13 Noise

Introduction

13.1 This chapter contains an assessment of the acoustic effect of the proposed Solwaybank Wind Farm. The chapter assesses wind farm operational noise and its effects upon the most acoustically sensitive neighbours in addition to noise effects during the construction period. As the emphasis of this chapter is on operational noise, potential effects during the operational phase are considered prior to potential construction effects. It is recognised that this is different to the approach adopted for the remaining assessment chapters.

13.2 This assessment has been undertaken by RES, with at least one in-house Member of the Institute of Acoustics involved in its production. RES has undertaken acoustic impact assessments for all its UK wind farm applications since 2000 (more than 30 wind farms in total). RES has also carried out noise assessments and reported to several local authorities on wind energy projects including taking measurements on newly constructed wind farms to ensure compliance with planning conditions.

Operational Noise

13.3 Noise levels from turbines are generally low and, under most operating conditions, it is likely that turbine noise would be completely masked by wind generated background noise such as the sound of wind blowing through trees and around buildings.

13.4 Noise is measured in decibels (dB) which are a measure of the sound pressure level, i.e. the magnitude of the pressure variations in the air. Measurements of environmental noise are usually made in dB(A) which includes a correction for the sensitivity of the human ear. Table 13.1 indicates the noise generated by wind turbines compared with other everyday activities (PPS22, 2004).

Table 13.1: Noise Generated by Wind Turbines Compared with Other Everyday Activities

Source/Activity	Indicative Noise Level dB(A)
Threshold of Pain	140
Jet aircraft at 250 m	105
Pneumatic drill at 7 m	95
Truck at 30 mph at 100 m	65
Busy general office	60
Car at 40 mph at 100 m	55
Wind farm at 350 m	35-45
Quiet bedroom	20
Rural night-time background	20-40
Threshold of hearing	0

13.5 As described by the Scottish Government in Onshore Wind Turbines Renewable Advice (Scottish Government, 2011):

"Technically, there are two quite distinct types of noise sources within a wind turbine - the mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise produced by the passage of the blades through the air. There has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design." (Scottish Government, 2011)

Construction Noise

13.6 The sources of construction noise, which are temporary, will vary both in location and their duration as the different elements of the wind farm are constructed and will arise primarily through the operation of large items of plant.

13.7 Noise will also arise due to the temporary increase in construction traffic near the site; this level also depends on the element of the wind farm being constructed.

Legislative Framework & Guidance

Operational Noise

13.8 Within Scotland, noise is defined within the planning context by 'Planning Advice Note 1/2011: Planning and Noise' (PAN 1, 2011). This Planning Advice Note provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. It supersedes Circular 10/1999 Planning and Noise and PAN 56 Planning and Noise. Planning Advice Note 1/2011 states that:

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

13.9 For wind turbines in Scotland, Planning Advice Note 1/2011 refers to the use of the Department of Trade and Industry's 'The Assessment and Rating of Noise from Wind Farms' (ETSU, 1996), hereafter referred to as 'ETSU-R-97', in the web based planning advice on renewable technologies for Onshore wind turbines (Scottish Government, 2011). In relation to noise from wind farms, the web-based renewables advice states:

"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."

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

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

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

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

"Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities." (ETSU, 1996)

13.14 ETSU-R-97 provides a robust basis for assessing the noise effect of a wind farm and has been applied at the vast majority of wind farms currently operating in the UK and is proposed as adequate for use in this assessment. This approach is consistent with relevant planning policy and has been agreed with the Dumfries and Galloway Council Environmental Health Officer, as appropriate (see Table 13.2 on consultation).

13.15 An article published in the Institute of Acoustics Bulletin Vol 34 No 2, March/April 2009 (Institute of Acoustics, 2009), recommends a methodology for addressing issues not made explicit by, or outside the scope of, ETSU-R-97, such as in relation to wind shear or noise propagation modelling. This article was authored by a group of independent acousticians experienced in wind farm noise issues working for wind farm developers, local planning authorities and third parties. The assessment presented herein adopts the recommendations made within this article.

Construction Noise

13.16 In the web based Scottish Government technical advice on construction noise assessment in 'Appendix 1: Legislative Background, Technical Standards and Codes of Practice' (Scottish Government, 2011) it is stated that:

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

13.17 This refers to BS 5228-1:2009 'Noise control on construction and open sites' Part 1 – Noise (BSI, 2009) and is identified as being suitable for the purpose of giving guidance on appropriate methods for minimising noise from construction activities, and is adopted herein.

Effects Assessed in Full

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

Operational Noise

13.19 The main focus of the acoustic impact assessment of operational noise from the wind farm presented here is based on the two most relevant types of noise emission for modern wind turbines: 'broadband' and 'tonal' noise, both of which are types of 'audible noise'. Implicitly incorporated within this assessment is the normal character of the noise associated with wind turbines, commonly referred to as 'swish') and consideration of a range of noise frequencies, including low frequencies.

Construction Noise

13.20 The acoustic impact assessment of construction noise from the wind farm presented here is based on the operation of the primary large items of construction equipment. Additionally, consideration is given to the increased noise levels due to increased traffic flows during the construction phase to, and from, the site.

13.21 Whilst noise will also arise during decommissioning of the wind farm (through turbine deconstruction and breaking of the exposed part of the concrete bases) this is not discussed separately as noise levels resulting from it are expected to be lower than those from the construction activity.

Effects Scoped Out

13.22 A number of potential effects during the operational phase of the wind farm have been 'scoped out'. These are discussed below.

Low Frequency Noise

13.23 The frequency range of 'audible noise' is generally taken to be 20 Hz to 20,000 Hz, with the greatest sensitivity to sound typically in the central 500 Hz to 4,000 Hz region. The range from 10 Hz to 200 Hz is generally used to describe 'low frequency noise', and noise with frequencies below 20 Hz used to describe 'infrasound', although there is sometimes a lack of consistency regarding the definition of these terms in both common usage and the literature. Low frequency noise is always present, even in an ambient 'quiet' background. It is generated by natural sources, including the sea, earthquakes, the rumble of thunder and wind. It is additionally an emission from many artificial sources found in modern life, such as household appliances (e.g. washing machines, dishwashers) and all forms of transport.

13.24 Noise emitted from wind turbines covers a broad spectrum from low to high frequencies. In 2004, a number of articles in the national press alleged that low frequency noise from wind turbines may give rise to adverse health effects.

13.25 One study on this issue is 'Assessment of Low Frequency Noise from the Proposed West Mill Wind Farm Watchfield' carried out by Dr Geoff Leventhall for Vale of the White Horse District Council, 8th March 2004 (Leventhall, G, 2004). Analysis in the low frequency region confirmed the presence of tonal peaks. However, the levels were below the average hearing threshold.

13.26 Leventhall (Leventhall, 2003) notes that despite the numerous published studies, there is little or no agreement about the biological effects of low frequency noise on human health and, in fact, direct evidence of adverse effects of exposure to low-intensity levels of low frequency noise (less than 90 dB) is lacking. He further notes that high levels of low frequency noise are required to exceed the hearing thresholds at these lower frequencies.

13.27 In February 2005, the BWEA[1] published background information on low frequency noise from wind farms (BWEA, 2005). The conclusion to this states that:

"It has been repeatedly shown, by measurements of wind turbine noise undertaken in the UK, Denmark, Germany and the USA over the past decade, and accepted by experienced noise professionals, that the levels of low frequency noise and vibration radiated from modern upwind configuration wind turbines are at a very low level; so low that they lie below the threshold of perception, even for those people who are particularly sensitive to such noise, and even on an actual wind turbine site". (BWEA, 2005)

[1] BWEA is now known as RenewableUK, a group representing the concerns of companies in the Renewable Energy Industry.

13.28 In May 2006, the DTI published a report on research by the Hayes McKenzie Partnership into claims that low frequency noise and/or infrasound emitted by wind turbines was causing human health effects (Hayes, 2006). The report concluded that there was no evidence that this was the case.

13.29 Whilst low frequency content of the noise from wind farms shall be considered through the use of octave band specific noise emission and propagation modelling within the assessment presented here, it is considered that specific and targeted assessment on low frequency content of noise emissions from the proposed wind farm is unjustified. Low frequency noise is therefore 'scoped out' of the assessment.

Infrasound

13.30 In relation to infrasound, Leventhall states that frequencies below 20 Hz may be audible, although tonality is lost below 16 - 18 Hz, thus losing a key element of perception (Leventhall, 2003). He concludes that people can be reassured that there will be no serious consequences to peoples' health from infrasound exposure.

13.31 The authors of the BWEA report explain that:

"The infrasound generated by wind turbines can only be detected by the most sensitive equipment, and again this is at levels far below that at which humans will detect the low frequency sound. There is no scientific evidence to suggest that infrasound has an impact on human health." (BWEA, 2005)

13.32 The BWEA report goes on to quote Leventhall, author of the DEFRA report on 'Low Frequency Noise and its Effects' (BWEA, 2005), as saying:

"I can state, quite categorically, that there is no significant infrasound from current designs of wind turbines". (BWEA, 2005)

13.33 A study by DEWI (The German Wind Institute) (Klug, 2002) made infrasound measurements on a V66-1.65 MW wind turbine. The study concluded that the level of infrasound emitted by the wind turbine was far below the threshold of human perception (30 dB below). Yearlong studies have also found that infrasound which cannot be heard is completely harmless and therefore that no danger is posed by wind turbines (Ising, Makrert, Schenoda, & Schwarze, 1982).

13.34 Therefore, in accordance with literature, it is not considered appropriate or relevant to undertake specific assessment in relation to infrasound for the proposed wind farm. Infrasound is therefore 'scoped out' of the assessment.

Vibration

13.35 Structure borne noise, originating in vibration, is also low frequency, as is neighbour noise heard through a wall, since walls generally block higher frequencies more than lower frequencies.

