysis), or the absolute noise level lower limit, whichever is the higher (assuming no financial involvement within the scheme).

11.2.21 Where a property has a financial involvement in the scheme, the document allows a relaxation of the derived noise limits, stating that '*It is widely accepted that the level of disturbance or annoyance caused by a noise source is not only dependent upon the level and*

character of noise but also the receiver's attitude towards the noise source in general. If the residents at the noise-sensitive properties were financially involved in the project then higher noise limits will be appropriate'. The guidance goes on to state that it is '*recommended that both the day and night-time lower fixed limits can be increased to 45 dB(A) and the consideration should be given to increasing the permissible margin above background where the occupier of the property has some financial involvement in the windfarm*'. The amount by which the permissible margin above background can be relaxed is not specified, but the allowable relaxation to 45dB(A) of the lower limits is an increase of (at least) 5dB during the daytime and 2dB during the night-time, so similar levels of relaxation might also be applied to background related element of the noise level limits.

11.2.22 The ETSU guidance states that the derived limits should be applied to noise from the proposed wind farm or turbines in terms of the $L_{A90,T}$ index, and that the $L_{A90,T}$ of the wind farm noise is typically 1.5 to 2.5 dB less than the $L_{Aeq,T}$ measured over the same period.

11.2.23 The derived noise limits are applicable to both the aerodynamic (e.g. 'blade swish') and mechanical (e.g. generator related) components of wind farm noise.

11.2.24 Where noise from the wind farm, is tonal, a correction of between 2 and 5 dB is to be applied to the wind farm noise. Guidance is provided on how to determine the level of correction required, but typically, for proposed developments, the need for any applicable correction is confirmed by the turbine manufacturers.

11.2.25 It is stated within this document that '*The Noise Working Group is of the opinion that absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question. It is clearly unreasonable to suggest that, because a windfarm was constructed in the vicinity in the past which resulted in increased noise levels at some properties, that residents of those properties are now able to tolerate still higher noise levels. The existing windfarm should not be considered as part of the prevailing background noise*'. Accordingly, where an existing wind farm contributes to the prevailing background noise levels, it is necessary to either include for the contribution of this wind farm when comparing against the allowable noise limit, or correct for this contribution when deriving a limit applicable to the proposed development acting alone.

The Institute of Acoustics: *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (IoA GPG)

11.2.26 The IOA GPG presents the report of a 'noise working group' (NWG) assembled in response to a request from the Department of Energy & Climate Change (DECC). The guide is intended to represent current good practice in applying the ETSU R 97 method to assessing the noise impact of wind turbine developments with a power rating of over 50kW.

11.2.27 In addition to detailed consideration of various issues and factors concerned with current 'state of the art' knowledge of UK wind turbine noise assessment, a series of 'summary boxes' (SBs) highlighting key guidance points are included.

11.2.28 The SBs provide clarification and updated guidance on a range of matters relating to ETSU-R-97 noise assessments, including consultation with relevant stakeholders, background noise survey methodology, noise survey data analysis, derivation of noise limits, noise prediction model input data, algorithms and parameters, cumulative impact assessment procedures, assessment reporting, planning conditions and amplitude modulation. A set of

supplementary guidance notes (SGN's) also form part of the publication and include further specific detail for different technical areas.

11.2.29 The detail of the IOA GPG has been considered in the preparation of this assessment. Some of the key considerations relevant to this assessment are summarised as follows:

- Background noise surveys should be carried out for sufficient duration to obtain a suitably-sized data set; as a guideline, it is suggested that no less than 200 data points be obtained within each of the night-time and amenity hour periods for a given survey location, with no less than five data points within each contiguous wind speed integer interval. Where the data have been filtered by wind direction the guideline values are reduced.
- Background noise survey data should be analysed and anomalous periods of noise removed from the dataset; anomalous noise might include rain-affected periods and increased noise from water courses following rainfall, seasonal effects such as early-morning birdsong ('dawn chorus'), atypical traffic movements and other unusual noise sources affecting measured levels.
- Due to the potential for non-standard site-specific wind shear (i.e. differences in wind speed at different heights above the ground – a 'standard' profile increases logarithmically with height) background noise levels should be correlated with 10m height wind speeds derived using a method that 'standardises' the wind speeds using the assumed shear profile. Since wind turbine sound power levels are determined using the same shear profile, this procedure ensures a link between the predicted sound levels at a given hub height wind speed and the background noise levels at receptors near the ground under the same wind speed conditions (obtained using the 'standardised' 10 m height wind speed).
- Derivation of the prevailing background noise levels should be carried out using polynomial regression analysis, of order one to four, depending on the nature of the noise environment. The regression curve used should reach minimum and maximum values at the lowest and highest wind speeds for which the dataset is valid, respectively.
- Calculations of predicted wind turbine noise may be carried out using ISO 9613-2: Acoustics – Attenuation of Sound during Propagation Outdoors (International Organization for Standardization, 1996); preferred receptor heights, meteorological and ground absorption input parameters for this calculation procedure are given.
- Turbine sound power level source data should include appropriate uncertainty corrections. Guidance is given for determining when such uncertainty corrections have been inherently included in turbine source emission data.
- 'Excess amplitude modulation' (i.e. where the wind turbine noise has higher variability with momentary time than the 2 – 3 dB(A) considered within ETSU-R-97) is still the subject of research; current practice (at the time of publishing of the IOA GPG) in relation to determining applications for wind turbine developments is to not impose a planning condition specific to this phenomenon.

11.2.30 In addition to the above, the IoA GPG confirms that the ETSU-R-97 noise level limits should be applied cumulatively, and provides guidance on appropriate assessment methods for a variety of different cumulative scenarios. These scenarios include 'concurrent applications', 'existing wind farm consented with less than total ETSU-R-97 limits', 'existing wind farm/s

consented to the total ETSU-R-97 limits currently operating', and 'permitted wind farm consented to total ETSU-R-97 limits but not yet constructed'.

11.2.31 This guidance is of particular relevance in the assessment of noise from the Proposed Development because it is proposed in the vicinity of a number of other wind farm developments which are either operational or proposed.

11.2.32 In the section entitled 'existing windfarm/s, consented to the total ETSU-R-97 limits, currently operating' it is stated that "*In the first instance, the consented noise limits should be used within the cumulative noise impact calculations unless otherwise agreed with the local authority. Provided the sum of the noise limits derived for the proposed site when added to those already consented for the operational sites does not exceed the limits that would otherwise be within the requirements of ETSU-R-97 for the cumulative impact, then the noise limits derived for the proposed site can be applied directly*".

11.2.33 In practical terms this can be achieved by ensuring that the noise limit for the proposed development is set 10dB or more below that permitted to be generated by the existing development.

11.2.34 It is however then discussed that this may not always be necessary, e.g. where there is a 'controlling' property', whereby compliance with the noise limit at that controlling property would result in noise levels never realising the noise level limit 'in full' at another property (e.g. because the second property is further removed from the existing development), thereby leaving a proportion of the limits available for use at the second property by the subsequently proposed development. Another reason that is discussed is where there is no realistic prospect of the existing windfarm producing noise levels up to the consented limit, again thereby leaving a proportion of the limit available for the subsequently proposed development.

11.2.35 In the section entitled 'concurrent applications' it is stated that where there are no pre-existing wind farms, this scenario permits the apportionment of the ETSU-R-97 limits between the concurrent developments, i.e. each of the developments could be subject to noise limits below the full ETSU-R-97 guidance, such that even if the individual limits applied to each development were utilised 'in full', the combined effect would be that the ETSU-R-97 guidance would not be exceeded cumulatively.

BS5228-1:2009+A1:2014: *Noise and Vibration Control on Construction and Open Sites. Noise*

11.2.36 This standard sets out techniques to predict the likely noise effects from construction works, based on detailed information on the type and number of plant being used, their location and the length of time they are in operation.

11.2.37 The noise prediction methods can be used to establish likely noise levels in terms of the $L_{Aeq,T}$ over the core working day. This standard also documents a database of information, including previously measured sound pressure level data for a variety of different construction plant undertaking various common activities.

11.2.38 Three example methods are presented for determining the significance of construction noise impacts. In summary, these methods adopt either a series of fixed noise level limits, are concerned with ambient noise level changes as a result of the construction operations or a combination of the two.

11.2.39 With respect to absolute fixed noise limits, those detailed within Advisory Leaflet 72: 1976: *Noise control on building sites* are presented. These limits are presented according to the nature of the surrounding environment, for a 12-hour working day. The presented limits are:

- 70 dB(A) in rural, suburban and urban areas away from main road traffic and industrial noise; and
- 75 dB(A) in urban areas near main roads and heavy industrial areas.

11.2.40 The above noise level limits are applicable at the façade of the receptor in question (not free-field).

11.2.41 The standard goes on to provide methods for determining the significance of construction noise levels by considering the change in the ambient noise level that would arise as a result of the construction operations. Two example assessment methods are presented, these are the 'ABC method' as summarised within Table 11.1 and the '5 dB(A) change' method as described below Table 11.1.

Table 11.1 - Example Threshold of Potential Significant Effect at Dwellings (Construction Noise) – ABC Method

Assessment Category and Threshold Value Period	Threshold Value, in Decibels (dB) ($L_{Aeq,T}$)		
	Category (A)	Category (B)	Category (C)
Night-time (23:00 – 07:00)	45	50	55
Evenings and weekends (D)	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
NOTE 1: A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level. *NOTE 2: If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3 dB due to site noise.* *NOTE 3: Applied to residential receptors only*			
A) Category A: threshold values to use when ambient levels (when rounded to the nearest 5 dB) are less than these values. *B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as Category A values.* *C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than Category A values.* *D) 19.00-23.00 weekdays, 13.00-23.00 Saturdays and 07.00-23.00 Sundays*			

11.2.42 With respect to the '5 dB(A) change' method, the guidance states:

> *"Noise levels generated by construction activities are deemed to be significant if the total noise (pre-construction ambient plus construction noise) exceeds the pre-construction ambient noise by 5 dB or more, subject to lower cut-off values of 65 dB, 55 dB and 45 dB L_{Aeq}, from construction noise alone, for the daytime, evening and night-time periods, respectively; and a duration of one month or more, unless works of a shorter duration are likely to result in significant impact."*

<u>BS5228-2:2009+A1:2014: Noise and Vibration Control on Construction and Open Sites. Vibration</u>

11.2.43 This standard provides recommendations for basic methods of vibration control relating to construction and open sites. The legislative background to vibration control is described and

guidance is provided concerning methods of measuring vibration and assessing its effects on the environment.

11.2.44 Guidance criteria are suggested for the assessment of the significance of vibration effects; such criteria are provided in terms of Peak Particle Velocities (PPV) and are concerned with both human and structural responses to vibration. Those applicable to human perception and disturbance are presented within Table 11.2.

Table 11.2 - Guidance Criteria for the Assessment of Significance of Vibration for Human Perception and Disturbance

Vibration Level (PPV)	Effect
0.14 mms^{-1}	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mms^{-1}	Vibration might be just perceptible in residential environments.
1.0 mms^{-1}	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mms^{-1}	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

11.2.45 The standard goes on to present guidance criteria applicable to the vibration response limits of buildings in terms of the component PPV. These are presented within Table 11.3. It should be noted that the values presented within Table 11.3 are applicable to cosmetic damage only. It is stated within BS 5228-2:2009+A1:2014 that minor damage is possible at vibration magnitudes which are greater than twice those given in the table.

Table 11.3 - Guidance Criteria for the Assessment of Significance of Transient Vibration for Cosmetic Building Damage

Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
Column sub-title	**4 Hz to 15 Hz**	**15 Hz and above**
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	50 mm/s at 4Hz and above
Unreinforced or light framed structures Residential or light commercial buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
NOTE 1: Values referred to are at the base of the building. *NOTE 2: At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded*		

British Standard 4142: 2014: Methods for Rating and Assessing Industrial and Commercial Sound

11.2.46 BS 4142 is applicable for use in the assessment of control building / substation and transformer noise. It sets out a method for rating and assessing sound of an industrial and/or commercial nature, including "*sound from fixed installations which comprise mechanical and electrical plant and equipment*".