13.36 A report by Snow gives details of low frequency noise and vibration measurements made at a wind farm (Snow, 1997). Measurements were made both on the wind farm site, and at distances of up to 1 km. It was found that the vibration levels at 100 m from the nearest turbine itself were a factor of 10 lower than those recommended for human exposure in the most critical buildings (i.e. laboratories for precision measurements), and lower again than the limits specified for residential premises (BSI, 1992). Noise and vibration levels were found to comply with recommended residential criteria, even on the wind turbine site itself, and the acoustic signal was below the generally assumed frequency range of audible noise, i.e. below 20 Hz. In addition, it was found that there was no clear relationship between vibration levels and wind speed, and that some vibrations appeared to come from other sources, as they were found even when the turbines were switched off.

13.37 More recently, in 2004/2005, researchers at Keele University investigated the effects of the extremely low levels of vibration resulting from wind farms on the operation of the seismic array at Eskdalemuir - one of the most sensitive installations in the world. The results of this study have frequently been misinterpreted and, to clarify the position, the authors have explained that:

"The levels of vibration from wind turbines are so small that only the most sophisticated instrumentation and data processing can reveal their presence, and they are almost impossible to detect" (Styles & Toon, 2005)

13.38 They continue to say:

"Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise - they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health" (Styles & Toon, 2005)

13.39 Therefore, in accordance with literature, it is not considered appropriate or relevant to undertake specific assessment in relation to vibration caused by the operation of the proposed wind farm. Vibration is therefore 'scoped out' of the assessment.

Excessive Aerodynamic Modulation

13.40 The noise associated with wind turbines and commonly referred to as 'Swish' is the modulation of aerodynamic noise produced at blade passing frequency (the frequency at which a blade passes a fixed point). This noise character is acknowledged by, and accounted for, in the recommendations of ETSU-R-97. However, the aforementioned DTI report (Hayes, 2006) researching low frequency noise and/or infrasound emitted by wind turbines noted that a related phenomenon known as 'Aerodynamic Modulation' (AM), alternatively referred to as 'Amplitude Modulation', was, in some isolated circumstances, occurring in ways not anticipated by ETSU-R-97.

13.41 In consequence the statement (BERR, 2007) makes it clear that the approach contained in the ETSU-R-97 report, to assess and rate noise from wind energy developments (ETSU, 1996), is still recommended. Therefore, in accordance with literature and advice, it is not considered appropriate or relevant to undertake specific assessment in relation to AM above and beyond that considered by ETSU-R-97 that may be potentially produced by the operation of the proposed wind farm.

13.42 To investigate whether or not AM was an issue which might require attention in the context of the rating advice in ETSU-R-97, the Government subsequently commissioned the University of Salford to undertake further research in the area (DTI, 2006). On 1 August 2007, the Government issued a statement (BERR, 2007) regarding the findings of the University of Salford report into AM of wind turbine noise (University of Salford, 2007) published earlier in 2007 which found that, of 133 operational wind farms in the UK at the time of the report, there were only 4 cases where AM may have been a factor. It is known that complaints have now subsided for 3 of these cases (one due to introduced mitigation by a wind farm control system) and in the remaining case, investigations are ongoing. The statement says that:

"…the Government does not consider there to be a compelling case for further work into AM and will not carry out any further research at this time."

13.43 Aerodynamic Modulation is therefore 'scoped out' of the assessment.

Wind Turbine Syndrome

13.44 The condition proposed by paediatrician Dr Nina Pierpont in her report 'Wind Turbine Syndrome: A Report on a Natural Experiment' (Pierpont, 2009) cites a range of physical sensations and effects as being caused by living near a wind farm. This study is based on a series of interviews comprising a study group of 10 families. It is a self published report with none of the research being published in any peer reviewed medical journal.

13.45 In an NHS response to the Pierpont report, a report titled 'Are wind farms a health risk?' (NHS, 2009) states that there is no conclusive evidence that wind turbines have an effect on health or are causing the set of symptoms described as 'wind turbine syndrome'. It was noted that the group study by Pierpont was not sufficient to grant the claims stated.

13.46 A scientific advisory panel conducted a review of current literature available on the issue of perceived health effects of wind turbines 'Wind Turbine Sound and Health Effects - An Expert Panel Review' (Colby, 2009). This was carried out by the American and Canadian Wind Energy Associations and the conclusion on Wind Turbine Syndrome was that it is:

"not a recognized medical diagnosis, is essentially reflective of symptoms associated with noise annoyance and is an unnecessary and confusing addition to the vocabulary on noise."

The report went on to say:

"There are no unique symptoms or combinations of symptoms that would lead to a specific pattern of this hypothesized disorder."

13.47 An independent review of the state of knowledge about the alleged health condition was carried out (RenewableUK, 2010). This report includes three expert opinions provided by: Richard J.Q. McNally - Reader in Epidemiology at the Institute of Health and Society Newcastle University; Geoff Leventhall - an independent consultant specialising in low frequency noise, infrasound and vibration; and Mark E. Lutman - Professor of Audiology at the University of Southampton. Their critique of Pierponts study concludes that the reported symptoms are the effects mediated by stress and anxiety when exposed to an adverse element in their environment. There is no evidence that they are patho-physiological effects of wind turbine noise.

13.48 Therefore, in accordance with literature, it is not considered appropriate or relevant to undertake specific assessment in relation to 'Wind Turbine Syndrome' potentially caused by the operation of the proposed wind farm. 'Wind Turbine Syndrome' is therefore 'scoped out' of the assessment.

Issues Identified during Consultation

13.49 The consultation undertaken is outlined in Table 13.2. Consultation was undertaken before the original 2009 application (in 2005 and 2009) and again during this assessment (2011)

Table 13.2: Acoustic Assessment Consultation

Consultees	Date of Consultation	Nature and Purpose of Consultation
DGC	14-Nov-05	Letter "Background Noise Survey for the Proposed Solwaybank Wind Farm" (ref. 01307L00044) sent to Kenneth Green, Senior Planning Officer, Dumfries and Galloway Council outlining proposed measurement locations and assessment methodology.
Dumfries and Galloway Council	16-Nov-05	Response received from David Suttee, Area Planning Manager (Annandale and Eskdale), Dumfries and Galloway Council suggesting additional survey locations.
Dumfries and Galloway Council	23-Nov-05	Phone call and e-mail with Richard Proctor, Environmental Health Officer (EHO), Dumfries and Galloway Council agreeing choice of survey locations.
Dumfries and Galloway Council	20-Dec-05	Email to Richard Proctor (EHO) confirming deployment of sound level meters at agreed survey locations.
Dumfries and Galloway Council	13-Feb-09	Scoping opinion provided by Richard Proctor (EHO)
Dumfries and Galloway Council	16-Mar-11	Letter "Solwaybank Detailed Scoping" (ref. 01307-001729) sent to Richard Proctor (EHO) detailing proposed assessment methodology.
Dumfries and Galloway Council	20-Jun-11	Confirmation e-mail from Richard Proctor (EHO) that proposed methodology is appropriate for use.

Assessment Methodology

Operational Noise

13.50 To ensure adequate assessment of the potential effects of the operational noise from the proposed wind farm, the following steps have been taken, in accordance with relevant guidance detailed above:

- The baseline noise conditions at each of the nearest neighbours to the wind farm are established by way of representative background noise surveys – refer to paragraph 13.78
- The noise levels at the nearest neighbours due to the operation of the proposed wind farm using a sound propagation model are calculated giving due regard to: the locations of the wind turbines; the locations of the nearest, or most noise sensitive neighbours; and the likely noise emission characteristics of the wind turbines. Refer to paragraph 13.91
- With due regard to relevant guidance or regulations, the acoustic assessment criteria are derived – refer to paragraph 13.97
- The evaluation of the acoustic effect is undertaken by comparing the estimated noise levels with the noise assessment criteria – refer to paragraph 13.100

Method for Establishing Baseline Conditions

13.51 Similar to other assessments of noise effects (most notably BS 4142, "The Method for Rating Industrial Noise affecting Mixed Residential and Industrial Areas" which ETSU-R-97 identifies as forming the basis of its recommendations), the ETSU-R-97 methodology recommended for assessment of wind farm noise is to compare likely noise levels due to turbine emissions (which vary with hub height wind speed) with noise limits based upon the noise levels existing under those same conditions (i.e. the baseline conditions).

13.52 Since background noise levels depend upon wind speed, as indeed do wind turbine noise emissions, it is important when making reference measurements to put them in that context. Thus, the assessment of background noise levels at potentially sensitive neighbouring locations requires the

measurement of not only noise levels, but concurrent wind conditions, covering a representative range of wind speeds. These wind measurements are made at the wind turbine site rather than at the properties, since it is this wind speed that will subsequently govern the wind farm's noise generation. Often the neighbouring properties themselves will be sheltered from the wind and will consequently have relatively low background noise.

13.53 To establish the baseline conditions, sound level meters and associated apparatus are set-up to record the required acoustic information at a selection of locations which are the most noise sensitive dwellings geographically spread around the proposed site and are likely to be representative of other houses in the locale.

13.54 This equipment is housed in weather-proof enclosures, and powered by lead-acid batteries. The microphones are placed at a height of 1.2 - 1.5 m above ground, and equipped with all-weather wind shields to provide an element of water resistance.

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

13.56 Wind speed and direction are recorded by a data logger mounted on a meteorological mast as 10 min averages for the same period as for the noise measurements, and are synchronised with the acoustic data to allow correlations to be established. The wind speed that is adopted for use is the same wind speed as that which drives the turbine noise levels.

13.57 The adoption of this wind speed was presented as appropriate within the article published in the Institute of Acoustics Bulletin (Institute of Acoustics, 2009). Paragraphs 13.59 to 13.62 provide details on the standardised wind speed calculations used for correlation.

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

- For each background noise measurement location, the measured noise data have been divided into two sets, as specified by ETSU-R-97 and shown in Table 13.3.

Table 13.3: Definition of Time of Day Periods

Time of Day	Definition
Quiet waking hours	• 18:00 - 23:00 every day • 13:00 - 18:00 Saturday • 07:00 - 18:00 Sunday
Night-time hours	• 23:00 - 07:00 every day

- Rainfall affected data is systematically removed from the acoustic data set. To do this, a rain gauge is deployed at site to record 10 minute rainfall data and identify potentially affected data.
- Periods of measured background noise data thought to be affected by extraneous noise sources, i.e. non-typical, and generally identified by means of inference, are removed from the acoustic data set. In practice, this means close inspection of the measured background noise data and comparison with concurrent data measured at nearby locations. Such analysis considers directional and temporal variation in the background noise for all survey locations. Whilst some 'extraneous' data may actually be real, in practice it tends to bias any trend lines upwards, so its removal is adopted as a conservative measure.

Calculating Standardised Wind Speed

13.59 In order to derive appropriate noise limits, the ETSU-R-97 guidance requires the correlation of background noise survey data with wind speed data referenced to 10 m height. In contrast to this, acoustic emission measurements on wind turbines are undertaken following an international standard which specifies that the turbine noise emission should be reported as a function of a 'standardised' wind speed at 10 m height. In practice, this translates as extrapolation of wind speed at hub height down to 10 m height, using a specified, and fixed, relationship.

13.60 However, whilst there are good reasons for this approach, for example it allows developers to compare noise emission data from different makes and models of wind turbine, it does create potential problems. If for example, the wind shear on a site where the turbines are to be deployed differs from the assumed values/model, the result is that, for a given 'standard' wind speed at 10 m height, the hub height wind speed may be very different. The consequence is that the turbine generates a different amount of power, and emits a different level of sound power, than might be expected from the standardised wind speed alone.

13.61 Two options are available in order to reconcile potential anomalies:

- The turbine sound power levels are re-calculated taking due consideration of site-specific wind shear.
- The noise limits are derived with reference to the same wind speed as the turbine noise levels.

13.62 In this assessment, RES has chosen to apply the second option. This approach was presented as appropriate by a group of independent acoustic consultants working for wind farm developers, local planning authorities and third parties in an article published in the Institute of Acoustics Bulletin (Institute of Acoustics, 2009). The methodology outlined below therefore is employed to those wind speeds measured on-site concurrently with the background noise survey:

1) Wind Speeds are Calculated for Hub Height

Where hub height wind speed has not been directly measured this may be estimated by extrapolating the wind speed measured at the uppermost anemometer to the hub height by use of the measured wind shear exponent. The wind shear exponent is a commonly used, empirically based, engineering description of the rate of change of wind speed with height and may vary according to atmospheric conditions and be affected by interactions between ground features and the wind flow.

It therefore follows that the hub height wind speed for each 10-minute period may be calculated from the wind speed measured at the uppermost anemometer and the calculated wind shear exponent.

2) 'Standardised' 10 m Wind Speeds are Calculated

The reporting of wind turbine noise emissions is carried out according to the international standard IEC 61400-11, 'Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques'. This standard specifies that the sound power level for the turbine is reported as a function of the 'standardised' wind speed at 10 m height. It should be noted that this standardised wind speed is not the wind speed that would be expected to be measured at 10 m height for any specific hub height wind speed, rather better considered as a proxy for the hub height wind speed (the primary driver of noise emission from the turbine).

The 'standardised' wind speed is calculated by extrapolating the hub height wind speed to 10 m height.

3) Correlation of 'Standardised' 10 m Wind Speeds with Background Noise Data

The standardised 10 m wind speed is correlated with the measured background noise survey data.

Method for Modelling Noise Propagation

13.63 Whilst there are several sound propagation models available, in this assessment RES has used the ISO 9613 Part 2 model (ISO, 1996), this being identified as most appropriate for use in such rural sites (ETSU, 2000). The specific interpretation of the ISO 9613 Part 2 propagation methodology has been employed as in the aforementioned Institute of Acoustics bulletin article (Institute of Acoustics, 2009) – refer to paragraph13.62.

13.64 To make noise predictions, it is assumed that:

- the turbines are identical
- the turbines radiate noise at the power specified in this assessment
- each turbine can be modelled as a point source at hub-height
- each dwelling is assigned a reference height to simulate the presence of an observer.

The model takes account of:

- attenuation due to geometric spreading
- atmospheric absorption
- ground effects
- barrier effects.

13.65 The barrier attenuations predicted by ISO 9613 Part 2 have been shown to be significantly greater than those measured in practice under downwind conditions (ETSU, 2000). Therefore, barrier attenuation according to the ISO 9613 Part 2 method has been discounted. In lieu of this, where there is no direct line of sight between the property in question and any part of the wind turbine, a 2 dB attenuation has been assumed, as recommended in the aforementioned Institute of Acoustics bulletin article (Institute of Acoustics, 2009).

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

13.67 The predicted noise levels are changed from the L_{Aeq} to the L_{A90} descriptor (to allow comparisons to be made) by the use of an adjustment factor of -2 dB, as specified by ETSU-R-97.

13.68 It has been shown by measurement based verification studies that the ISO 9613 Part 2 model tends to slightly over-estimate noise levels at nearby dwellings (ETSU, 2000). Examples of additional conservatism modelled are:

- downwind propagation is modelled in all directions. In reality, noise propagation biases towards downwind locations, therefore predicted values are over-estimations upwind and crosswind of the proposed wind turbines
- although, in reality, the ground is predominantly porous (acoustically absorptive) it has been modelled as 'mixed', i.e. a combination of hard and porous, corresponding to a ground absorption coefficient of 0.5 as recommended by the Institute of Acoustics bulletin article (Institute of Acoustics, 2009)
- receiver heights are modelled at 4.0 m above local ground level, which equates roughly to first floor window level. This results in a predicted noise level anything up to 2 dB(A) higher than at the 'standard' assessment height of 1.2 - 1.8 m
- trees and other non-terrain shielding effects have not been considered

Method for Deriving the Assessment Criteria

13.69 As discussed earlier, measurements of environmental noise are usually made in dB(A) which includes a correction for the sensitivity of the human ear. Table 13.4 indicates the subjective effect of changes in noise level (Barber, 1992).

Table 13.4: Subjective Effect of Change in Noise Level

Change in Level (dB)	Subjective Effect
3	Just perceptible
5	Clearly perceptible
10	Twice as loud

13.70 In accordance with the recommendations of ETSU-R-97, the acceptance of the proposed wind farm is established by comparing the noise levels produced by the combined operation of the wind turbines with appropriate noise limits at nearby residential properties.

13.71 Whilst ETSU-R-97 presents a comprehensive and detailed assessment methodology for wind farm noise, it also states a simplified methodology:

"if the noise is limited to an $L_{A90,10min}$ of 35dB(A) up to wind speeds of 10 m/s at 10 m height, then these conditions alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary" (ETSU, 1996).

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

Table 13.5: Permissible Noise Level Criteria

Time of Day	Permissible Noise Level
Quiet waking hours	• 35-40 dB(A) for L_B less than 30-35 dB(A) • L_B + 5 dB, for L_B greater than 30-35 dB(A)
Night-time hours	• 43 dB(A) for L_B less than 38 dB(A) • L_B + 5 dB, for L_B greater than 38 dB(A)

13.73 A higher noise level is permissible during night-time hours than during quiet waking hours, as it is assumed that residents would be indoors. The night-time criterion is derived from sleep disturbance

criterion referred to in ETSU-R-97, with an allowance of 10 dB for attenuation through an open window.

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

Method for Construction Noise Assessment

13.75 To ensure adequate assessment of the potential effects of the construction noise from the proposed wind farm the following steps have been taken:

- Baseline noise criteria are established from the appropriate guidance BS 5228-1:2009 'Noise control on construction and open sites' (BSI, 2009) – refer to paragraph 13.84
- Noise predictions are made at the most critically sensitive properties due to on-site construction activities. These are calculated using the BS 5228-1:2009 standard – refer to paragraph 13.105
- Predictions are made at the same properties due to construction traffic and are calculated using the BS 5228-1:2009 standard – refer to paragraph 13.108
- The combined effect of on-site construction activities with construction traffic is compared with the target level specified by BS 5228-1:2009 – refer to paragraph 13.112

13.76 As acceptable limits for construction and operational noise are defined in guidance, the 'test' for assessment purposes is whether or not noise levels are below these levels. If predicted noise levels are below the defined thresholds, the noise is considered acceptable; if predicted noise levels are above the defined thresholds, the noise is considered 'unacceptable'. Unacceptable noise levels are considered to equate to significant effects in accordance with the EIA Regulations.

Baseline Conditions

Operational Noise

13.77 The proposed Solwaybank Wind Farm is located 1.5 km east of the village of Kirtleton and 7.6 km west of Langholm. The surrounding area is predominantly rural in nature with B-class roads running to the west and north of the site.

13.78 Background noise measurements were undertaken by RES in accordance with ETSU-R-97 as detailed in Table 13.6. Measurements were made at these locations as they are the most noise sensitive dwellings geographically spread around the proposed site and are likely to be representative of other houses in the locale. The background noise measurement locations were agreed in consultation with Dumfries and Galloway Council (RES, 2005). Subsequent consultation has confirmed that the data from this survey is still appropriate for use. The meter at Bigholms Cottages was installed at the same time as those at the other three properties but due to instrument error no data was recorded until 05/01/06. Sufficient data was captured to enable the background levels at this location to be calculated.

Table 13.6: Background Noise Survey Details

House Name	Measurement Period			Instrument Type
	Start	End	Duration (days)	
ALLFORNOUGHT	19/12/2005	18/01/2006	30	Rion NL31
BIGHOLMS COTTAGES	05/01/2006	18/01/2006	13	Rion NL31
KIRTLETON HOUSE	19/12/2005	18/01/2006	30	Rion NL31
PINGLE FARM	19/12/2005	18/01/2006	30	Rion NL31

13.79 The meters were placed in moderately exposed positions, away from reflecting walls and vegetation. Photos of the equipment, in situ, may be seen in **Appendix 13.1**. The apparatus were calibrated before and after the survey period and no significant drift was detected. All instrumentation had been subject to laboratory calibration traceable to national standards within the previous 24 months.