11.2.47 The assessment procedure contained within BS4142 requires that initially the 'rating level' ($L_{Ar,Tr}$) that is (or would be) generated by the source under assessment is determined, externally, at the assessment location. Where this source does not include any acoustic features, such as tonality, impulsivity or intermittency etc., then the rating level ($L_{Ar,Tr}$) equals

the specific sound level (L_s), which is the sound pressure level produced by the source using the $L_{Aeq,T}$ noise index. Where the source under assessment does include acoustic characteristics, then a series of corrections are added to the specific sound level to determine the rating level. The degree of correction applied to determine the rating level depends upon the results of either subjective or objective appraisals.

11.2.48 The background sound level at the assessment location, measured using the $L_{A90,T}$ index, is then subtracted from the rating level. The result provides an indication of the magnitude of impact, where the greater the difference, the greater the magnitude of impact.

11.2.49 The following scale is presented:

- A difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact.
- Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

11.2.50 It can be seen from the above that the degree of impact is also dependent upon the context in which the sound arises. Factors that are considered with respect to context include: the absolute level of sound, and the character and level of the residual sound (that in absence of the source under assessment) compared to the character and level of the specific sound.

11.2.51 With regards to the absolute level, it is stated, amongst other points, that "*where background sound levels and rating levels are low, absolute levels might be as, or more relevant than the margin by which the rating level exceeds the background. This is especially true at night*".

11.2.52 The 1997 version of BS4142 stated that rating levels below 35 dB and background noise levels below 30 dB(A) were considered to be "*very low*".

11.3 Consultation

11.3.1 The Environmental Health Department of Dumfries and Galloway Council (DGC) was contacted to agree an appropriate method for updating the noise assessment of the Consented Development to reflect the changes associated with the Proposed Development. The proposed approach submitted to and agreed with DGC is outlined below:

- The EIA Report for the Proposed Development would consider the same receptors and the same consented noise limits as the Consented Development Environmental Statement (ES).
- Updates to the consented or constructed cumulative developments (change of turbine type, hub height or number of turbines) would be included within our assessment.
- The same approach would be taken to the apportionment of noise limits at the receptor Hillend between cumulative developments as adopted in the Consented Development ES.

- Where necessary, consideration would be given to mitigation to the operation of the Proposed Development using low-noise mode turbines or curtailment under certain wind speeds to demonstrate the noise limits can be met. Any such mitigation would be indicative only; subsequent supplementary detailed analysis using directivity corrections may be used to demonstrate that such mitigation is not required.
- The assessment of the construction phase will remain as per the Consented Development ES, as no change to the layout of the Proposed Development is proposed, and no additional information is available regarding proposed construction activities.

11.3.2 DGC confirmed that they were satisfied with the proposed approach.

11.4 Assessment Methodology

Construction Noise

11.4.1 As the Proposed Development is currently at the planning stage, detailed information on construction (and decommissioning) techniques and the equipment that would be used is not available. The potential effects associated with the construction phase have therefore been assessed based on a number of assumptions with regards to the likely operations undertaken and machinery used, drawing upon the content of Chapter 3.

11.4.2 A series of preliminary construction noise level predictions have been undertaken in accordance with the methodology presented in BS 5228-1:2009+A1:2014. These predictions have been undertaken to establish the noise levels that could be generated at the distance of the closest identified noise sensitive receptors to the anticipated works.

11.4.3 The predicted construction noise levels have been assessed following the impact magnitude and effect significance criteria described in the '*assessment of potential effect significance*' section below.

Construction Traffic Noise

11.4.4 Drawing upon the content of the content of Chapter 12, general consideration has been given to the road traffic noise level changes anticipated to arise during the construction phase.

11.4.5 Anticipated road traffic noise level changes have been assessed by following the impact magnitude and effect significance criteria described in the '*assessment of potential effect significance'* section below.

Construction Vibration

11.4.6 The assessment of ground-borne vibration associated with typical construction activities has been undertaken drawing upon the guidance in BS 5228-2:2009+A1: 2014.

11.4.7 Predictions have been conducted in order to determine the likely levels of vibration produced by typical construction activities at varying distances. Predictions have employed the empirical methods detailed in BS 5228-2:2009+A1:2014, in the Transport and Road Research Laboratory Research Report 246: *Traffic induced vibrations in buildings* (TRRL RR 246: 1990), and within the Transport Research Laboratory Report 429 (2000): *Ground-borne vibration caused by mechanical construction works*.

11.4.8 The impact magnitude and effect significance have been determined following the criteria described in the *assessment of potential effect significance* section below.

Operational Wind Turbine Noise

11.4.9 The following assessment methodology was adopted for the assessment of operational wind turbine noise:

- A desk review has been undertaken of existing and proposed wind farm developments in the vicinity of the site. This review has been completed to identify those developments which have the potential to give rise to a cumulative noise impact when operating simultaneously with the Proposed Development. The results of this desk review have been used to inform the assessment of operational turbine noise.
- A sample of the closest, and therefore potentially worst affected, noise sensitive receptors to the Proposed Development have been identified and adopted for the evaluation of noise impacts. These include a sample of receptors both with and without a financial involvement in the Proposed Development and have been selected to represent a geographic spread across the local area, including those located between the Proposed Development and the considered cumulative developments.
- An assessment of the baseline noise levels has been undertaken in accordance with the IoA GPG. This has included calculation of the daytime and night-time noise level limits in accordance with ETSU-R-97 and the IoA GPG.
- A detailed noise model has been prepared for the site and surrounding area, including the adopted noise sensitive receptors. This model was prepared using the CadnaA® noise modelling software. The model was set to use the ISO 9613 prediction method, which includes prescribed methods for accounting for the effects of geometric divergence, ground absorption, and atmospheric absorption.
- The noise model incorporated each of the cumulative developments for which a potentially significant cumulative noise impact was considered possible.
- The model was used to determine the operational noise levels from the Proposed Development and each considered cumulative development operating in isolation and simultaneously.
- Noise level predictions were undertaken for each receptor for integer wind speeds between 4 and 12 m/s. Prediction results were updated and include appropriate corrections for propagation across a valley, where required in accordance with the IoA GPG.
- For the noise sensitive receptors which do not have a financial involvement in any of the considered developments, the cumulative operational noise levels have been assessed by comparison against the derived non-financial involvement noise level limits.
- For noise sensitive receptors which have a financial involvement in the Proposed Development, the cumulative operational noise levels have been assessed by comparison with the derived financial involvement noise level limits.
- For properties which have a financial involvement in one of the considered cumulative developments, but not the Proposed Development, an example apportionment of the applicable noise level limits has been undertaken. This has included determination of the

limits to which each individual development would need to comply with when operating in isolation. The predicted levels from the Proposed Development (operating in isolation), have then been assessed by comparison against the apportioned noise level limits for the Proposed Development.

- The impact magnitude and effect significance have been determined following the criteria described in the assessment of potential effect significance section below.

Fixed (Non turbine) Plant Noise

11.4.10 Drawing upon the results of the completed baseline noise survey, and the guidance contained within BS 4142:2014, a series of applicable fixed plant noise level limits have been determined for non-turbine plant, such as electrical transformers. It has been demonstrated how these fixed plant noise limits could be incorporated into a conditional planning discharge to ensure a commensurate level of protection against noise for local receptors.

11.4.11 The impact magnitude and effect significance have been determined following the criteria described in the assessment of potential effect significance section below.

Assessment of Potential Effect Significance

11.4.12 The effect significance has been determined taking into consideration the noise sensitive receptor sensitivity and the impact magnitude criteria, as described below. Different impact magnitude criteria have been determined for each assessed impact, to reflect the applicable guidance in each case.

Receptor Sensitivity

11.4.13 The guidance contained within Technical Advice Note to PAN 1/2011 has been drawn upon in the generation of an appropriate set of significance criteria. The receptor sensitivity criteria for both the construction, operational and decommissioning phases of the Proposed Development are considered to be the same. These are presented within Table 11.4 and are applicable to both noise and vibration effects.

Table 11.4 - Noise and Vibration Receptor Sensitivity Criteria

Receptor Sensitivity	Description	Examples
High	Receptors where people or operations are particularly susceptible to noise and/or vibration.	Residential, quiet outdoor recreational areas, schools and hospitals.
Medium	Receptors moderately sensitive to noise and/or vibration, where it may cause some distraction or disturbance.	Offices and restaurants.
Low	Receptors where distraction or disturbance from noise and/or vibration is minimal.	Buildings not occupied, factories and working environments with existing levels of noise.

Impact Magnitude - Construction Noise

11.4.14 Construction noise has been assessed based on noise level criteria determined following a worst case interpretation of the guidance contained within BS 5228 1:2009+A1:2014. This Standard details 3 example methods for determining the significance of potential construction noise impacts. With regards to the presented absolute noise level criteria (example method 1), following a worst case approach, the lowest absolute noise level

criteria for the daytime period (07:00 to 19:00) is 70 dB(A) $L_{Aeq,T}$ façade, (equivalent to 67 dB(A) free-field), which is stated to apply in rural areas.

11.4.15 Following the ABC assessment method (example method 2), the most stringent assessment criteria (Category A), applies during the daytime (07:00 to 19:00 weekdays and 07:00 to 13:00 Saturdays) where the prevailing ambient noise levels are up to 62.4 dB(A) $L_{Aeq,T}$. Where Category A applies, the allowable noise level arising from the construction site is 65 dB(A) $L_{Aeq,T}$.

11.4.16 With regards to the 5 dB(A) change method (example method 3), the allowable construction noise level during the daytime is 65 dB $L_{Aeq,T}$, or higher where the resulting ambient noise level change would be less than +5 dB(A). Accordingly, the most stringent allowable 'construction only' noise level following this approach is again 65 dB $L_{Aeq,T}$.

11.4.17 With regards to the above, it can be seen that applying the ABC or 5dB Change method gives rise to the most stringent daytime construction noise level criteria of 65 dB(A) $L_{Aeq,T}$. This limit has therefore been adopted as the level above which moderate impacts could arise and applies to the free-field noise levels.

11.4.18 It can be seen that a 5 dB step is present between the absolute noise level criteria, and each of the Category A, B and C criteria (ABC method), whilst the 5 dB(A) method also inherently considers the same degree of change. Therefore, to determine the impact magnitude associated with construction noise, this 5 dB step change has been applied to the adopted criteria of 65 dB(A) $L_{Aeq,T}$. The resulting impact magnitude scale is set out in Table 11.5.

Table 11.5 - Criteria Used to Determine Impact Magnitude for Construction Noise, Free-field, dB(A)

Receptor Construction Noise Level, $L_{Aeq,T}$ (dB)	Impact Magnitude
≥ 70.0 dB(A)	High
65.0 dB(A) to 69.9 dB(A)	Medium
60.0 dB(A) to 64.9 dB(A)	Low
≤ 59.9 dB(A)	Slight

Impact Magnitude - Construction Traffic Noise

11.4.19 The design manual for roads and bridges states that "*In the period following a change in traffic flow, people may find benefits or disbenefits when the noise changes are as small as 1 dB(A) – equivalent to an increase in traffic flow of 25% or a decrease in flow of 20%. These effects last for a number of years*", whilst PAN1/2011 advises that a change of 3 dB(A) is the minimum perceptible under normal conditions.

11.4.20 Accordingly, where road traffic noise level changes of less than 1 dB(A) are anticipated to arise from development generated road traffic noise, an impact magnitude of slight is registered. Where a change of between 1 and 3 dB(A) is anticipated to arise, an impact magnitude of low is registered. Where changes of greater than 3 dB(A) are anticipated to arise, impact magnitudes of medium or high are registered, depending upon the degree of increase.

Impact Magnitude - Construction Vibration

11.4.21 The impact magnitude has been determined according to the resulting construction vibration levels in absolute terms, as presented in Table 11.6, based on the guidance contained within BS 5228-2:2009+A1:2014 for human perception.

Table 11.6 - Criteria Used to Determine the Impact Magnitude for Construction Vibration (Human Perception, Absolute Levels)

Vibration Level (PPV)	Effect	Impact Magnitude
> 10.0 mms^{-1}	Vibration is likely to be intolerable for any more than a very brief exposure to this level.	High
1.0 > 10.0 mms^{-1}	Onset of complaints in residential environments	Medium
0.3 > 1.0 mms^{-1}	Onset of perceptibility in residential environments.	Low
< 0.3 mms^{-1}	Unlikely to be perceptible in residential environments	Slight

Impact Magnitude - Operational Wind Turbine Noise

11.4.22 For noise from the proposed wind turbines once operational, the impact magnitude scale has been derived based on the guidance contained with ETSU-R-97. It is considered that where cumulative wind turbine noise meets the applicable noise limits (and is up to 10dB below the limits), an impact magnitude of low would arise. Where cumulative wind turbine noise falls ≥10 dB below the applicable limits, the impact magnitude is considered to be slight. Where cumulative wind turbine noise exceeds the applicable limits by up to 5dB, an impact magnitude of medium is considered to arise. Where the there is an exceedance of limit by >5 dB, an impact magnitude of high is considered to arise.