13.80 In **Appendix 13.2**, Chart 13.1 shows the measured wind rose at Solwaybank over the background noise survey period at three of the survey locations, 19/12/05 – 18/01/06, as measured by the meteorological mast located on site. Chart 13.2 shows the measured wind rose over the background noise survey period at Bigholms Cottages, 05/01/06 – 18/01/06.

13.81 For illustrative purposes, Chart 13.3 shows the measured wind rose over an extended period (21/03/2003 – 15/01/2008) from the meteorological mast located on the proposed wind farm site. As discussed before, the noise prediction model employed is likely to overestimate the real noise immission levels for locations not downwind of the turbines. Chart 13.3 therefore may aid the reader as to the likelihood of over-estimation due to this factor.

13.82 Charts 13.4-13.7 show $L_{A90,10min}$ correlated against wind speed for quiet waking hour periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the suggested noise limits added (see paragraph 13.97). Charts 13.8-13.11 show $L_{A90,10min}$ correlated against the wind speed for night-time periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the suggested noise limits added (see paragraph 13.97). Table 13.7 and Table 13.8 detail the $L_{A90,10min}$ background noise levels calculated from the derived 'best fit' lines, as described above:

Table 13.7: Quiet Waking Hours Noise Levels (dB(A) re 20 μPa)

House Name	Quiet Waking Hours Noise Levels at Indicated Locations Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
ALLFORNOUGHT	22.9	24.0	25.3	26.6	28.2	29.9	31.8	33.9	36.4	39.1	42.1	42.1
BIGHOLMS COTTAGES	27.0	27.0	28.2	29.4	30.4	31.4	32.6	33.9	35.4	37.1	37.1	37.1
KIRTLETON HOUSE	26.2	26.6	27.2	27.9	28.9	30.2	31.7	33.5	35.6	38.1	40.8	40.8
PINGLE FARM	24.4	24.4	24.8	25.5	26.6	28.1	29.9	32.1	34.5	37.2	40.1	40.1

Table 13.8: Night-time Noise Levels (dB(A) re 20 μPa)

House Name	Night Time Noise Levels at Indicated Locations Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
ALLFORNOUGHT	22.4	22.6	23.4	24.7	26.6	28.8	31.5	34.5	37.7	41.2	41.2	41.2
BIGHOLMS COTTAGES	25.9	25.9	27.3	28.3	29.2	30.1	30.9	31.9	33.1	34.8	34.8	34.8
KIRTLETON HOUSE	24.0	24.5	25.4	26.6	28.1	29.8	31.9	34.3	36.9	39.8	42.9	46.2
PINGLE FARM	22.4	22.7	23.4	24.6	26.1	28.0	30.2	32.7	35.5	38.5	41.8	45.4

Construction Noise

13.83 One of the factors affecting the acceptability of noise arising from construction sites is the existing background noise levels. The likelihood of complaint increases as the difference between the construction noise level and the existing background noise level increases. A method to determine the significance of construction noise levels is to consider the change in the ambient noise level with the construction noise.

13.84 Annex E of BS 5228-1:2009 'Code of practice for noise and vibration control on construction and open sites' Part 1 – Noise (BSI, 2009) provides guidance on setting environmental noise targets based upon noise change. The ABC method has been selected to assess the construction noise of the proposed Solwaybank wind farm. The ABC method allows the significance of noise levels to be assessed by setting threshold noise levels for specific periods based on the ambient noise levels. Further details can be found in Annex E.3.2 of BS 5228-1:2009 (BSI, 2009). For the proposed Solwaybank wind farm, the classification is Category A.

Future Baseline ('Do-nothing' Scenario)

13.85 In the absence of Solwaybank Wind Farm, it is likely that the site would continue to be grazed and used for commercial forestry. The future noise environment is not anticipated to differ significantly from the existing situation as identified in the baseline survey.

Wind Farm Layout Considerations

13.86 One of the key turbine layout design considerations was the minimisation of potential noise effects at the nearest residential receptors. As such, the turbine layout was designed to ensure a separation distance of at least ten rotor diameters between any of the proposed turbines and the nearest neighbour.

Potential Effects

Operational Noise

Noise Propagation Modelling

13.87 The locations of the proposed Solwaybank turbines (RES, 2011) are provided in Table 13.9 and all considered turbines are shown in Figure 13.1.

Table 13.9: Location of Proposed Turbines

Turbine	Co-ordinates		Elevation (m)
	Easting	Northing	
T1	329197	580210	228
T2	329443	579938	241
T3	329787	579724	239
T4	330033	579449	231
T5	330286	579195	226
T6	328722	580013	222
T7	328998	579716	231
T8	329268	579425	233
T9	329558	579165	228
T10	329941	578828	211
T11	328579	579503	207
T12	328825	579240	205
T13	329113	579022	213
T14	329535	578764	203
T15	328335	579769	205

13.88 The locations of the nearest neighbours to the turbines have been determined by inspection of relevant maps and through site visits. More properties may have been identified but have not been considered critical to this acoustic assessment or may be adequately represented by another property. The locations considered are listed in Table 13.10 and are also shown in Figure 13.1. Elevations, given in metres above mean sea level, have been determined from digital terrain data.

13.89 The distances from each house to the nearest turbine are given in Table 13.10. It can be seen that the minimum house-to-turbine separation is 938 m.

Table 13.10: Location of Nearby Neighbours & Distances to Nearest Proposed Turbine

House Name	OSGB Co-ordinates		Elevation (m)	Distance (m)	Nearest Turbine
	Easting	Northing			
ALLFORNOUGHT	329294	577858	172	938	T14
STABLE COTTAGE, EAST LINNBRIDGEFORD	326974	579529	149	1382	T15
EAST LINNBRIDGEFORD	326949	579514	147	1409	T15
BARN COTTAGE, EAST LINNBRIDGEFORD	326949	579514	147	1409	T15
MEGSFIELD	327603	580990	194	1424	T15
CALLISTERHALL	328925	581617	230	1433	T1

House Name	OSGB Co-ordinates		Elevation (m)	Distance (m)	Nearest Turbine
	Easting	Northing			
CHAPELHILL	327933	578102	143	1446	T12
CONHESS FARM	327649	578387	134	1453	T11
KIRTLETON HOUSE	326899	580144	140	1484	T15
HALSYKE	327087	578946	138	1495	T15
HALSYKE COTTAGE	327087	578946	138	1495	T15
CARVANNE, LAURIES CLOSE	326748	579927	138	1595	T15
LAURIES CLOSE COTTAGE	326747	579951	139	1598	T15
LAURIES CLOSE CHURCH	326727	579868	137	1611	T15
POKESKINE VIEW, LAURIES CLOSE	326722	579828	138	1614	T15
KIRTLETON LODGE	326755	580111	141	1617	T15
KIRTLE KNOWE	326722	579894	138	1618	T15
BARR COTTAGE, CANOBIE	330186	577218	149	1629	T10
SOLWAYBANK HOUSE	330757	577391	141	1653	T10
SOLWAYBANK	330757	577391	141	1653	T10
CONHESS COTTAGE	327229	578536	128	1656	T15
KIRTLETON FARM COTTAGE	326686	580026	142	1669	T15
WOODSIDE COTTAGE, SOLWAYBANK	331083	577577	123	1694	T10
BARR COTTAGE, WATERBECK	326840	580587	146	1704	T15
LINNBRIDGEFORD COTTAGE	326627	579481	145	1732	T15
WALLACEHALL EAST	328743	577215	161	1740	T14
LINNBRIDGEFORD MILL	326733	579066	128	1749	T15
SOLWAYBANK COTTAGE	330832	577322	134	1750	T10
WEST LINNBRIDGEFORD	326617	579350	145	1768	T15
BURNSTONES	326593	579434	145	1774	T15
SETTHORNS	326917	580838	154	1776	T15
COLLIN	330429	581507	165	1789	T1
DUNRAGIT	326724	580584	148	1805	T15
FALFORD LODGE	326772	580724	147	1832	T15
HIGH STENRIES	329022	576991	168	1846	T14
WALLACEHALL WEST	328551	577155	152	1886	T14
PINGLE FARM	332019	578373	130	1918	T5
HOLMFOOT	330609	581523	161	1928	T1
THE BEECHES	326669	578731	120	1963	T15
THE BEECHES (POULTRY LTD.)	326669	578731	120	1963	T15

House Name	OSGB Co-ordinates		Elevation (m)	Distance (m)	Nearest Turbine
	Easting	Northing			
2 BIGHOLMS COTTAGES	331140	581149	155	1965	T3
1 BIGHOLMS COTTAGES	331140	581149	155	1965	T3
1 RIGGFOOT, LINNBRIDGEFORD	326389	578877	126	2141	T15
2 RIGGFOOT, LINNBRIDGEFORD	326385	578869	126	2148	T15
RIGGFOOT HOUSE	326382	578825	125	2169	T15
BARNGLIESHEAD	332392	578594	140	2190	T5
PAITRICKHOLM	326609	578399	116	2204	T15
WESTFIELD COTTAGE	328123	577018	136	2235	T13
CROWDIEKNOWE COTTAGE	326126	580127	139	2238	T15
WESTWATER FARM	330465	582317	176	2459	T1
NORTH CRAIGS COTTAGE	326209	578525	112	2463	T15
NORTH CRAIGS	326209	578525	112	2463	T15
WATTAMAN	332137	577508	122	2504	T5
WESTWATER COTTAGE	330612	582316	174	2537	T1
SNAB FARM	327846	576787	152	2569	T13
SNAB CORNER	327652	576846	156	2621	T13
GREENCLEUCH	330392	582632	178	2701	T1
WINTERHOPE COTTAGE	327121	582190	167	2702	T6
FILTERMANS COTTAGE	327247	582289	175	2712	T6
WINTERHOPE FARM	327189	582283	174	2739	T6
KENNEDYS CORNER	327528	576679	156	2829	T13
BARNGLIES FARM	332856	577577	109	3037	T5
2 BARNGLIES COTTAGE	332765	577348	103	3091	T5
1 BARNGLIES COTTAGE	332776	577356	104	3095	T5
BLOCH FARM	332823	581273	150	3279	T5
1 CLEUCHFOOT COTTAGES	331755	582393	144	3316	T3
2 CLEUCHFOOT COTTAGES	331768	582395	145	3325	T3
OLD SCHOOLHOUSE	332514	581699	138	3349	T4