11.4.23 These criteria is summarised in Table 11.7 below.

Table 11.7 - Impact Magnitude Scale – Cumulative Wind Turbine Noise

Difference (d)between Cumulative Turbine Noise Level and Applicable Limit (dB)	Impact Magnitude
d ≥+5	High
0 ≤ d < +5	Medium
-10 ≤ d < 0	Low
d < -10	Slight

Impact Magnitude - Fixed (Non-turbine) Plant Noise

11.4.24 For noise from any fixed (non-turbine) plant such as any transformers, control buildings or substations, it is appropriate to determine significance criteria based on the guidance contained within BS4142, i.e. by consideration of the difference between the rating level from the plant noise and the prevailing background sound levels, but also with respect to context and the resulting sound levels in absolute terms.

11.4.25 The impact magnitude associated with noise generated from fixed plant are presented in Table 11.8.

Table 11.8 - Impact Magnitude for Fixed (non-turbine) Plant Noise

Difference between Rating Level ($L_{Ar,Tr}$) and Background Sound Level (L_{A90})	BS4142 Guidance	Impact Magnitude
≥+10	Indication of significant adverse impact	High
+5	Indication of adverse impact	Medium
0	Indication of low Impact	Low
-10	-	Slight
Where the rating level ($L_{Ar,Tr}$) is below 35dB the impact magnitude is classified as 'Slight' regardless of the relationship to the background noise level. *+ indicates rating level above background noise level* *- indicates rating level below background noise level*		

Effect Significance

11.4.26 The effect significance has been determined by consideration to both the receptor sensitivity and the impact magnitude according to the matrix detailed in Table 11.9.

Table 11.9 - Effect Significance Matrix

Impact Magnitude	Receptor Sensitivity		
	High	**Medium**	**Low**
High	Major	Moderate	Minor
Medium	Moderate	Minor	Negligible
Low	Minor	Negligible	Negligible
Slight	Negligible	Negligible	Negligible

Requirements for Mitigation

11.4.27 Consideration has been given to available mitigation measures in order to reduce adverse effects and enhance beneficial effects. Where mitigation measures are detailed, these are committed to by the applicant and have been determined through professional judgement and the implementation of best practice.

11.4.28 Where required, modern turbines allow the control/reduction in the noise levels generated by operation in various reduced noise operational modes. Whilst the use of such modes has an associated reduction in power generation, and so should be avoided where possible, they can be operated where necessary to ensure compliance with applicable noise level limits. A turbine management scheme can be operated which monitors the prevailing meteorological conditions (e.g. wind speed and direction) and controls the applicable operational mode (e.g. standard setting or a reduced noise operational mode) accordingly.

11.4.29 The turbine layout has been subject to an iterative design process. This has included development of an example operational noise management scheme, operation of which would ensure compliance with the derived noise level limits for the candidate turbine being assessed.

11.4.30 The example noise management scheme has been detailed and accounted for in the assessment of noise impact at the noise sensitive receptor of Hillend.

Assessment of Residual Effects

11.4.31 Residual effects have been assessed following the methodologies described above, but taking into account the committed mitigation measures.

Limitations to Assessment

11.4.32 Sufficiently detailed information on techniques and equipment for the construction phase of the Proposed Development is not available to calculate the noise impacts from earthworks and construction operations. The potential impacts associated with the earthworks / construction phase of the Proposed Development have therefore been assessed based on a number of assumptions with regards to the likely operations undertaken and machinery used.

11.4.33 The assessment of operational impacts associated with the wind turbines has been undertaken adopting source noise levels for a candidate turbine. Following completion of the tendering process, it is possible that the precise turbine make / model adopted and / or the operational mode will change from that adopted within the assessment. It should be noted, however, that it is expected that there are a number of options available which will not result in the exceedance of the derived noise level limits.

11.5 Baseline Conditions

Cumulative Developments

11.5.1 The completed assessment has included a cumulative noise assessment for operational turbine noise. This has considered the simultaneous operation of the Proposed Development in conjunction with other existing or approved wind farm developments across the local area, as well as those where a valid planning application has been made (see paragraph 11.2.4).

11.5.2 To assist in determining those developments which should be scoped-in and scoped-out of the cumulative assessment, a detailed desk-based literary review has been undertaken for wind farm developments within approximately 5km of the Proposed Development boundary. The results of this review have been considered with respect to the guidance contained within the IoA GPG which is as follows:

> "*During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.*
>
> *Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary.*"

11.5.3 The full results of the desk based review are detailed within Appendix 11.2. Drawing on the results of this review, the following wind farm developments have been scoped-in to the completed cumulative assessment:

- Hare Hill Wind Farm – Operational;
- Hare Hill Extension Wind Farm – Operational;
- Sanquhar Community Wind Farm – Consented; and
- Sanquhar 'Six' Wind Farm – Consented.

11.5.4 The following developments, which are all more than 4 km from the Proposed Development have been scoped out the cumulative assessment. The reasons for scoping these developments out of the assessment are detailed within Appendix 11.2.

- Glenmuchloch Wind Farm;
- Lethans Wind Farm;
- Ulzieside Wind Farm; and
- Whiteside Hill Wind Farm.

11.5.5 A summary of the review findings is presented below for each of the developments scoped-in to the cumulative noise assessment.

Hare Hill Wind Farm

- Operational;
- East Ayrshire Planning Reference 94/0097/DPP;
- NW of Proposed Development;
- Installed turbines: 20 × Vestas V47;
- Hub height: 39m;
- Separation distance of 1.635 km between closest turbines (Hare Hill - Proposed Development);
- No noise related planning conditions, but Reporters decision states that levels are likely to be below the 35dB $L_{A90,10min}$ limit proposed in the then emerging guidelines (ETSU-R-97); and
- Closest common receptor to Proposed Development is Hillend.

Hare Hill Extension Wind Farm

- Proposed (operational);
- East Ayrshire Planning Reference 07/0809/FL;
- SW of Proposed Development;
- Candidate turbine: 36 × Gamesa G52 850kW;
- Hub height: various, 44, 49, 55, 60 and 65m;
- Separation distance of 800m between closest turbines (Hare Hill Extension - Proposed Development); and
- Closest common receptor to Proposed Development is Hillend.

Sanquhar Community Wind Farm

- Approved;
- Dumfries and Galloway Planning Reference 10/P/3/0182;
- SE of Proposed Development;

- Turbine: 9 × Vestas V112-3.45 (on basis of information approved under the requirements of Planning Condition 7 and subsequent non-material variation of turbine model and number; from 12 turbines to 9);
- Hub height: 74 m;
- Separation distance of 1.750 km between closest turbines (Sanquhar Community - Proposed Development);
- This development is conditioned for compliance with a series of noise level limits. In addition it is conditioned that technical detail for the turbine to be installed, including noise emission data, is submitted and then approved by the Local Authority prior to commencement, and subsequently complied with; and
- Closest common receptor to Proposed Development is Hillend.

Sanquhar 'Six' Wind Farm

- Approved;
- Dumfries and Galloway Planning Reference 15/P/3/0166;
- SW of Proposed Development;
- Candidate Turbine: 6 x Senvion MM92 3.0MW (on the basis of the ES submitted for the development);
- Hub Height: 77.5 m;
- Separation distance of 1.790 km between closest turbines (Sanquhar Six - Proposed Development); and
- Closest common receptor to Proposed Development is Hillend.

Noise Sensitive Receptors

11.5.6 Local noise-sensitive receptors in the vicinity of the site have been identified by means of a site walk-over, a review of freely available aerial photography and Ordnance Survey mapping. These were agreed with DGC through consultation for the Permitted Development and therefore include receptors which are no longer considered habitable, e.g. Corserig.

11.5.7 Table 11.10 presents the identified noise sensitive receptors in the vicinity of the site including those which do and do not have a financial involvement in the Proposed Development. The receptors which are considered to constitute a representative sample of those closest to the Proposed Development are presented in bold type. These receptors have the greatest potential to be subject to significant noise impacts and have therefore been brought forward into the completed assessments.

11.5.8 Also presented are the approximate grid Ordnance Survey X-Y co-ordinates for each receptor, the distance to the closest existing or proposed wind turbine. Where there are two or more properties at a receptor location, distances and coordinates have been provided with respect to the closest property to the proposed turbines.

11.5.9 The location of these receptors is presented in Figure 11.1 along with the Proposed Development layout.

11.5.10 The receptors referenced within Table 11.10 include Hillend which is the receptor with greatest potential to be subject to a cumulative operational noise impact.

Table 11.10 Summary of Noise Sensitive Receptors in the Vicinity of the Site /Financial Involvement

Receptor Name	Description	X	Y	Distance to Closest Turbine	Wind Farm in Which There is a Financial Involvement
Corserig	1 dwelling	272088	610469	1325 m (Proposed Development T23 and T24)	-
Hillend	1 dwelling	268205	608915	800 m (Hare Hill Ext T28) 1065 m (Proposed Development T8)	Hare Hill Extension
High Cairn	1 dwelling	268741	612330	1085 m (Proposed Development T2)	-
Nether Cairn	2 dwellings	269679	612348	955 m (Proposed Development T1)	Proposed Development
Rigg Farm	2 dwellings	271247	612213	1670 m (Proposed Development T17)	Proposed Development
Polneul	1 dwelling	270096	612387	1120 m (Proposed Development T1)	-
Crockroy	1 dwelling	270448	611945	1030 m (Proposed Development T1)	Proposed Development
Burnside	1 dwelling (pet hotel)	272118	612247	2205 m (Proposed Development T23 and T24)	-
Kelloside Farm	1 dwelling	272800	611880	2455 m (Proposed Development T17)	-
Rigg Cottage	1 dwellings	271481	612264	1830 m (Proposed Development T17)	Proposed Development
Guildhall Cottage	1 dwelling	272050	612276	2190 m (Proposed Development T23 and T24)	-

11.5.11 Section F of the Local Development Plan Supplementary Guidance, Part 1 Wind Energy Development: Development management considerations is pertinent to the Historic Environment and Cultural Heritage, and advises on a number of issues that should be considered in the assessment of "*magnitude and significance of change*". These issues include "*proximity including factors such as noise….*" Figure 10.1 and Appendix 10.1 detail the cultural heritage sites and features within the Proposed Development Site. These constitute 2 shaft sites, 3 sheep shelters, 4 sheep folds, a find-spot and an earthworks. For the purpose of this assessment it is considered that local residential properties constitute those with the greatest potential for impact as a result of noise.

Baseline Noise Survey

11.5.12 A noise survey was undertaken in 2012 the results of which have been used to inform this assessment.

11.5.13 ETSU-R-97 states that "*If there are several properties within ear-shot of the proposed wind farm then to conduct noise surveys at each and every property would be time-consuming, costly, and unnecessary and would therefore impose an unreasonable burden on developers. In such situations it is suggested that the developer and local authority identify groups of properties that through their exposure and proximity to other noise sources would be expected to have similar background noise levels.*"

11.5.14 Accounting for this guidance, and in consultation with DGC, background noise monitoring was undertaken at two locations. The adopted noise measurement locations are described in Table 11.11 with further details presented in Appendix 11.3. The background noise survey was mostly unattended, as appropriate for long term surveys.

Table 11.11 - Summary of Measurement Locations

Measurement Location	Description
High Cairn	For the duration of the background noise survey at this location, the sound level meter was placed within a grassed area to the front of the property. The background noise levels measured at this location have been considered to be representative of those at Hillend, Crockroy Cottage and Corserig.
Nether Cairn	For the duration of the background noise survey at this location, the sound level meter was placed within the garden located to the north of the property. The background noise levels measured at this location have been considered to be representative of those at Polneul and Rigg Farm.

11.5.15 Table 11.12 below presents the durations over which noise monitoring was undertaken at each measurement location.

Table 11.12 - Noise Monitoring Durations at Each Measurement Location

Measurement Location	Monitoring Periods	Total Number of Days Monitored
High Cairn	14:00 22/05/12 to 20:20 29/05/12 15:40 12/06/12 to 04:30 23/06/12	18 Days
Nether Cairn	13:30 22/05/12 to 05:40 29/05/12 13:50 29/05/12 to 02:20 26/06/12	35 Days

11.5.16 Appendix 11.4 presents a wind rose detailing the prevailing wind direction conditions over the course of the baseline noise survey.

11.5.17 At both survey locations, measurements were subject to free-field conditions with the microphones mounted approximately 1.5 m above ground level. The measurements were carried out using sound level meters compliant with type 1 specification, as set out in BS EN 61672-1:2013, '*Electroacoustics: Sound Level Meters – Specifications'*. The meters were installed by a consultant competent in environmental noise monitoring, in accordance with the principles of BS 7445 '*Description and Measurement of Environmental Noise*' (2003).

11.5.18 All sound level meters had a certificate of conformance and had been calibrated to traceable standards within the preceding 12 months. The sound level meters were calibrated at the beginning and end of the baseline survey period and no significant drifts in calibration were recorded. Details of the sound level meters used are given below in Table 11.13, and the certificates of confirmation / calibration certificates for each meter are presented in Appendix 11.5.

Table 11.13 - Summary of Noise Measurement Equipment

Measurement Location	Equipment	Make and Model	Serial Number
High Cairn	Sound Level Meter	01dB Solo	65469
	Preamplifier	01dB Pre21S	15983
	Microphone	01dB MCE212	142646
Nether Cairn	Sound Level Meter	Rion NL-52	00510144
	Preamplifier	Rion NH-25	10137
	Microphone	Rion UC-59	02849

11.5.19 All noise meters were calibrated at the beginning and end of each measurement period and no significant drifts in calibration were recorded.

11.5.20 The Rion NL-52 sound level meter was installed at Nether Cairn with the standard outdoor windshield of substantial dimensions (reticulated foam spheres with 200 mm diameter).

11.5.21 The 01dB Solo sound level meter was fitted with a standard factory fit wind shield, as well as a secondary wind shield system which comprised a cylinder of 20 mm thick 45 ppi reticulated foam was installed at High Cairn. This secondary cylinder had a diameter of approximately 220 mm, a height of approximately 300 mm and was mounted on a wire mesh frame. The secondary wind shield was designed in line with the conclusions of the ISVR '*Noise Measurements in Windy Conditions*' document (1996), as referenced by ETSU-R-97 and the IoA GPG. This ISVR document states that, "overall the preferred windscreen configuration of those tested is a two layer windscreen, with an outer cover of 45 ppi foam, a diameter of 200 to 300 mm and the standard UA0237 or UA0570/0393 as the inner screen".

11.5.22 Samples of the secondary wind screen have been tested by an independent acoustic laboratory which found that the effect of adding the secondary screen gave rise to an insertion loss of less than +/-1 dB in all octave bands between 63 Hz and 8 kHz. In accordance with the above referenced ISVR document, this insertion loss is considered to be "*satisfactory*" with insertion losses of between 1 and 3 dB being classified as "*marginal*", and insertion losses of greater than 3 dB being classified as "unsatisfactory".

Meteorological Survey

11.5.23 For the duration of the background noise survey, simultaneous 10 minute meteorological measurements were undertaken on the site. Measurements including average wind speed and direction were obtained. Average wind speed was measured at heights of 10, 30, 38, 48 and 70 m above local ground. Wind direction was measured at heights of 28 and 68m above local ground.

Site Specific Wind Shear

11.5.24 Wind shear, the rate at which wind speed changes with changing height above ground, is dependent upon two key factors. The first factor is wind shear due to atmospheric conditions, and the second is wind shear due to ground cover conditions (known as ground roughness). Because the noise emission level from a given turbine is dependent upon wind speed, it is necessary that wind turbine noise emission data are specified with reference to wind speed at a standardised height above ground.

11.5.25 Manufacturers' wind turbine noise emission data are generally specified over a range of wind speeds at a standardised height of 10 m above ground. In accordance with IEC 61400-11, wind speed at this standardised height is calculated from the hub height wind speed by applying a reference ground roughness length of 0.05. Amongst other beneficial factors, this approach allows developers to compare the noise emission data from different turbines on a like for like basis.

11.5.26 However, a consequence of this approach is that it is necessary to account for how the wind shear on the development site may differ from the site at which the turbine noise emission data were generated (the 'emission site'). For example, if the wind shear is greater on the development site than the emission site, for a given 10m high wind speed, the hub height wind speed will also be greater on the development site. The result is that the noise emission on the development site would be greater than on the emission site.

11.5.27 The IOA GPG provides advice on appropriate ways in which to determine hub height wind speed which is then required to be corrected to a standardised 10 m height. The method adopted for this assessment is to take measured data from two heights, one at least 60% of proposed hub height and another at least 15 m lower. The measured wind speeds at the upper height are corrected to hub height wind speed based on the measured site specific wind shear (by consideration to the differential between the two measured wind speeds). The derived hub height wind speed is then corrected to a 10 m height by applying the same reference ground roughness value of 0.05, as stipulated within IEC 61400-11. This approach ensures that the resulting assessment is compliant with the ETSU-R-97 requirement to consider 10 m high wind speeds whilst also allowing a fair comparison against predicted wind turbine noise levels determined using emission data calculated within IEC 61400-11.

11.5.28 The candidate turbine hub height for this development is 75 m. Accordingly, the adopted wind speed data measured at 70 m complies with the 'at least 60% of hub height' criterion whilst the 48 m height data is more than 15 m below this. These data sets have therefore been used to derive the standardised 10 m height wind speed data in accordance with the IoA GPG.

Prevailing Background Noise Levels

11.5.29 In accordance with ETSU-R-97 and the IoA GPG. The prevailing background noise levels for each location have been determined for 'quiet daytime hours' and night-time hours, as defined in paragraph 11.2.17.

11.5.30 Initially the time histories of each adopted measurement location were inspected such that any identified a-typical events could be removed from the data sets.

11.5.31 The remaining noise measurement data have been analysed by plotting the $L_{A90,10min}$ noise levels against the derived 10m average wind speeds for both quiet waking hours and night-time hours. The resulting graphs, Graphs 11A.1 to 12A.4 are presented in Appendix 11.6.

11.5.32 Also presented on these graphs are 2nd or 3rd order polynomial lines of best fit through the plotted data. This polynomial regression analysis, as specifically defined in ETSU-R-97, is a simple statistical analysis which gives an indication of the relationship that exists, in this case, between background noise levels and wind speeds. Where, at upper speeds, the number of plotted data points is less than 5 per 1 m/s wind speed bin (in this case daytime periods only), the lines of best fit have been capped and re-plotted in accordance with the IoA GPG.

11.5.33 The lines of best fit / capped lines of best fit are used in the determination of the applicable wind turbine noise level limits. The tabulated lines of best / capped lines of best fit are presented in Table 11.14.

Table 11.14 – Tabulated Background Noise Levels, $L_{A90,10mins}$, Free-field, dB

Period	10m Height Wind Speed (m/s)										
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
High Cairn											
Quiet Daytime Periods	33.6	34.2	34.8	35.5	36.2	37.1	38.0	39.0	40.2	*40.2*	*40.2*
Night-time	31.5	31.6	31.9	32.4	33.1	34.1	35.2	36.6	38.2	40.0	42.0
Nether Cairn											
Quiet Daytime Periods	30.3	32.2	34.3	36.6	39.1	41.8	44.5	47.4	50.3	53.2	*53.2*

Period	10m Height Wind Speed (m/s)										
	2	3	4	5	6	7	8	9	10	11	12
Night-time	26.8	27.7	28.9	30.4	32.2	34.6	37.6	41.3	45.7	51.0	57.3
Capped Values in italic text											

11.6 Assessment of Do-Nothing Scenario

11.6.1 Should the Proposed Development not be consented, the "do-nothing scenario" will apply to the current baseline environment, in that the Applicant will construct the Consented Development.

11.6.2 The Consented Development was environmentally assessed and consented in 2015 and the assessment is reported within the Sandy Knowe Wind Farm Environmental Statement (2015).

11.7 Assessment of Proposed Development Potential Effects

Construction Noise

11.7.1 It is anticipated that the construction works that have the greatest potential to generate noise will be:

- tree felling of forested areas, including the use of chain saws;
- construction of on-site access tracks, temporary construction compound, laydown areas and water crossings, including possible use of excavators, lorries or dumper trucks / tippers;
- excavation and backfilling of cable trenches including use of excavators;
- construction of turbine foundations including use of excavators, delivery of materials with lorries/dumper trucks, delivery and pumping of concrete, and possible use of piling if ground conditions dictate this necessary; and
- installation of turbines, including the use of a mobile or crawler crane and a smaller tail crane.

11.7.2 For the majority of the site, construction noise effects will be significantly tempered by the distance that such activities will be undertaken from existing noise-sensitive receptors. BS5228 states that increasing the distance from noise sensitive premises is often the most effective method of controlling noise.

11.7.3 Whilst the '*Design Manual for Roads and Bridges*' (DMRB) is specific to the assessment of effects associated with new or updated road schemes, the guidance associated with construction effects can be applied more generally. Within Volume 11 Section 3 Part 3, '*Disruption due to Construction*', it is stated that "*one study has shown that at least half the people living within 50 m either side of the site boundary were seriously bothered by construction nuisance in one form or another, but that beyond 100 m less than 20 % of people were seriously bothered.*"(Highways Agency et al., 1993)

11.7.4 In the case of this development, the closest noise-sensitive receptor to the main site area (that not including the eastern or western access tracks) is Nether Cairn (a residential dwelling) which is located approximately 955m north of Turbine T1.

11.7.5 The only construction works proposed in the vicinity of existing dwellings is the formation of the start (the north-east end) of the eastern site access track.

11.7.6 The eastern access track would lead into the site, south-west from the Heads of the Valleys Road / C125N. This access track would start on the opposite side of the Heads of the Valleys Road to Burnside, which is set back from associated works by approximately 30 m. The eastern access road would also be approximately 60 m from Guildhall Cottage.

11.7.7 Notwithstanding that the considerable distances between the main site area and local receptors, and that the eastern access track works in the vicinity of Burnside and Guildhall Cottage would be short in duration, noise level predictions have been undertaken for a sample of key construction working operations.

11.7.8 Table 11.15 presents a sample of construction working operations associated with the main site area, and a typical range of associated sound pressure levels at 10 m, obtained from BS 5228-1:2009+A1:2014.

Table 11.15 - Sample of Construction Activities and Associated Typical Sound Pressure Level Data at 10m (BS 5228-1:2009+A1:2014) – Main Site Area, Free-field dB(A)

Plant / Operation	Sound Pressure Level ($L_{Aeq,T}$ / L_{AFmax} at 10m) from BS 5228 – L_{AFmax} level denoted by*
Chain Saw – Felling	86
Tracked Excavator - Trenching	71 - 77
Tracked Excavator - Earthworks	68 - 80
Tracked Excavator - Dumping / Spreading Load / Compacting	78 - 86
Dumper Truck - Distribution	56* - 92*
Dumper Truck - Tipping / Load	74 - 86
Lorry - Pass-by / Movement of Materials	76* - 88*
Impact Piling	77-89
Mixing Concrete – Truck discharging / idling / mixing	71 - 80
Tracked Crane	71-93
Wheeled Crane	70 - 78

11.7.9 Drawing on the data presented in Table 11.15, Table 11.16 presents the noise levels calculated at a distance of 955m from each operation (the turbine to closest receptor distance). These calculations assume that each plant item would be operational for 100% of the working day, and do not include for attenuation due to screening, or atmospheric absorption. Acoustically absorptive ground has been assumed as appropriate given the nature of the local area.

Table 11.16 - Sample of Construction Activities and Associated Worst Case Sound Pressure Levels at 955m, Free-field dB(A)

Plant / Operation	Predicted Sound Pressure Level ($L_{Aeq,T}$ or L_{AFmax}) at Closest Receptor to T1 – L_{AFmax} Level Denoted by*
Chain Saw - Felling	39
Tracked Excavator - Trenching	24 – 30
Tracked Excavator - Earthworks	21 – 33
Tracked Excavator - Dumping / Spreading Load / Compacting	31 – 39
Dumper Truck - Distribution	9 – 45*
Dumper Truck - Tipping / Load	27 – 39
Lorry - Pass-by / Movement of Materials	29 – 41*

Plant / Operation	Predicted Sound Pressure Level ($L_{Aeq,T}$ or L_{AFmax}) at Closest Receptor to T1 – L_{AFmax} Level Denoted by*
Impact Piling	30 – 42
Mixing Concrete – Truck discharging / idling / mixing	24 – 33
Tracked Crane	24 – 46
Wheeled Crane	23 – 31

11.7.10 It can be seen from Table 11.16 that at 955 m, the noise levels associated with each individual construction operation are no higher than 46 dB(A). Even if all of the events presented within the table above were to occur simultaneously, a worst case noise level of only 51 dB(A) is calculated at 955 m.