13.90 Although not finalised, the turbine type for the proposed Solwaybank wind farm is likely to be acoustically similar to the Vestas V90 2 MW machine. This assessment uses the acoustic data from the manufacturer's general specification from this machine for all analysis (Vestas, 2011). This turbine has sound power levels equal to or greater than other turbines in the 2.0 to 2.5 MW range. The manufacturer has identified these values as warranted and an uncertainty of 1 dB has been added to the warranted turbine noise levels to allow for measurement uncertainty. Details assumed in this analysis are as follows:

- a hub height of 80 m and a rotor diameter of 90 m (within the turbine size envelope assessed in **Chapter 8: Landscape and Visual** and elsewhere in the ES);
- sound power levels, LWA, for standardised 10 m height wind speeds (v10) as shown in Table 13.11;
- 1/1 octave band spectra, standardised 10 m height wind speeds (v10), as shown in Table 13.12;
- tonal emission characteristics such that no clearly audible tones are present at any wind speed

Table 13.11: Sound Power Levels for the Vestas V90 2 MW Wind Turbine

Standardised 10 m Height Wind Speed, v_{10} (ms^{-1})	A-Weighted Sound Power Level (dB(A) re 1 pW)	
	Warranted noise levels	+1dB uncertainty
4	95.6	96.6
5	99.8	100.8
6	102.8	103.8
7	103.7	104.7
8	104.0	105.0
9	104.0	105.0
10	104.0	105.0
11	104.0	105.0
12	104.0	105.0

Table 13.12: Assumed Octave Band Sound Power Level Spectra for the Vestas V90 2 MW Wind Turbine

Octave Band (Hz)	A-Weighted Sound Power Level at 10 m standardised wind speeds (dB(A) re 1 pW)			
	6 ms^{-1}	7 ms^{-1}	8 ms^{-1}	9 ms^{-1}
63	85.6	86.4	88.6	88.4
125	90.9	92.0	93.9	93.7
250	94.4	95.4	96.2	96.1
500	96.0	97.2	97.5	97.5
1000	97.2	98.1	97.4	97.7
2000	95.8	96.3	96.4	96.5
4000	92.0	92.5	93.4	92.9
8000	77.9	78.6	79.4	79.1
OVERALL	102.8	103.7	104.0	104.0

Predictions of Noise Levels at Receivers

13.91 Table 13.13 shows the predicted noise immission levels at the nearest neighbours at each wind speed considered, calculated from the operation of the proposed wind farm. The property with the highest predicted noise immission level is Allfornought at 37.3 dB(A) and is highlighted in bold.

13.92 Figure 13.1 shows an isobel (i.e. noise contour) plot for the site at a 10 m height wind speed of 8 ms^{-1}. Such plots are useful for evaluating the noise 'footprint' of a given development.

Table 13.13: Predicted Noise Levels At Nearby Dwellings (dB(A) re 20 μPa)

House Name	Reference Wind Speed (Standardised v_{10}) (ms^{-1})								
	4	5	6	7	8	9	10	11	12
ALLFORNOUGHT	**28.5**	**32.7**	**35.7**	**36.7**	**37.3**	**37.3**	**37.3**	**37.3**	**37.3**
STABLE COTTAGE, EAST LINNBRIDGEFORD	24.3	28.5	31.5	32.6	33.2	33.2	33.2	33.2	33.2
EAST LINNBRIDGEFORD	24.2	28.4	31.4	32.4	33.1	33.1	33.1	33.1	33.1
BARN COTTAGE, EAST LINNBRIDGEFORD	24.2	28.4	31.4	32.4	33.1	33.1	33.1	33.1	33.1
MEGSFIELD	24.8	29	32	33	33.7	33.7	33.7	33.7	33.7
CALLISTERHALL	24.7	28.9	31.9	32.9	33.6	33.6	33.6	33.6	33.6
CHAPELHILL	25.8	30	33	34	34.7	34.7	34.7	34.7	34.7
CONHESS FARM	25.7	29.9	32.9	34	34.6	34.6	34.6	34.6	34.6
KIRTLETON HOUSE	23.6	27.8	30.8	31.8	32.6	32.5	32.5	32.5	32.5
HALSYKE	24.4	28.6	31.6	32.6	33.3	33.3	33.3	33.3	33.3
HALSYKE COTTAGE	24.4	28.6	31.6	32.6	33.3	33.3	33.3	33.3	33.3
CARVANNE, LAURIES CLOSE	23	27.2	30.2	31.3	32	32	32	32	32
LAURIES CLOSE COTTAGE	23	27.2	30.2	31.2	32	31.9	31.9	31.9	31.9
LAURIES CLOSE CHURCH	22.9	27.1	30.1	31.2	32	31.9	31.9	31.9	31.9
POKESKINE VIEW, LAURIES CLOSE	22.9	27.1	30.1	31.2	31.9	31.9	31.9	31.9	31.9
KIRTLETON LODGE	22.9	27.1	30.1	31.1	31.9	31.8	31.8	31.8	31.8
KIRTLE KNOWE	22.9	27.1	30.1	31.1	31.9	31.9	31.9	31.9	31.9
BARR COTTAGE, CANOBIE	23.6	27.8	30.8	31.9	32.6	32.6	32.6	32.6	32.6
SOLWAYBANK HOUSE	23.2	27.4	30.4	31.4	32.2	32.1	32.1	32.1	32.1
SOLWAYBANK	23.2	27.4	30.4	31.4	32.2	32.1	32.1	32.1	32.1
CONHESS COTTAGE	24.1	28.3	31.3	32.4	33.1	33	33	33	33
KIRTLETON FARM COTTAGE	22.6	26.8	29.8	30.8	31.6	31.6	31.6	31.6	31.6
WOODSIDE COTTAGE, SOLWAYBANK	22.8	27	30	31	31.8	31.7	31.7	31.7	31.7
BARR COTTAGE, WATERBECK	22.5	26.7	29.7	30.7	31.5	31.5	31.5	31.5	31.5
LINNBRIDGEFORD COTTAGE	22.5	26.7	29.7	30.7	31.5	31.4	31.4	31.4	31.4
WALLACEHALL EAST	23.6	27.8	30.8	31.8	32.6	32.5	32.5	32.5	32.5

House Name	Reference Wind Speed (Standardised v_{10}) (ms^{-1})								
	4	5	6	7	8	9	10	11	12
LINNBRIDGEFORD MILL	22.5	26.7	29.7	30.7	31.5	31.4	31.4	31.4	31.4
SOLWAYBANK COTTAGE	22.6	26.8	29.8	30.9	31.6	31.6	31.6	31.6	31.6
WEST LINNBRIDGEFORD	22.4	26.6	29.6	30.6	31.4	31.3	31.3	31.3	31.3
BURNSTONES	22.3	26.5	29.5	30.5	31.3	31.3	31.3	31.3	31.3
SETTHORNS	22.1	26.3	29.3	30.4	31.1	31.1	31.1	31.1	31.1
COLLIN	23.4	27.6	30.6	31.6	32.3	32.3	32.3	32.3	32.3
DUNRAGIT	22	26.2	29.2	30.2	31	31	31	31	31
FALFORD LODGE	21.9	26.1	29.1	30.1	30.9	30.9	30.9	30.9	30.9
HIGH STENRIES	22.8	27	30	31	31.8	31.7	31.7	31.7	31.7
WALLACEHALL WEST	22.9	27.1	30.1	31.1	31.9	31.9	31.9	31.9	31.9
PINGLE FARM	20.9	25.1	28.1	29.2	30	29.9	29.9	29.9	29.9
HOLMFOOT	22.7	26.9	29.9	30.9	31.7	31.7	31.7	31.7	31.7
THE BEECHES	21.9	26.1	29.1	30.1	31	30.9	30.9	30.9	30.9
THE BEECHES (POULTRY LTD.)	21.9	26.1	29.1	30.1	31	30.9	30.9	30.9	30.9
2 BIGHOLMS COTTAGES	21.4	25.6	28.6	29.7	30.4	30.4	30.4	30.4	30.4
1 BIGHOLMS COTTAGES	21.4	25.6	28.6	29.7	30.4	30.4	30.4	30.4	30.4
1 RIGGFOOT, LINNBRIDGEFORD	20.7	24.9	27.9	29	29.8	29.7	29.7	29.7	29.7
2 RIGGFOOT, LINNBRIDGEFORD	20.7	24.9	27.9	28.9	29.8	29.7	29.7	29.7	29.7
RIGGFOOT HOUSE	20.6	24.8	27.8	28.8	29.7	29.6	29.6	29.6	29.6
BARNGLIESHEAD	20.1	24.3	27.3	28.4	29.3	29.2	29.2	29.2	29.2
PAITRICKHOLM	21.1	25.3	28.3	29.3	30.2	30.1	30.1	30.1	30.1
WESTFIELD COTTAGE	21.5	25.7	28.7	29.8	30.6	30.6	30.6	30.6	30.6
CROWDIEKNOWE COTTAGE	19.9	24.1	27.1	28.2	29.1	29	29	29	29
WESTWATER FARM	20	24.2	27.2	28.3	29.2	29.1	29.1	29.1	29.1
NORTH CRAIGS COTTAGE	19.6	23.8	26.8	27.9	28.8	28.7	28.7	28.7	28.7
NORTH CRAIGS	19.6	23.8	26.8	27.9	28.8	28.7	28.7	28.7	28.7
WATTAMAN	19.2	23.4	26.4	27.5	28.4	28.4	28.4	28.4	28.4
WESTWATER COTTAGE	19.9	24.1	27.1	28.1	29	29	29	29	29
SNAB FARM	20.4	24.6	27.6	28.7	29.6	29.5	29.5	29.5	29.5
SNAB CORNER	20.9	25.1	28.1	29.1	30.1	30	30	30	30
GREENCLEUCH	18.3	22.5	25.5	26.6	27.5	27.4	27.4	27.4	27.4
WINTERHOPE COTTAGE	16.7	20.9	23.9	25	25.9	25.8	25.8	25.8	25.8
FILTERMANS COTTAGE	16.7	20.9	23.9	24.9	25.9	25.8	25.8	25.8	25.8
WINTERHOPE FARM	16.6	20.8	23.8	24.8	25.8	25.7	25.7	25.7	25.7
KENNEDYS CORNER	20.1	24.3	27.3	28.4	29.4	29.3	29.3	29.3	29.3