11.7.11 In addition, it should also be noted that the calculated combined noise level includes operations for which BS 5228-1:2009+A1:2014 only presents noise data in terms of the L_{Amax} noise index. Noise levels adopting this noise index will typically be significantly higher than the corresponding $L_{Aeq,T}$ noise levels, and strictly should therefore not be compared against a noise level criterion adopting the $L_{Aeq,T}$ noise index. Including such noise levels within the calculation (as above) represents a worst case.

11.7.12 The assessment considers construction works undertaken at shortest distance between the closest noise sensitive receptor and on-site areas of substantial works. Lower noise levels would be predicted at the next closest receptors, and when works are undertaken within more remote site areas.

11.7.13 The predicted noise levels correspond to impact magnitudes of slight. With reference to Table 11.9, for receptors of high sensitivity, these correspond to effect significances of **negligible** (not significant). Such effects would be temporary and local in nature.

11.7.14 Since works in closer proximity to existing dwellings would be undertaken for limited periods for the start of the eastern site access road, an additional set of construction noise calculations has been undertaken. It should however be noted that these calculations have been undertaken through the adoption of worst-case distances, and such works would only be undertaken for very limited durations.

11.7.15 These calculations have been undertaken in accordance with the methodology detailed within BS5228-1:2009+A1:2014. The assumed plant type, number and utilisation (the percentage of time plant is likely to be operating during the working day – the 'on time') used within the calculations is set out within Table 11.17.

Table 11.17 - Assumed Construction Plant Details for Access Track Upgrade Works

Construction Phase	Plant Type	Assumed Sound Pressure Level ($L_{Aeq,T}$ / L_{AFmax} at 10m) – L_{AFmax} level denoted by*	Assumed Plant On-Time
Access Track Work	Tracked excavator – earthworks	80	50
	Dumper truck - tipping load	86	20
	Lorry - pass-by / movement of materials	88*	10

11.7.16 Table 11.18 presents the resulting noise levels calculated at Burnside and Guildhall Cottage, assuming propagation over acoustically reflective ground.

Table 11.18 - Predicted Construction Noise Levels at Burnside and Guildhall Cottage During Closest Access Track Works, dB(A), Free-field

Receptor	$L_{Aeq,10hour}$, dB(A)
Burnside	73
Guidehall Cottage	67

11.7.17 Drawing upon Table 11.5, the predicted noise levels correspond to impact magnitudes ranging from medium to high. With reference to Table 11.9, for receptors of high sensitivity, these correspond to effect significances ranging from **moderate** to **major** (significant). However, such impacts would be temporary, local and very short in duration. Noise levels and resulting effects would also reduce as the access track works progress away from these properties.

Construction Traffic Noise

11.7.18 In Chapter 12 it is detailed that two site access would be formed, one directly onto the A76(T) to the west, and one onto the C125n road, also leading to the A76(T), to the east. The eastern site access would be used by HGVs, LGVs and cars, with all abnormal loads and some HGVs utilising the western site access.

11.7.19 Two different construction traffic routes have been considered, one from the west using the A76(T) and one form the east using the A76 (T). Therefore, in total, the following links have been considered:

- Link 1 – A76(T) east of the site;
- Link 2 – A76(T) west of the site; and
- Link 3 - C125n from the A76(T) junction to the site access road.

11.7.20 The construction programme is anticipated to last for 18 months. With the exception of turbine base concreting works, the daily traffic profiles have been calculated assuming an average of 20 working days per months, based on the proposed five-day working week. Normal construction working hours would be between 07:00 and 19:00 Mondays to Fridays. Arrivals and departures will therefore be primarily daytime only.

11.7.21 Maximum two-way construction traffic trip generation figures have been generated for both foundation concrete pouring days (worst case) and non-concrete pouring days. These data are as follows:

A76(T) east and A76(T) west

- Concrete pouring days – 136 HGVs and 50 LGVs / cars
- Non concrete pouring days - 74 HGVs and 38 LGVs/cars

C125n

- Concrete pouring days – 0 HGVs and 62 LGVs / cars
- Non concrete pouring days - 0 HGVs and 62 LGVs/cars

11.7.22 It should be noted that a maximum of only 25 concrete pouring days are anticipated.

11.7.23 The traffic assessment includes a series of baseline traffic counts, the results of which are provided in Table 11.19.

Table 11.19 – Baseline Traffic Data – 12 hour day (07:00-19:00)

Route	Non HGVs	HGVs	Totals
A76(T) East	2012	297	2309
C125N	280	7	287
A76(T) West	2151	299	2450

11.7.24 Table 11.20 presents the resulting 'with development' flows on these routes for both concrete pouring and non-concrete pouring days, including the percentage increase in total flow over the baseline.

Table 11.20 – 'With development' Traffic Data – 12 hour day (07:00-19:00)

Route	Non HGVs	HGVs	Totals (Percentage increase over baseline)
Concrete pouring days			
A76(T) East	2062	433	2489 (8% increase)
C125N	342	7	467 (22% increase)
A76(T) West	2201	435	2630 (8% increase)
Non-Concrete pouring days			
A76(T) East	2050	371	2445 (5% increase)
C125N	342	7	426 (22% increase)
A76(T) West	2189	373	2586 (5% increase)

11.7.25 Considering Table 11.19 and Table 11.20, it can be seen that the percentage increase in traffic on the A76(T) east and A76(T) west would remain less than 10% and the composition of the traffic (split of HGV and non HGV traffic) would remain broadly similar to the existing situation with only a small increases in the percentage of HGVs. Such changes would give rise to noise level increases of less than 1 dB, corresponding to an impact magnitude of slight.

11.7.26 For the C125n, increases in total traffic of 22% are identified whilst the composition of the traffic would again remain broadly similar to the existing situation, but with a small decrease in the percentage of HGVs. These would give rise to noise level increases of less than 1dB, based on DMRB criteria, corresponding to an impact magnitude of slight.

11.7.27 With reference to Table 11.9, for receptors of high sensitivity, identified impacts correspond to effect significances of **negligible** (not significant). Such impacts would be temporary and local.

Construction Vibration

11.7.28 Table 11.21 presents the possible distances at which the adopted impact magnitude criteria may be registered (BS5228-2) based on a specified confidence limit (where applicable), and the empirical prediction procedures presented within the same document, TRL RR 246 (applicable to HGV induced vibration), and TRL Report 429 (applicable to vibratory rollers).

Table 11.21 - Predicted Ground-borne Vibration Levels Applicable to Typical Vibration Generating Construction Activities

Operation	Confidence Limit	Distance (m)	PPV (mm/s)
Vibratory Rollers – start & end	95	60	0.3
	95	23	1.0
Vibratory Rollers – steady state[1]	95	3.3	10
	95	215	0.3

Operation	Confidence Limit	Distance (m)	PPV (mm/s)
Piling – Driven cast in place	95	85	1.0
	95	15	10
Rotary Bored Piling - Augering	N/A	20	0.3
	N/A	6	1.0
	N/A	0.6	10
Rotary Bored Piling – Auger hitting base	N/A	45	0.3
	N/A	14	1.0
	N/A	1.4	10
Rotary Bored Piling – Driving casing	N/A	75	0.3
	N/A	23	1.0
	N/A	2.3	10
HGVs[2]	N/A	50	0.3[3]
	N/A	17	1.0[3]
	N/A	2.5	10[3]

[1] Assumes 2 rollers, 0.4mm amplitude, drum width of 1.3m, e.g. heavy duty ride on roller
[2] Assumes max height / depth of surface defect of 50mm, max speed of 30km/h, and that surface defect occurs at both wheels.
[3] Where alluvium soils are present, higher vibration levels can be expected.

11.7.29 It should be noted that there may be a variety of different potential vibration generating activities employed during the construction phase, other than those presented above. The data presented within Table 11.21 are general in nature and not specific to any one site. However, the vibration levels and associated distances can be used to determine the typical distances at which specific impacts may be registered.

11.7.30 Based on a worst case receptor distance of 955 m (for operations in the main site area) and 30 m (for site access construction works), the data presented in Table 11.21 and the impact magnitude scale presented in Table 11.6, the impact magnitudes can be determined. The resulting impact magnitudes are presented in Table 11.22.

Table 11.22 - Predicted Impact Magnitudes for Ground-borne Vibration

Activity	Comparison with Criterion	Resultant Impact Magnitude
Vibratory Rollers (30m)	>0.3 but <1	Low
Driven Piling (955m)	<0.3	Slight
Auger Bored Piling (955m)	<0.3	Slight
HGVs (30m)	>0.3 but <1	Low

11.7.31 It should be noted that the impact magnitudes presented within this table, in some cases, have been generated based on a 95% confidence limit. In reality it is likely that lower vibration levels would prevail for the majority of activities.

11.7.32 With reference to Table 11.9, for receptors of high sensitivity, these impact magnitudes correspond to effect significances ranging from **negligible** to **minor** (not significant). Such effects would be temporary and local in nature.

Operational Wind Turbine Noise

Derived Noise Level Limits

11.7.33 Noise limits for the Proposed Development have been derived based on measured background noise levels, and in accordance with ETSU-R-97 as follows:

Properties without a Financial Involvement (FI) in the Proposed Development:

Daytime Limit	The quiet daytime hours background noise level (L_{A90}) +5 dB or 35 dB(A), whichever is the higher
Night-time Limit	The night-time hours background noise level (L_{A90}) +5dB or 43 dB(A), whichever is the higher

Properties with a Financial Involvement (FI) in the Proposed Development:

Daytime Limit	The quiet daytime hours background noise level (L_{A90}) +5 dB or 45 dB(A), whichever is the higher
Night-time Limit	The night-time hours background noise level (L_{A90}) +5dB or 45 dB(A), whichever is the higher

11.7.34 The background noise levels have been adopted from the lines of best fit / capped line of best fit presented in Graphs 11A.1 to 11A.4 in Appendix 11.6.

11.7.35 The resulting noise level limits are presented in Graphs 12A.5 to Graph 12A.8 of Appendix 11.7, and are presented in Table 11.23.

Table 11.23 - Tabulated Noise Level Limits, dB $L_{A90,T}$, Free-field

Limit	10m Height Wind Speed (m/s)										
	2	3	4	5	6	7	8	9	10	11	12
High Cairn (also representative of Hillend, Crockoy Cottage and Corserig)											
Lower Daytime Non-FI	38.6	39.2	39.8	40.5	41.2	42.1	43.0	44.0	45.2	45.2	45.2
Night-time Non-FI	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	45.0	47.0
Daytime FI	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.2	45.2	45.2
Night-time FI	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.0
Nether Cairn (also representative of Polneul and Rigg Farm)											
Lower Daytime Non-FI	35.3	37.2	39.3	41.6	44.1	46.8	49.5	52.4	55.3	58.2	58.2
Night-time Non-FI	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.3	50.7	56.0	62.3
Daytime FI	45.0	45.0	45.0	45.0	45.0	46.8	49.5	52.4	55.3	58.2	58.2
Night-time FI	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.3	50.7	56.0	62.3

Detailed Noise Modelling

11.7.36 In order to determine the noise levels that would be generated by the proposed development acting both in isolation and simultaneously with the considered cumulative developments, a detailed noise model has been prepared for the site and surrounding area.

11.7.37 The model has been prepared in the CadnaA® noise modelling suite. The noise model was set to use the ISO 9613-2 prediction method which includes prescribed methods for accounting for the effects of geometric divergence, ground absorption and atmospheric absorption. The ISO 9613 prediction method is for the calculation of sound pressure levels at a 'downwind' location and the research findings presented in *Development of a windfarm noise prediction model* (Bass et al 1998), identified that this model tends to over predict the noise levels whilst also being the best available. This noise prediction model is referenced as appropriate for use within the IoA GPG.

11.7.38 Whilst the IoA GPG presents methodologies for the determination of additional corrections to account for propagation directivity, which could be used for example to account for the effects of wind direction where a receptor is located between two developments, such corrections have not been included within this assessment. The predicted operational noise levels can therefore be considered worst case in this regard.