House Name	Reference Wind Speed (Standardised v_{10}) (ms^{-1})								
	4	5	6	7	8	9	10	11	12
BARNGLIES FARM	17.3	21.5	24.5	25.5	26.6	26.5	26.5	26.5	26.5
2 BARNGLIES COTTAGE	17.2	21.4	24.4	25.4	26.5	26.4	26.4	26.4	26.4
1 BARNGLIES COTTAGE	17.2	21.4	24.4	25.4	26.5	26.4	26.4	26.4	26.4
BLOCH FARM	15.2	19.4	22.4	23.4	24.4	24.3	24.3	24.3	24.3
1 CLEUCHFOOT COTTAGES	15.3	19.5	22.5	23.5	24.5	24.4	24.4	24.4	24.4
2 CLEUCHFOOT COTTAGES	15.2	19.4	22.4	23.5	24.5	24.4	24.4	24.4	24.4
OLD SCHOOLHOUSE	17.2	21.4	24.4	25.5	26.5	26.4	26.4	26.4	26.4

NB Values in bold indicate the maximum predicted noise level
Shading indicates properties with predicted noise levels greater than 35 dB(A), refer to paragraph 13.94

13.93 Noise levels at 67 of the 68 nearest neighbours are below 35 dB(A) level, indicating that the noise immission levels would be regarded as acceptable and the householders' amenities as receiving 'sufficient protection' without further assessment requiring to be undertaken (refer to paragraph 13.71).

13.94 There is one property that does not pass this simplified noise criteria as indicated in Table 13.13. Therefore the 'full' acoustic assessment need only be considered here. However, as a background noise survey was carried out at Bigholms Cottages, Kirtleton House and Pingle Farm as agreed with the local authority (RES, 2005), these properties have also been considered in the full acoustic assessment so as to provide a more comprehensive description of the acoustic effect of the proposed wind farm.

Acoustic Acceptance Criteria

13.95 As described in paragraph 13.72, during quiet waking hours and at low background noise levels, a permissible noise level of 35 - 40 dB(A) should be used. The exact value is dependent upon a number of factors: the number of nearby dwellings, the effect of the noise limits on energy produced and the duration and level of exposure. Through consideration of these factors, RES has adopted a 37.5 dB(A) level.

Table 13.14: Permissible Noise Level Criteria in Vicinity of Solwaybank Wind Farm

Time of Day	Permissible Noise Level
Quiet waking hours	• 37.5 dB(A) for L_B less than 32.5 dB(A) • L_B + 5 dB, for L_B greater than 32.5 dB(A)
Night-time hours	• 43 dB(A) for L_B less than 38 dB(A) • L_B + 5 dB, for L_B greater than 38 dB(A)

13.96 A higher noise level is permissible during night-time hours than during quiet waking hours, as it is assumed that residents would be indoors.

Calculation of Acceptable Noise Limits from Baseline Conditions

13.97 The 'best-fit' lines of Charts 13.4-13.11 in **Appendix 13.2** have been used to deduce the acceptable noise limits at the background noise measurement locations. Table 13.15 shows the suggested quiet waking hours noise limits and Table 13.16 the suggested night time noise limits.

Table 13.15: Recommended Quiet Waking Hours Noise Limits (dB(A) re 20 μPa)

House Name	Quiet Waking Hours Noise Limits at Indicated Locations Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
ALLFORNOUGHT	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.9	41.4	44.1	47.1	47.1
KIRTLETON HOUSE	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.5	40.6	43.1	45.8	45.8
PINGLE FARM	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	39.5	42.2	45.1	45.1
BIGHOLMS COTTAGES	37.5	37.5	37.5	37.5	37.5	37.5	37.6	38.9	40.4	42.1	42.1	42.1

Table 13.16: Recommended Night-time Noise Limits (dB(A) re 20 μPa)

House Name	Night Time Noise Limits at Indicated Locations Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
ALLFORNOUGHT	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.2	46.2	46.2
KIRTLETON HOUSE	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.8	47.9	51.2
PINGLE FARM	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.5	46.8	50.4
BIGHOLMS COTTAGES	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

13.98 The recommendations of ETSU-R-97 state that where there are groups of properties that are likely to have a similar background noise environment, it is appropriate to use data from one representative location as the basis for assessment at the other properties. The survey results inferred to be representative for each property is shown in Table 13.17. The specific choice of noise survey chosen has been made taking into account the distance to the nearest survey location and the likelihood of experiencing a broadly similar exposure as the survey.

Table 13.17: Assumed Representative Background Noise Survey Locations

House Name	Assumed Representative Background Noise Survey
ALLFORNOUGHT	ALLFORNOUGHT
STABLE COTTAGE, EAST LINNBRIDGEFORD	KIRTLETON HOUSE
EAST LINNBRIDGEFORD	KIRTLETON HOUSE
BARN COTTAGE, EAST LINNBRIDGEFORD	KIRTLETON HOUSE
MEGSFIELD	KIRTLETON HOUSE
CALLISTERHALL	BIGHOLMS COTTAGES
CHAPELHILL	ALLFORNOUGHT
CONHESS FARM	ALLFORNOUGHT
KIRTLETON HOUSE	KIRTLETON HOUSE
HALSYKE	KIRTLETON HOUSE
HALSYKE COTTAGE	KIRTLETON HOUSE
CARVANNE, LAURIES CLOSE	KIRTLETON HOUSE
LAURIES CLOSE COTTAGE	KIRTLETON HOUSE
LAURIES CLOSE CHURCH	KIRTLETON HOUSE
POKESKINE VIEW, LAURIES CLOSE	KIRTLETON HOUSE
KIRTLETON LODGE	KIRTLETON HOUSE
KIRTLE KNOWE	KIRTLETON HOUSE
BARR COTTAGE, CANOBIE	ALLFORNOUGHT
SOLWAYBANK HOUSE	ALLFORNOUGHT
SOLWAYBANK	ALLFORNOUGHT
CONHESS COTTAGE	ALLFORNOUGHT
KIRTLETON FARM COTTAGE	KIRTLETON HOUSE
WOODSIDE COTTAGE, SOLWAYBANK	ALLFORNOUGHT
BARR COTTAGE, WATERBECK	ALLFORNOUGHT
LINNBRIDGEFORD COTTAGE	KIRTLETON HOUSE
WALLACEHALL EAST	ALLFORNOUGHT
LINNBRIDGEFORD MILL	KIRTLETON HOUSE
SOLWAYBANK COTTAGE	ALLFORNOUGHT
WEST LINNBRIDGEFORD	KIRTLETON HOUSE
BURNSTONES	KIRTLETON HOUSE
SETTHORNS	KIRTLETON HOUSE
COLLIN	BIGHOLMS COTTAGES
DUNRAGIT	KIRTLETON HOUSE
FALFORD LODGE	KIRTLETON HOUSE
HIGH STENRIES	ALLFORNOUGHT
WALLACEHALL WEST	ALLFORNOUGHT
PINGLE FARM	PINGLE FARM
HOLMFOOT	BIGHOLMS COTTAGES
THE BEECHES	KIRTLETON HOUSE
THE BEECHES (POULTRY LTD.)	KIRTLETON HOUSE
2 BIGHOLMS COTTAGES	BIGHOLMS COTTAGES
1 BIGHOLMS COTTAGES	BIGHOLMS COTTAGES

House Name	Assumed Representative Background Noise Survey
1 RIGGFOOT, LINNBRIDGEFORD	KIRTLETON HOUSE
2 RIGGFOOT, LINNBRIDGEFORD	KIRTLETON HOUSE
RIGGFOOT HOUSE	KIRTLETON HOUSE
BARNGLIESHEAD	PINGLE FARM
PAITRICKHOLM	KIRTLETON HOUSE
WESTFIELD COTTAGE	ALLFORNOUGHT
CROWDIEKNOWE COTTAGE	KIRTLETON HOUSE
WESTWATER FARM	BIGHOLMS COTTAGES
NORTH CRAIGS COTTAGE	KIRTLETON HOUSE
NORTH CRAIGS	KIRTLETON HOUSE
WATTAMAN	PINGLE FARM
WESTWATER COTTAGE	BIGHOLMS COTTAGES
SNAB FARM	ALLFORNOUGHT
SNAB CORNER	ALLFORNOUGHT
GREENCLEUCH	BIGHOLMS COTTAGES
WINTERHOPE COTTAGE	KIRTLETON HOUSE
FILTERMANS COTTAGE	KIRTLETON HOUSE
WINTERHOPE FARM	KIRTLETON HOUSE
KENNEDYS CORNER	ALLFORNOUGHT
BARNGLIES FARM	PINGLE FARM
2 BARNGLIES COTTAGE	PINGLE FARM
1 BARNGLIES COTTAGE	PINGLE FARM
BLOCH FARM	BIGHOLMS COTTAGES
1 CLEUCHFOOT COTTAGES	BIGHOLMS COTTAGES
2 CLEUCHFOOT COTTAGES	BIGHOLMS COTTAGES
OLD SCHOOLHOUSE	BIGHOLMS COTTAGES

13.99 As recommended in ETSU-R-97, the absolute lower noise limits may be increased up to 45 dB(A) if the occupant has a financial involvement in the wind farm. However, whilst some of the nearby properties may qualify for such an increase, these limits have not been adopted in the presented results.

Acoustic Assessment

13.100 Table 13.18 shows a comparison of the predicted noise levels with the recommended quiet waking hours noise limits for each house where the full assessment procedure is being applied. The predicted noise levels at 1 ms^{-1}, 2 ms^{-1} and 3 ms^{-1} have been assumed as equal to 4 ms^{-1}, though this is a conservative measure as noise levels at these wind speeds would typically be less. The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit. A negative value indicates that the predicted noise level is within the limit. Table 13.19 shows a comparison with the recommended night-time noise limits.

13.101 Noise levels at all locations are within both the quiet waking hours limit and night-time noise limits, at all wind speeds considered. The minimum margin of predicted noise levels below derived noise limits, for all wind speeds considered, during quiet waking hours, is -0.8 dB(A). Similarly the minimum margin during night time periods, for all wind speeds considered, is -5.7 dB(A). These are highlighted in Table 13.18 and Table 13.19.

Table 13.18: Comparison of Predicted Noise Levels and Quiet Waking Hours Limits - (dB(A) re 20 μPa)

House Name	Reference Wind Speed (v_{10}) / ms^{-1}																																			
	1			2			3			4			5			6			7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
ALLFORNOUGHT	25.5	37.5	-12.0	25.5	37.5	-12.0	25.5	37.5	-12.0	28.5	37.5	-9.0	32.7	37.5	-4.8	35.7	37.5	-1.8	36.7	37.5	-0.8	37.3	38.9	-1.6	37.3	41.4	-4.1	37.3	44.1	-6.8	37.3	47.1	-9.8	37.3	47.1	-9.8
KIRTLETON HOUSE	20.6	37.5	-16.9	20.6	37.5	-16.9	20.6	37.5	-16.9	23.6	37.5	-13.9	27.8	37.5	-9.7	30.8	37.5	-6.7	31.8	37.5	-5.7	32.6	38.5	-5.9	32.5	40.6	-8.1	32.5	43.1	-10.6	32.5	45.8	-13.3	32.5	45.8	-13.3
PINGLE FARM	17.9	37.5	-19.6	17.9	37.5	-19.6	17.9	37.5	-19.6	20.9	37.5	-16.6	25.1	37.5	-12.4	28.1	37.5	-9.4	29.2	37.5	-8.3	30.0	37.5	-7.5	29.9	39.5	-9.6	29.9	42.2	-12.3	29.9	45.1	-15.2	29.9	45.1	-15.2
BIGHOLMS COTTAGES	18.4	37.5	-19.1	18.4	37.5	-19.1	18.4	37.5	-19.1	21.4	37.5	-16.1	25.6	37.5	-11.9	28.6	37.5	-8.9	29.7	37.6	-7.9	30.4	38.9	-8.5	30.4	40.4	-10.0	30.4	42.1	-11.7	30.4	42.1	-11.7	30.4	42.1	-11.7

The term Lp is used to denote the predicted noise level due to the operation of the proposed wind farm
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit
The shaded value denotes the minimum quiet waking hours ΔL value

Table 13.19: Comparison of Predicted Noise Levels and Night Time Limits - (dB(A) re 20 μPa)

House Name	Reference Wind Speed (v_{10}) / ms^{-1}																																			
	1			2			3			4			5			6			7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
ALLFORNOUGHT	25.5	43.0	-17.5	25.5	43.0	-17.5	25.5	43.0	-17.5	28.5	43.0	-14.5	32.7	43.0	-10.3	35.7	43.0	-7.3	36.7	43.0	-6.3	37.3	43.0	-5.7	37.3	43.0	-5.7	37.3	46.2	-8.9	37.3	46.2	-8.9	37.3	46.2	-8.9
KIRTLETON HOUSE	20.6	43.0	-22.4	20.6	43.0	-22.4	20.6	43.0	-22.4	23.6	43.0	-19.4	27.8	43.0	-15.2	30.8	43.0	-12.2	31.8	43.0	-11.2	32.6	43.0	-10.4	32.5	43.0	-10.5	32.5	44.8	-12.3	32.5	47.9	-15.4	32.5	51.2	-18.7
PINGLE FARM	17.9	43.0	-25.1	17.9	43.0	-25.1	17.9	43.0	-25.1	20.9	43.0	-22.1	25.1	43.0	-17.9	28.1	43.0	-14.9	29.2	43.0	-13.8	30.0	43.0	-13.0	29.9	43.0	-13.1	29.9	43.5	-13.6	29.9	46.8	-16.9	29.9	50.4	-20.5
BIGHOLMS COTTAGES	18.4	43.0	-24.6	18.4	43.0	-24.6	18.4	43.0	-24.6	21.4	43.0	-21.6	25.6	43.0	-17.4	28.6	43.0	-14.4	29.7	43.0	-13.3	30.4	43.0	-12.6	30.4	43.0	-12.6	30.4	43	-12.6	30.4	43	-12.6	30.4	43	-12.6

The term Lp is used to denote the predicted noise level due to the operation of the proposed wind farm
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit.
The shaded values denotes the minimum night time ΔL value

Construction Noise

13.102 Primary construction activities for which noise arises during the construction period are from: the construction of the turbine bases; the erection of the turbines; the excavation of trenches for cables; and the construction of associated hard standings, access tracks and construction compound. Noise from vehicles on local roads and access tracks will also arise due to the delivery of turbine components and construction materials, notably aggregates, concrete and steel reinforcement.

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

Construction Noise Predictions

13.104 The plant assumed for each construction activity is shown in Table 13.20. The number of items indicates how many of each plant are required for the specified activity, and the duration of activity is a percentage of a given 12 hour day period needed for that plant to operate. Overall sound power levels are based upon the data in Annex C of BS 5228-1:2009.

Table 13.20: Construction Phases and Sound Power Levels

Activities	Plant	Sound Power (L_{WA})	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA})
Upgrade Access Track	Tracked excavator	113	2	100	120
	Dump truck	113	2	100	
	Tipper lorry	107	4	50	
	Dozer	109	2	75	
	Vibratory roller	102	1	75	
Construct temporary site compounds and parking area	Tracked excavator	113	2	100	119
	Dump truck	113	2	100	
	Tipper lorry	107	2	50	
	Vibratory roller	102	1	75	
	Lorry	108	1	75	
Construct site tracks	Tracked excavator	113	3	100	120
	Dump truck	113	2	75	
	Tipper lorry	107	4	50	
	Dozer	109	1	100	
	Vibratory roller	102	1	75	
Construct Sub-Station	Tracked excavator	113	1	100	117
	Concrete mixer truck	108	2	50	
	Lorry	108	1	50	
	Telescopic Handler	99	1	100	
	Piling Rig	117	1	50	
Construct crane	Tracked excavator	113	3	100	120
hardstandings	Dump truck	113	2	100	
	Tipper lorry	107	4	50	
	Vibratory roller	102	1	50	
Construct turbine foundations	Tracked excavator	113	2	75	120
	Dump truck	113	2	75	
	Concrete mixer truck	108	4	50	
	Mobile telescopic crane	110	1	50	
	Concrete pump	106	2	50	
	Hand-held pneumatic breaker	111	1	75	
	Compressor	103	3	50	
	Poker vibrator	106	3	50	
Excavate and lay site cables	Tracked excavator	113	2	100	119
	Dump truck	113	2	75	
	Tractor with hydraulic winch (towing equipment)	108	1	75	
	Tractor (towing trailer)	107	1	75	
	Vibratory plate	108	1	50	
Erect turbines	Mobile telescopic crane	110	2	75	119
	Lorry	108	1	75	
	Diesel generator	102	1	100	
	Torque guns	111	4	100	
Reinstate crane bases	Tracked excavator	113	1	75	115
	Dump truck	113	1	75	
Lay cable to substations	Wheeled loader	108	1	100	120
	Saw	114	1	50	
	Hydraulic breaker	121	1	50	
	Dump truck	113	1	75	
	Tipper lorry	107	1	50	
	Vibratory plate	108	1	75	
	Tandem roller	102	1	75	
	Tractor & cable drum trailer	108	1	50	
	Lorry	108	1	75	
Tree Felling	Saw	114	1	100	116
	Wheeled loader	108	2	100	

13.105 Predictions of noise levels have been carried out using the methods prescribed in Annex F of BS 5228-1:2009[2] with adoption of the worst case scenario where all major construction activities take place at the nearest possible location to each assessed house. The locations of the construction activities are taken from the infrastructure drawing (Figure 4.1). The results of these predictions, made at 6 representative critical properties to the proposed wind farm, are shown in Table 13.21.

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

Table 13.21: Construction Noise Predictions

Activity*	Predicted Sound Pressure Level (dB L_{Aeq})					
	Allfornought	Pingle Farm	Kirtleton House	Barr Cottage, Waterbeck	Bigholms Cottages	Callisterhall
Upgrade nearest Access Track	38.4	34.3	43.1	43.0	39.9	70.5
Construct temporary site compound	42.4	40.2	42.8	42.2	40.1	53.6
Construct parking area	34.9	33.0	39.1	39.7	39.4	63.0
Construct site access track	39.5	34.9	43.6	43.1	38.9	45.9
Construct nearest site tracks	49.2	75.8	44.6	43.3	41.8	45.9
Construct Sub-Station	36.8	32.0	40.8	40.1	35.3	41.3
Construct nearest crane hardstandings	48.9	41.9	44.4	43.1	41.7	44.8
Construct nearest turbine foundations	48.5	41.5	44.0	42.7	41.3	44.4
Excavate and lay nearest site cables	47.6	40.6	43.1	41.8	40.4	43.5
Erect nearest turbine	47.2	40.2	42.7	41.3	40.0	43.0
Reinstate crane bases	43.2	36.2	38.7	37.4	36.0	39.1
Lay cable to substations	49.1	42.1	44.6	43.3	41.9	45.0
Tree Felling	47.8	34.6	43.1	40.9	37.6	43.5

*Note that these activities do not take place simultaneously, see paragraph 13.109

[2] A 50% mixed ground attenuation, midway between hard and soft ground, has been used throughout to conservatively account for the nature of the ground conditions at Solwaybank

Construction Traffic

13.107 Due to the provision of construction material and wind farm components, vehicle movements either into or away from the site shall increase levels of traffic flow on public roads in the area. Traffic regularly accessing the site is shown in **Chapter 15: Access, Traffic and Transport** and is assumed to be characterised by the sound power levels of Dump Trucks and Concrete Mixers as a worst case. It is estimated therein that a total of 62 vehicle movements per day would be required during the most intensive period of activity.