11.7.39 The noise model was configured to ensure noise level predictions in compliance with the IoA GPG, including the following:

- Ground absorption: G=0.5;
- Receptor Height: 4 m;
- A correction from $L_{Aeq,T}$ to $L_{A90,T}$ of -2 dB was applied;
- No acoustic screening from buildings or topography was included in the calculated noise levels (worst case);
- Temperature: 10°C; and
- Humidity: 70%.

11.7.40 The requirement to apply valley corrections was determined with reference to the IoA GPG. No valley corrections have been applied to noise predictions from the Proposed Development turbines at any noise sensitive receptors. No valley corrections are applicable at identified noise sensitive receptors for any cumulative schemes, with the exception of Hillend, which has been dealt with separately. Noise from the Proposed Development at Hillend has been evaluated against apportioned noise limits for the Proposed Development in isolation, rather than cumulatively, therefore no application of valley correction was required.

Wind Turbine Noise Emission Data – Proposed Development

11.7.41 The candidate turbine for this development is the Siemens SWT3.4–101. This turbine can be operated in its standard setting or in any of up to six sound management modes providing broad-band reductions in 1 dB increments up to a maximum reduction of 6 dB compared with the standard setting.

11.7.42 A-weighted broad-band sound power level data for this turbine at hub height of was provided by the manufacturer, for each operating mode[1]. The quoted levels have been standardised to a reference height of 10 m, in accordance with the method provided in IEC 61400-11, as specified by the IoA GPG.

11.7.43 In addition to the broad-band levels, A-weighted octave band spectra were provided for the turbine at wind speeds of 6 m/s and 8 m/s. These spectra have been applied to the broad-band levels with the noise model. At wind speeds of up to 8 m/s the spectrum for 6 m/s has been applied. At wind speeds of 8 m/s and above, the spectrum for 8 m/s has been applied. A 2 dB correction for uncertainty has also been applied to the manufacturer's quoted sound power levels.

11.7.44 The data adopted in the noise modelling exercise is detailed within Table 11.24.

[1] Siemens technical document titled: Standard Acoustic Emission, SWT-3.4-101, Rev. 0 document ID: WP TE-400000-C995-00 dated 21/04/2015 for 4 m/s wind speed, and
Siemens technical document titled: Standard Acoustic Emission, SWT-3.4-101, Rev. 0 document ID: WP ON EMEA EN L&OS-40-0000-G220-00 dated 09/03/2016 for wind speeds 5 m/s – 9 m/s

Table 11.24 – Sound Power Level Data (L_{WA}) for Siemens SWT-3.4-101, 75m Hub Height, dB(A)

Operational Mode	Wind Speed at 10m, V_{10} (m/s)					
	4	5	6	7	8	9+
Standard setting	96.0	101.6	106.3	108.5	109.0	109.0
-1dB	-	101.6	106.3	108.0	108.0	108.0
-2dB	-	101.6	106.1	107.0	107.0	107.0
-3dB	-	101.6	105.8	106.0	106.0	106.0
-4dB	-	101.6	105.0	105.0	105.0	105.0
-5dB	-	101.6	104.0	104.0	104.0	104.0
-6dB		101.6	103.0	103.0	103.0	103.0
Includes uncertainty correction of +2 dB						

11.7.45 Table 11.25 presents the octave band sound power level data also provided by the manufacturer.

Table 11.25 - Octave Band Sound Power Level Spectra (L_{WA}) for Siemens SWT-3.4-101, 75 m Hub, dB(A)

10m height Wind Speed, V_{10}, m/s	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
6 m/s wind speed								
Standard Setting	85.9	90.0	94.7	97.0	100.0	97.5	92.0	78.0
-1dB	85.9	90.0	94.7	97.0	100.0	97.5	92.0	78.0
-2dB	85.9	90.0	94.5	96.8	99.8	97.3	91.8	77.8
-3dB	85.8	89.9	94.2	96.5	99.5	97.0	91.5	77.5
-4dB	85.3	89.9	93.5	95.7	98.7	96.3	90.7	76.8
-5dB	85.1	89.5	92.4	94.6	97.6	95.2	89.6	75.7
-6dB	84.8	89.1	91.3	93.5	96.5	94.1	88.5	74.6
8 m/s wind speed								
Standard Setting	87.4	93.8	97.7	99.5	102.5	100.6	94.5	80.9
-1dB	87.2	93.5	96.7	98.5	101.5	99.6	93.5	79.9
-2dB	86.9	93.1	95.6	97.4	100.4	98.5	92.4	78.8
-3dB	86.7	92.7	94.6	96.4	99.4	97.5	91.4	77.8
-4dB	86.5	92.4	93.5	95.3	98.3	96.4	90.3	76.7
-5dB	86.3	92.0	92.4	94.2	97.2	95.3	89.2	75.6
-6dB	86.1	91.6	91.3	93.1	96.1	94.2	88.1	74.5

11.7.46 For each wind speed, the adopted spectrum has been adjusted in level to correspond to the single figure sound power level data presented in Table 11.24.

Wind Turbine Noise Emission Data – Hare Hill Wind Farm

11.7.47 The noise emission data used for this development is that detailed within Tables 1 (plus a further r +2dB correction) and 2 of Appendix 11.2. For each wind speed, the adopted spectrum from Table 2 has been adjusted in level to correspond to the single figure sound power level data presented in Table 1 +2 dB.

Wind Turbine Noise Emission Data – Hare Hill Extension Wind Farm

11.7.48 The noise emission data used for this development is that detailed within Tables 5 and 6 of Appendix 11.2. For each wind speed, the adopted 'pessimistic' spectrum from Table 6 has been adjusted in level to correspond to the single figure sound power level data presented in Table 5.

Wind Turbine Noise Emission Data – Sanquhar Community Wind Farm

11.7.49 The noise emission data used for this development is that detailed within Tables 8 and 9 of Appendix 11.2. It has been assumed that the turbines would operate in standard setting. For each wind speed, the adopted spectrum from Table 9 has been adjusted in level to correspond to the single figure sound power level data presented in Table 8. The spectrum for 6 m/s has been applied to wind speeds of 6 m/s and below. The spectrum for 8m/s has been applied to wind speeds of 7 m/s and above.

11.7.50 In the absence of sound power level data at 4 and 5 m/s, the data for 6 m/s has been applied to represent a worst case.

Wind Turbine Noise Emission Data – Sanquhar 'Six' Wind Farm

11.7.51 The same noise emission data has been adopted for this development as for the Sanquhar Community Wind Farm. The adopted data is higher than the candidate turbine data detailed in Table 11A.11 of Appendix 11.2 therefore representing a worst case.

Predicted noise levels – Proposed Development only

11.7.52 Operational noise levels have been predicted for the Proposed Development alone, with all turbines operating in standard setting (unconstrained modes). The resulting receptor noise levels are presented in Table 11.26

Table 11.26 - Predicted Operational Receptor Noise Levels, Proposed Development Only, dB $L_{A90,T}$, Free-field

Receptor	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Corserig	25.6	31.2	35.9	38.1	38.6	38.6	38.6	38.6	38.6
High Cairn	27.2	32.8	37.5	39.7	40.2	40.2	40.2	40.2	40.2
Nether Cairn	28.0	33.6	38.3	40.5	41.0	41.0	41.0	41.0	41.0
Rigg Farm	24.4	30.0	34.7	36.9	37.4	37.4	37.4	37.4	37.4
Polneul	26.9	32.5	37.2	39.4	39.9	39.9	39.9	39.9	39.9
Crockroy	28.6	34.2	38.9	41.1	41.6	41.6	41.6	41.6	41.6
Hillend	27.0	32.6	37.3	39.5	40.0	40.0	40.0	40.0	40.0

Predicted Cumulative noise levels

11.7.53 For all receptors with the exception of Hillend (see further below), the cumulative operational noise levels have been predicted with all turbines operating in standard setting (unconstrained modes). The resulting receptor noise levels are presented in Table 11.27.

Table 11.27 - Predicted Cumulative Operational Receptor Noise Levels, dB $L_{A90,T}$, Free-field

Receptor	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Corserig	27.0	31.9	36.4	38.5	39.2	39.3	39.3	39.1	39.1
High Cairn	29.6	34.0	38.2	40.3	40.8	40.9	40.9	40.9	40.9
Nether Cairn	29.4	34.2	38.7	40.8	41.4	41.4	41.4	41.4	41.4
Rigg Farm	25.9	30.7	35.2	37.3	37.9	38.0	37.9	37.9	37.9
Crockroy	29.6	34.7	39.3	41.4	41.9	42.0	42.0	41.9	41.9
Rigg Farm	25.9	30.7	35.2	37.3	37.9	38.0	37.9	37.9	37.9
Hillend	34.8	38.4	42.0	43.7	44.5	44.7	44.7	44.4	44.5

11.7.54 The noise limits derived for High Cairn and Nether Cairn have been applied to wider receptors according to the detail in Table 11.28 and in accordance with the method followed in the Consented Development ES.

Table 11.28 – Application of Noise Limits at Wider Receptors

Limits Derived for	Limits Applied to
High Cairn	Corserig High Cairn Crockroy (FI) Hillend
Nether Cairn	Nether Cairn (FI) Rigg Farm (FI) Polneul

11.7.55 The predicted levels are cumulative noise levels and are compared with the consented noise limits at receptors in Table 11.29 to Table 11.34. Where there are no positive values in the compliance check rows (bottom two rows of each table), this is confirmation that cumulative turbine noise levels comply with the ETSU-R-97 guidance for wind turbine noise.

Table 11.29 - Corserig – Comparison of Predicted Cumulative Operational Turbine Noise with Derived Noise Level Limits, dB $L_{A90,T}$, Free-field

	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Predicted Cumulative Turbine Noise Level [A]	27.0	31.9	36.4	38.5	39.2	39.3	39.3	39.1	39.1
Lower Daytime Noise Level Limit (Non FI) [B]	39.8	40.5	41.2	42.1	43.0	44.0	45.2	45.2	45.2
Night-time Noise Level Limit (Non FI) [C]	43.0	43.0	43.0	43.0	43.0	43.0	43.2	45.0	47.0
Lower Daytime Compliance Check [A-B]	-12.8	-8.6	-4.8	-3.6	-3.8	-4.7	-5.9	-6.1	-6.1
Night-time Compliance Check [A-C]	-16.0	-11.1	-6.6	-4.5	-3.8	-3.7	-3.9	-5.9	-7.9

Table 11.30 – High Cairn – Comparison of Predicted Cumulative Operational Turbine Noise with Derived Noise Level Limits, dB $L_{A90,T}$, Free-field

	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Predicted Cumulative Turbine Noise Level [A]	29.6	35.9	37.6	38.5	38.6	38.5	38.5	38.6	38.6
Lower Daytime Noise Level Limit (Non FI) [B]	39.8	40.5	41.2	42.1	43.0	44.0	45.2	45.2	45.2
Night-time Noise Level Limit (Non FI) [D]	43.0	43.0	43.0	43.0	43.0	43.0	43.2	45.0	47.0
Lower Daytime Compliance Check [A-B]	-10.2	-4.6	-3.6	-3.6	-4.4	-5.5	-6.7	-6.6	-6.6
Night-time Compliance Check [A-D]	-13.4	-7.1	-5.4	-4.5	-4.4	-4.5	-4.7	-6.4	-8.4

Table 11.31 – Nether Cairn – Comparison of Predicted Cumulative Operational Turbine Noise with Derived Noise Level Limits, dB $L_{A90,T}$, Free-field

	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Predicted Cumulative Turbine Noise Level [A]	29.4	34.2	38.7	40.8	41.4	41.4	41.4	41.4	41.4
Daytime Noise Level Limit (FI) [B]	45.0	45.0	45.0	46.8	49.5	52.4	55.3	58.2	58.2
Night-time Noise Level Limit (FI) [C]	45.0	45.0	45.0	45.0	45.0	46.3	50.7	56.0	62.3
Lower Daytime Compliance Check [A-B]	-15.6	-10.8	-6.3	-6.0	-8.1	-11.0	-13.9	-16.8	-16.8
Night-time Compliance Check [A-C]	-15.6	-10.8	-6.3	-4.2	-3.6	-4.9	-9.3	-14.6	-20.9

Table 11.32 – Rigg Farm – Comparison of Predicted Cumulative Operational Turbine Noise with Derived Noise Level Limits, dB $L_{A90,T}$, Free-field

	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Predicted Cumulative Turbine Noise Level [A]	25.9	30.7	35.2	37.3	37.9	38.0	37.9	37.9	37.9
Daytime Noise Level Limit (FI) [B]	45.0	45.0	45.0	46.8	49.5	52.4	55.3	58.2	58.2
Night-time Noise Level Limit (FI) [C]	45.0	45.0	45.0	45.0	45.0	46.3	50.7	56.0	62.3
Lower Daytime Compliance Check [A-B]	-19.1	-14.3	-9.8	-9.5	-11.6	-14.4	-17.4	-20.3	-20.3
Night-time Compliance Check [A-C]	-19.1	-14.3	-9.8	-7.7	-7.1	-8.3	-12.8	-18.1	-24.4

Table 11.33 - Polneul – Comparison of Predicted Cumulative Operational Turbine Noise with Derived Noise Level Limits, dB $L_{A90,T}$, Free-field

	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Predicted Cumulative Turbine Noise Level [A]	28.3	33.2	37.6	39.8	40.3	40.4	40.3	40.3	40.3
Lower Daytime Noise Level Limit (Non FI) [B]	39.3	41.6	44.1	46.8	49.5	52.4	55.3	58.2	58.2
Night-time Noise Level Limit (Non FI) [C]	43.0	43.0	43.0	43.0	43.0	46.3	50.7	56.0	62.3
Lower Daytime Compliance Check [A-B]	-11.0	-8.4	-6.5	-7.0	-9.2	-12.0	-15.0	-17.9	-17.9
Night-time Compliance Check [A-C]	-14.7	-9.8	-5.4	-3.2	-2.7	-5.9	-10.4	-15.7	-22.0

Table 11.34 – Crockroy – Comparison of Predicted Cumulative Operational Turbine Noise with Derived Noise Level Limits, dB $L_{A90,T}$, Free-field

	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Predicted Cumulative Turbine Noise Level [A]	29.6	34.7	39.3	41.4	41.9	42.0	42.0	41.9	41.9
Daytime Noise Level Limit (FI) [B]	45.0	45.0	45.0	45.0	45.0	45.0	45.2	45.2	45.2
Night-time Noise Level Limit (FI) [C]	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.0
Lower Daytime Compliance Check [A-B]	-15.4	-10.3	-5.7	-3.6	-3.1	-3.0	-3.2	-3.3	-3.3
Night-time Compliance Check [A-C]	-15.4	-10.3	-5.7	-3.6	-3.1	-3.0	-3.0	-3.1	-5.1

11.7.56 At all of the considered receptors (with the exception of Hillend which is considered separately below) the predicted operational noise levels remain below the consented cumulative noise level limits.

11.7.57 With reference to the criteria provided in Table 11.7, the predicted noise levels corresponding to impact magnitudes of slight to low. With reference to Table 11.9, for receptors of high sensitivity, these correspond to effect significances of **negligible** to **minor** (not significant). Such effects would be permanent/long term, for the duration of operation of the scheme, and local in nature.

11.7.58 To allow preparation of appropriate noise related planning conditions the Consented Development ES apportioned the available noise level limit between the Consented Development and the considered cumulative developments. The apportionment was made such that when each cumulative development is operating up to, but within, its apportioned limit, the overall combined operational noise level does not exceed the 'full' ETSU-R-97 noise level limit at any receptor. The apportioned limit provided in the ES for the Consented Development has been adopted for the evaluation of predicted noise levels at Hillend, the results of which are provided in Table 11.35.

Table 11.35– Comparison of Predicted Proposed Development Only Turbine Noise with Apportioned Noise Level Limit for Hillend, $L_{A90,T}$,dB(A)

	Wind Speed at 10m, V_{10} (m/s)								
	4	5	6	7	8	9	10	11	12
Predicted noise level, Sandy Knowe only [A]	27.0	32.6	37.3	39.5	40.0	40.0	40.0	40.0	40.0
Apportioned Sandy Knowe Lower Daytime Noise Limit [B]	31.3	32.6	33.9	33.2	34.2	36.4	38.4	38.3	38.2
Apportioned Sandy Knowe Night-time Noise Limit [C]	36.8	36.8	36.7	35.3	34.2	34.0	34.4	37.9	40.9
Lower Daytime Compliance Check [A-B]	-4.3	0.0	3.4	6.3	5.8	3.6	1.6	1.7	1.8
Night-time Compliance Check [A-C]	-9.8	-4.2	0.6	4.2	5.8	6.0	5.6	2.1	-0.9

11.7.59 The predicted levels indicate that the Proposed Development will exceed the derived noise limits at Hillend at wind speeds between 6 m/s and 12 m/s during the daytime period, and between 6 m/s and 11 m/s during the night-time period. The greatest exceedance, 6.3 dB

above the apportioned noise limit, occurs at 7 m/s wind speed during the daytime period. The greatest exceedance during the night-time period office at 9 m/s.

11.7.60 To demonstrate compliance with the example apportioned noise level limits, the example noise management schemes detailed in Table 11.36 have been derived. These management schemes constitute the operation of the proposed turbines in different modes with lower noise emission levels for different wind speeds. These management schemes constitute the operation of the proposed turbines in different modes with lower noise emission levels for different wind speeds.

Table 11.36 – Example Daytime and Night-time Noise Management Schemes

	Wind Speed at 10m, V_{10} (m/s)								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Daytime	SS	SS	-6*	-6**	-6*	-6	-6	-6	-6
Night-time	SS	SS	-6	-6**	-6*	-6	-6	-6	SS
SS = All turbines in Standard Setting *-6 = All Turbines in "minus 6 dB" mode* ** Turbine 8 switched off* *** Turbine 8 and Turbine 12 switched off*									

11.7.61 The above management schemes are an example only and have been derived on the basis of downwind propagation. Other management scheme could be operated and lesser curtailment would be required during cross-wind and up wind propagation conditions.

11.7.62 Table 11.37 presents the predicted noise levels from the Proposed Development operating in isolation, with the derived management schemes in operation.

Table 11.37 - Predicted Operational Noise Levels at Hillend, Proposed Development, with Noise Management Schemes in Place dB $L_{A90,T}$, Free-field

Period	Wind Speed at 10m, V_{10} (m/s)								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Daytime	27.0	32.6	33.3	32.6	33.6	33.6	33.6	34.5	34.5
Night-time	27.0	32.6	34.2	33.3	33.0	33.6	33.6	34.5	34.5

11.7.63 The predicted noise levels are evaluated against the daytime and night-time noise limits in Table 11.38.

Table 11.38 - Hillend – Comparison of Predicted the Proposed Development (in isolation) Operational Turbine Noise with Apportioned Noise Level Limits, dB $L_{A90,T}$, Free-field

	Wind Speed at 10m, V_{10} (m/s)								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Predicted Daytime Turbine Noise Level [A]	27.0	32.6	33.3	32.6	33.6	33.6	33.6	34.5	34.5
Predicted Night-time Turbine Noise Level [B]	27.0	32.6	34.2	33.3	33.0	33.6	33.6	34.5	34.5
Apportioned Lower Daytime Noise Level Limit (Non FI) [C]	31.3	32.6	33.9	33.2	34.2	36.4	38.4	38.3	38.2
Apportioned Night-time Noise Level Limit (Non FI) [D]	36.8	36.8	36.7	35.3	34.2	34	34.4	37.9	40.9
Lower Daytime Compliance Check [A-C]	-4.3	0.0	-0.6	-0.6	-0.6	-2.8	-4.8	-3.8	-3.7
Night-time Compliance Check [B-D]	-9.8	-4.2	-2.5	-2.0	-1.2	-0.4	-0.8	-3.4	-6.4

11.7.64 The predicted operational noise levels for the Proposed Development (in isolation) meet the apportioned noise level limits during both daytime and night-time periods with the noise management schemes in place.

11.7.65 Drawing upon Table 11.7, the predicted noise levels corresponding to impact magnitudes of low. With reference to Table 11.9, for receptors of high sensitivity, these correspond to effect significances of **minor** (not significant). Such effects would be permanent and local in nature.

Fixed (Non turbine) Plant Noise

11.7.66 The proposed redevelopment includes one transformer at the base of each turbine, either external or within the tower, and a control building/substation which would have associated plant items and the potential to generate noise once operational.

11.7.67 At this stage, precise transformer/plant details are not known, but these facilities are proposed at considerable distances from the nearest noise sensitive receptors.

11.7.68 Notwithstanding this, appropriate noise limits for such plant have been determined.

11.7.69 It can be seen from Graphs 1 to 4 of Appendix 11.6, that during both daytime and night-time periods, relatively low background sound levels can arise at local sensitive receptors, being as low as 19-25 dB(A) $L_{A90,10mins}$ during quiet daytime periods and 16-20 dB(A) $L_{A90,10mins}$ during night-time periods.

11.7.70 In light of this context, the guidance contained within BS4142 and the impact magnitude scale adopted for this assessment (see Table 11.9), it is considered that the rating level for noise from transformers and the control building/substation should be limited to be no more than 35dB ($L_{Ar,Tr}$) at any local dwelling.

11.7.71 This limit should apply to noise from all plant associated with the Proposed Development in order to avoid a cumulative noise impact from individual plant items. Where applicable, appropriate acoustic character corrections should be applied, in accordance with BS4142, in determining the plant rating level, prior to comparison against this rating level limit.

11.7.72 With reference to Table 11.8, compliance with this limit would ensure an impact magnitude of slight. For receptors of high sensitivity, this impact magnitude corresponds to an effect significance of **negligible** (not significant). Such effects would be permanent and local in nature.

11.8 Mitigation Measures

Construction Noise

11.8.1 The nature of construction noise is inherently temporary. Human receptors will generally tolerate higher impacts where it is known that they will only be present for a limited time period. Several safeguards exist to minimise the effects of construction noise and it is anticipated that these would be implemented, where necessary, during the construction of the turbines. These safeguards included:

- the various EC Directives and UK Statutory Instruments that limit noise emissions of a variety of construction plant;

- guidance set out in BS 5228-1:2009+A1:2014 which covers noise control on construction sites; and
- the powers that exist for local authorities under Section 60 of the Control of Pollution Act 1974 to control environmental noise on construction sites.

11.8.2 In addition, the adoption of Best Practicable Means (as defined in Section 72 of the Control of Pollution Act 1974) is usually the most effective means of controlling noise from construction sites. Such measures will include the following:

- any compressors brought on to site to be silenced or sound reduced models fitted with acoustics enclosures;
- all pneumatic tools to be fitted with silencers or mufflers;
- the majority of deliveries to be programmed to arrive during normal working hours only;
- care to be taken when unloading vehicles to minimised noise. Delivery vehicles to be routed so as to minimise disturbance to local residents;
- delivery vehicles to be prohibited from waiting within or in the vicinity of the site with their engines running;
- all plant items to be properly maintained and operated according to manufacturers' recommendations in such a manner as to avoid causing excessive noise;
- all plant to be sited so that the noise impact at nearby noise-sensitive receptors is minimised;
- local hoarding, screens or barriers to be erected as necessary to shield particularly noisy activities;
- Normal working hours will be between 0800 and 1800 on all days; and
- Night time deliveries will be minimal and will only be undertaken with special consideration. Care will be taken to minimise noise when unloading vehicles.

11.8.3 As part of the construction contract, the contractor will be required to comply with the above mitigation measures, as well as ensuring effective liaison with the local community. These requirements will be included in a Construction and Decommissioning Environmental Management Plan (CDEMP) (refer to Appendix 3.2).

Construction Traffic Noise

11.8.4 For general construction traffic, arrivals and departures would be timed such that they would be during the working daytime and not at night. Construction traffic would be prohibited from un-necessary idling within the site boundary or at the site access points.

11.8.5 It is proposed that the Access directly onto the A76(T), which is removed from local receptors, would be used by all HGV traffic. Whilst site access via the C125N would be used by only cars and LGVs.

11.8.6 These mitigation measures would be committed by inclusion within the CEMP (refer to Appendix 3.2)

Construction Vibration

11.8.7 Given that the effect significance for construction vibration is only negligible to minor, consideration to mitigation is not considered warranted.

Operational Wind Turbine Noise

11.8.8 The various measures available for the control of noise from wind turbines include the following:

- selection of appropriate turbines;
- selection of appropriate turbine locations;
- use of turbine management schemes, e.g. to back rate turbine operations under certain wind conditions; and
- financial involvement of local residents where appropriate (ETSU-R-97 states that "*the level of disturbance or annoyance caused by a noise source is not only dependent upon the level and character of the noise, but also on the receivers attitude towards the noise source in general*", going on to state that "*if the residents at the noise-sensitive properties were financially involved in the project then higher noise limits will be appropriate*.").

11.8.9 In due course, a detailed apportionment of the ETSU-R-97 noise level limits can be determined for conditioning purposes, thereby ensuring a commensurate level of protection against wind turbine noise for local residents.

11.8.10 The final turbine model will be selected to ensure compliance with an appropriate limit apportionment, by operation of noise management scheme where necessary.

Fixed (Non turbine) Plant Noise

11.8.11 Any fixed plant will, where necessary, include a noise mitigation scheme to ensure that the derived plant noise limits will be achieved. This scheme will include measures such as appropriate plant selection, building fabrication, plant enclosures and appropriate plant orientations etc.

11.8.12 If necessary, the derived noise level limits could be incorporated into an appropriately worded conditional planning approval to ensure a commensurate level of protection against fixed plant noise for existing local residents.

11.9 Assessment of Proposed Development Residual Effects

Construction Noise

11.9.1 The implementation of the above mitigation measures will serve to minimise any disturbance caused to the closest sensitive receptors as a result of construction activity. With the above mitigation measures in place, short term construction noise at Burnside and Guildhall Cottage from the construction of the start of the eastern access track would be reduced to low to medium impact magnitude. Construction noise from works on the main site area would remain of slight impact magnitude.

11.9.2 With reference to Table 11.9, for receptors of high sensitivity, these residual impact magnitudes correspond to effect significances ranging from **negligible** to **minor** for the

majority of the time (not significant), occasionally rising to **moderate** (significant) for very short periods. Such effects would be temporary and local in nature.

Construction Traffic Noise

11.9.3 Impact magnitudes remain as slight. With reference to Table 11.9, for receptors of high sensitivity, identified impacts correspond to effect significances ranging of **negligible** (not significant). Such impacts would be temporary and local.

Construction Vibration

11.9.4 Consideration of mitigation measures is not considered necessary. Accordingly, the identified impact magnitudes of slight to low at worst would remain. In accordance with the adopted significance matrix, for high sensitivity receptors, the effect significance would be **negligible** rising to occasionally **minor** for very short periods.

Operational Wind Turbine Noise

11.9.5 Compliance with the derived daytime and night-time noise level limits would ensure that noise from the operation of the proposed turbines would give rise to impacts magnitude of slight to low at worst.

11.9.6 With reference to Table 11.9, for receptors of high sensitivity, these residual impact magnitudes correspond to effect significances ranging from **negligible** to **minor** at worst (not significant). Such effects would be permanent and local in nature.

Fixed (Non turbine) Plant Noise

11.9.7 Compliance with the derived noise level limits would ensure that noise from the operation of the proposed fixed plant would give rise to an impact magnitude of slight.

11.9.8 With reference to Table 11.9, for receptors of high sensitivity, this impact magnitude corresponds to an effect significance of **negligible** (not significant). Such effects would be permanent and local in nature.

11.10 Assessment of Proposed Development Cumulative Effects

11.10.1 As required by ETSU-R-97, the completed assessment of operational turbine noise has included for potential cumulative impacts from other local wind farm developments which are operational, approved, and subject to valid planning applications. It has been demonstrated that the ETSU-R-97 noise level limits, which are applicable to cumulative noise can be complied with.

11.10.2 For construction noise, construction vibration and noise from fixed (non turbine) plant, the considered cumulative developments are sufficiently removed, that the no change in the identified effect significances are anticipated to arise should construction works or operation arise simultaneously.

11.10.3 It is anticipated that construction traffic from the Proposed Development could arise on the A76 at the same time as that for the considered cumulative developments which are yet to be built-out, should the respective construction periods overlap. However given the low percentage increases in traffic identified on this route for the Proposed Development, it is considered unlikely the combined traffic with other developments would give rise to a change in the identified effect significance.

11.11 Conclusions

11.11.1 This chapter has considered the potential noise and vibration effects that could arise due to the Proposed Development on the closest sensitive receptors in the vicinity of the site. The assessment has taken account of current guidance which is contained in the Energy Technology Support Units: *The assessment and rating of noise from wind farms* (ETSU-R-97) and the Institutes if Acoustics': *A good practice guide to the application of ETSU-R-97* (IoA GPG), as well as local and national planning policy and relevant British Standards.

11.11.2 This assessment of operational turbine noise has been based upon the adoption of manufacturers sound power level data for the Siemens SWT3.4-101 3.4MW wind turbine, which is typical of the size and type of turbine which may be considered for this site.

11.11.3 For the construction phase, predicted noise levels have been compared against an appropriate absolute assessment criterion derived from BS5228-1:2009+A1:2014. The assessment has determined that noise levels associated works on the main site area (i.e. not including the site access roads) do not exceed the adopted criterion, resulting in an effect significance of **negligible** (not significant) at local receptors. Further calculations have been undertaken to consider potential construction noise impacts associated with the formation of the start of the eastern site access, as this would be in closer proximity to the existing dwellings of Burnside and Guildhall Cottage (than works on the main site area). These have identified that with appropriate mitigation in place, an effect significance of **moderate** would arise, but this would be temporary, local and of very short duration. These effects would reduce as the access road works progress into the site and away from these receptors.

11.11.4 It has been identified that noise level changes arising on the A76(T) and the C125(N) from construction related traffic would be small, corresponding an effect significance of **negligible** (not significant). This assessment accounts for limiting the C125N access to use by cars and LGVs only, with the all HGV construction traffic utilising the western access which is removed from local receptors.

11.11.5 Drawing upon the guidance and historic measurement data contained within BS 5228-2:2009+A1:2014, the set-back distances at which different degrees of human perception to vibration would arise have been determined for a sample of different construction operations. It has been identified that local receptors are sufficiently removed from proposed construction works such that the effect significance would be **negligible** to **minor** at worst (not significant).

11.11.6 The assessment of operational noises levels has been undertaken in accordance with the guidance contained within ETSU-R-97 and the IoA GPG and has considered the potential cumulative effect of the Proposed Development when operating simultaneously with the existing Hare Hill Wind Farm and the approved Sanquhar Community Wind Farm, the Hare Hill Extension Wind Farm and Sanquhar Six Wind Farm.

11.11.7 Drawing upon the results of a detailed background noise survey, a series of noise level limits have been derived in accordance with ETSU-R-97, for both the daytime and night-time periods, appropriate to protect both the outdoor amenity and the sleep of local residents. These limits have been derived taking into account the site specific wind shear and reflect financial involvement in the Proposed Development where this is the case.

11.11.8 For a sample of the closest receptors to the site which either have a financial involvement in the Proposed Development or do not have a financial involvement in the Proposed

Development or the considered cumulative developments, predicted cumulative noise levels have been compared against the derived limits. It has been identified that the cumulative noise levels would be below the derived limits at all of these receptors during both daytime and night-time periods, confirming compliance with the ETSU-R-97 guidance.

11.11.9 For Hillend, which has a financial involvement in the Hare Hill Extension Wind Farm, but not the Proposed Development, residual daytime and night-time noise level limits have been determined by compliance with the noise limits derived for the Consented Development, following the method used in the Consented Development ES. In accordance with the IoA GPG, an example apportionment was made by splitting these residual limits between the 3 other proposed developments for which valid planning applications were lodged at the time of the Consented Development ES (the Proposed Development, Sanquhar Six Wind Farm and Hare Hill Extension Wind Farm). It has been demonstrated how, with use of an appropriate noise management scheme, the noise levels generated by the Proposed Development could be controlled to ensure compliance with the apportioned limits, thereby demonstrating compliance with the ETSU-R-97 guidance. It should be noted that the apportionment used constitutes only an example at this stage to demonstrate the principle of compliance. It should also be noted that the noise management scheme derived to demonstrate compliance with the apportioned noise level limits has been prepared for downwind propagation from all wind turbines. Less constraining management schemes will be available during side wind and upwind propagation conditions, whilst still being able to comply with the apportioned noise level limits.

11.11.10 The magnitude of the impact from operational turbine noise has been identified to be slight to low, corresponding to an effect significance of **Negligible** to **Minor** (not significant).

11.11.11 It has been demonstrated how compliance with noise level limits could be achieved to ensure a commensurate level of protection against any fixed (non-turbine) plant noise associated with the development, in accordance with the guidance contained within BS 4142:2014. Accordingly, potential fixed plant noise impacts will be of slight magnitude corresponding to an effect significance of **negligible** (not significant).

11.11.12 It has been demonstrated that the Proposed Development design and the mitigation measures proposed achieve the criteria derived in accordance with BS 5228:2009, BS 4142:1997 and ETSU-R-97. This in turn has demonstrated that the scheme can achieve compliance with relevant planning policy at the national, regional and local level.

11.11.13 Accordingly, noise or vibration need not be considered a determining factor in granting planning approval for this development.

11.11.14 In summary, the completed noise and vibration assessment has drawn upon national and local planning guidance, and current best practice, and it has been identified that with appropriate mitigation measures in place, potential impacts can be controlled to within appropriate levels of significance and durations. Table 11.39 provides a summary of the noise and vibration effects.

11.11.15 The predicted residual significant effects for the Proposed Development are exactly the same as those which would arise from the 'do-nothing scenario', which would result in the implementation of the Consented Development.

11.11.16 The Consented Development includes a noise limit condition as follows:

"…at wind speeds not exceeding 12 m/s as measured or calculated at a height of 10m above ground level at the wind farm, the wind farm noise immission level at any dwelling existing at the time of this permission shall comply with the following with regards only to the cumulative contributions from all wind farms that are either operational or consented on or before the date of this permission and operating within their agreed limits:

(a) During night time hours, as defined in ETSU-R-97 as 23.00 to 07.00 on all days, the cumulative wind farm noise immission level shall not exceed 43 dB $L_{A90,\ 10\ min}$ or the ETSU-R-97 derived "night hours" noise limit based on the measured LA90, 10 min background noise level plus 5dB(A), whichever is the greater;

(b) At all other times, the wind farm noise immission level shall not exceed 35dB $L_{A90,\ 10\ min}$ or the ETSU-R-97 derived "quiet waking hours" noise limit based on the measured $L_{A90,\ 10\ min}$ background noise level plus 5dB(A), whichever is the greater.

(c) The above cumulative noise immission limits may be increased to 45 dB $L_{A90,\ 10\ min}$ or the relevant ETSU-R-97 derived "quiet waking hours" or "night hours" noise limit based on the measured $L_{A90,\ 10\ min}$ noise level plus 5dB(A), whichever is the greater, when measured at any dwelling owned by persons with financial involvement with the wind farm.

(d) Measured background noise levels referred to in this condition shall be those recorded by the regression lines in the ES and associated appendices."

11.11.17 The Proposed Development can meet the conditioned noise limits of the Consented Development.

11.11.18 The EIA Regulations, at Schedule 4, require the EIA Report to provide a

"description of the likely significant effects of the development on the environment resulting from, inter alia:

… (e) the cumulation of effects with other existing and/or approved development, taking into account any existing environmental problems relating to areas of particular environmental importance likely to be affected or the use of natural resources;"

11.11.19 In this regard, the Proposed Development would be indiscernible from the Consented Development.

Table 0.39 – Summary of Proposed Development Effects

Description of Effect	Potential Effect		Mitigation	Residual Effect	
	Significance	Adverse/Beneficial		Significance	Adverse/Beneficial
Construction and decommissioning					
Construction Noise	Negligible, to occasionally Moderate to Major (temporary, local)	Adverse	Adoption of Best practice mitigation measures to include: All plant items to be properly maintained and operated; works to take place during normal construction hours and not at night. Good local communications	**Negligible**, to occasionally Minor to Moderate (temporary, local)	Adverse
Construction Traffic Noise	Negligible (temporary local)	Adverse	Appropriate timing of arrivals and departures. No night-time movements for general construction. No unnecessary idling or waiting at site access	**Negligible** (temporary local)	Adverse
Construction Vibration	Negligible to Minor (temporary local)	Adverse	-	**Negligible** to **Minor** (temporary local)	Adverse
Operation					
Operational Wind Turbine Noise	Negligible to Minor (permanent local)	Adverse	Implementation of appropriate noise management scheme.	**Negligible** to **Minor** (permanent local)	Adverse
Fixed (non-turbine) Noise	Negligible (permanent local)	Adverse	Incorporation of appropriate mitigation scheme, where necessary, to comply with derived limits	**Negligible** (permanent local)	Adverse

No changes in impacts anticipated as a result of cumulative effects

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