13.108 Construction traffic noise has been quantified at this location using the method described in BS 5228:2009 Part 1. Using the distances from residential properties to the centre of the relevant carriageway where site traffic will be, the noise levels predicted are presented in Table 13.22. According to the assumptions made, the maximum sound pressure level due to traffic flows at the most intensive period of activity will be 54.9 dB L_{Aeq}.

Table 13.22: Results of the Traffic Noise Predictions

Activity	Predicted Sound Pressure Level (dB L_{Aeq})					
	Allfornought	Pingle Farm	Kirtleton House	Barr Cottage, Waterbeck	Big Holms Cottages	Callisterhall
Dump truck	29.7	27.7	37.2	50.6	30.0	43.6
Concrete mixer truck	32.1	30.0	39.5	53.0	32.4	46.0
Total	34.1	32.0	41.5	54.9	34.4	48.0

13.109 Worst case construction noise levels may arise when the following simultaneous activities occur: construction of nearest access tracks; construction of substation; construction of nearest crane hardstandings; construction of nearest turbine foundations; and felling of trees in the nearest part of the forestry felling area. Therefore cumulative predictions of these construction activities and the additional noise contribution from construction traffic have been calculated and are shown in Table 13.23.

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

13.111 There are three instances when construction noise activity is predicted to be greater than shown in Table 13.23. The first instance is for Pingle Farm when work is taking place on the access track closest to the property. The second and third instances are for Callisterhall when work is taking place on the access track closest to the property and on the parking area.

Construction noise for constructing the site access track at the nearest point to Pingle Farm indicates predicted noise levels of 75.8 dB(A). Construction noise when upgrading the access track and constructing the parking area close to Callisterhall is predicted to be 70.5 dB(A) and 63.0 dB(A) respectively. It should be noted that these increased noise levels are only temporary and will only occur in the limited time period when the activity is at the closest point to the property. An estimate of the amount of time for which the relevant criteria are estimated to be exceeded is detailed in paragraph 13.114.

Table 13.23: Predicted Noise Due to Combined Traffic Noise and Turbine Construction

Activity	Predicted Sound Pressure Level (dB L_{Aeq})					
	Allfornought	Pingle Farm	Kirtleton House	Barr Cottage, Waterbeck	Big Holms Cottages	Callisterhall
Construction Plant Noise	53.5	45.7	50.3	49.1	46.5	51.2
Traffic Noise	34.1	32.0	41.5	54.9	34.4	48.0
Combined Noise	53.5	45.9	50.9	56.0	46.8	52.9

Acceptable Noise Limits from Baseline Conditions

13.112 Due to the relatively low levels of ambient noise at the site, a Category A assessment of the ABC method in BS 5228-1:2009 is used for acceptable limits as stated in paragraph 13.84. This category sets minimum L_{Aeq} criteria of: 65 dB(A) during weekdays (0700-1900) and Saturdays (0700-1300); below 55 dB(A) at evenings and weekends; and below 45 dB(A) for night-time (2300-0700).

Assessment of Construction Noise

13.113 Table 13.23 shows that predicted noise levels from the combined effect of increased traffic flows and activities associated with peak construction of the wind farm are below the 65 dB(A) daytime target level specified by BS 5228-1:2009 at all locations. The predictions made represent the worst case combination of most intensive traffic activity with simultaneous construction activity at the nearest possible location to each noise receptor.

13.114 The temporary higher levels of construction noise during construction of the site access track at the nearest point to Pingle Farm and the upgrade of the access track close to Callisterhall will only occur for a limited time period when the activity is at the closest point to the properties. Noise levels are predicted to drop below the 65 dB(A) criteria once the construction activity is greater than 180 m away. The 65 dB(A) criteria will be exceeded for up to five days at Pingle Farm and up to three days at Callisterhall based on typical rates of construction.

Mitigation

Operational Noise

13.115 Due to consideration in the design of the wind farm, no mitigation measures are required for the operation of the proposed turbines as the site complies with noise criteria.

13.116 It is worth noting that the operation of many modern turbines may be altered by changing the pitch of the wind turbine blades resulting in a trade-off between power production & noise reduction. Therefore in the unlikely event that noise levels at nearby neighbours need readdressed once they become operational, there is potentially a mechanism for enacting this.

13.117 Before a turbine type could be employed, RES standard practice would be to seek to obtain a warranty from the manufacturer that the turbines will not incur a tonal penalty at the nearest noise sensitive properties, based upon the ETSU-R-97 guideline definition (ETSU, 1996).

13.118 If the wind farm was granted planning permission, any resulting decision notice would likely contain noise conditions which would provide a degree of protection to nearby residents in the unlikely event that the wind farm noise would give rise to complaint. **Appendix 13.3** contains a set of conditions that RES considers appropriate. Any final conditions attached to the proposal, if accepted, would be according to the discretion of DGC.

Construction Noise

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

13.120 BS 5228-1:2009 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local authority should occur along with letter drops to inform residents of intended activity. Non-acoustic factors, which influence the overall level of complaints such as mud on roads and dust generation, will also be controlled.

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

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

13.122 Site operations will be limited to 0700-1900 Monday to Saturday except during turbine erection and commissioning or during periods of emergency work. Should it be considered necessary to reduce noise levels from the conservative predicted levels made, then the following mitigation measures would be considered to adhere to the 55 dB(A) target level for Saturdays 1300-1900 only:

- The number of construction activities occurring simultaneously would be reduced;
- Construction traffic would also be reduced as appropriate.

Assessment of Residual Effects

Operational

13.123 The acoustic assessment shows that predicted noise levels at the nearest properties do not exceed either night time or quiet day time limits under all considered conditions. This should not be interpreted to mean that wind farm operational noise will be inaudible (or masked by background noise) under all conditions, but that the levels of noise are acceptable, in accordance with relevant legislation and guidance and accepted standards.

Construction

13.124 There will be a temporary increase in noise levels at two properties due to the upgrade and construction of access tracks. The increased effect is judged to be acceptable due to the temporary nature of the noise which will be at a maximum when the construction activity is at its closest point to the property and decrease as the activity moves away. At all other times, predicted noise from a worst case combination of increased traffic and site construction noise will not exceed relevant criteria and therefore no significant effects are expected.

Cumulative Effects

Cumulative Operational Noise Assessment

13.125 An assessment of the cumulative acoustic impact of the proposed Solwaybank Wind Farm was considered with: the existing operational Craig and Minsca Wind Farms; the consented Craig Extension and Ewe Hill Wind Farms; and the proposed Ewe Hill Extension Wind Farm.

13.126 The location of the proposed Solwaybank Wind Farm in relation to: the existing operational Craig and Minsca Wind Farms; the consented Craig Extension and Ewe Hill Wind Farms; and the proposed Ewe Hill Extension Wind Farm can be seen in Figure 13.2. Craig is approximately 6 km north, Ewe Hill is approximately 5 km north and Minsca is approximately 6 km west of Solwaybank.

13.127 In the first instance it was necessary to establish if, considering houses in the vicinity of the Solwaybank proposal as detailed elsewhere in this chapter, a cumulative acoustic impact – that is, more than one wind farm contributing to potentially elevated noise levels, may theoretically exist. In acoustic practice it is generally accepted that where a difference in noise immission levels due to each noise source is greater than 10 dB(A) that there is negligible cumulative effect and the smaller source can be ignored. Therefore, conversely, a cumulative impact of any magnitude can only be possible if both sources (i.e. wind farms) theoretically produce noise levels within 10 dB of each other at the property in question.

13.128 Therefore, considering predictions carried out for each existing, consented or proposed wind farm according to the propagation model already specified, it was determined if a cumulative impact (as defined above) existed. If the Solwaybank Wind Farm is found to be the dominant noise source at a location by >10 dB then the assessment as detailed for the Solwaybank proposal alone, detailed elsewhere in this chapter, adequately addresses the acoustic impact. Such was the case with 14 of the 68 properties originally considered: High Stenries; Westfield Cottage; Wallacehall West; Wallacehall East; Barr Cottage, Canobie; Solwaybank Cottage; Solwaybank House; Solwaybank; Woodside Cottage, Solwaybank; Allfornought; Chapelhill; Pingle Farm; Conhess Farm and Conhess Cottage.

13.129 Thereafter at the remaining properties it was necessary to combine the predicted noise levels that would be experienced in practice from the relevant wind farms at each location to form a cumulative prediction. It was found that the maximum predicted noise level at any property was less than 35 dB(A) as detailed in Table 13.24.

Table 13.24: Maximum Predicted Noise Level at Properties with Cumulative Impact

House Name	Maximum Predicted Noise Level / dB(A)
KENNEDYS CORNER	30.3
SNAB FARM	30.4
SNAB CORNER	30.9
2 BARNGLIES COTTAGE	27.2
1 BARNGLIES COTTAGE	27.2
WATTAMAN	28.6
BARNGLIES FARM	27.4
PAITRICKHOLM	31.5
NORTH CRAIGS COTTAGE	30.7
NORTH CRAIGS	30.7
BARNGLIESHEAD	29.9
THE BEECHES	32.1
THE BEECHES (POULTRY LTD.)	32.1
RIGGFOOT HOUSE	31.5
2 RIGGFOOT, LINNBRIDGEFORD	31.6
1 RIGGFOOT, LINNBRIDGEFORD	31.6
HALSYKE	33.7
HALSYKE COTTAGE	33.7
LINNBRIDGEFORD MILL	32.5
WEST LINNBRIDGEFORD	33.0
BURNSTONES	33.0
LINNBRIDGEFORD COTTAGE	33.1
EAST LINNBRIDGEFORD	34.0
BARN COTTAGE, EAST LINNBRIDGEFORD	34.0
STABLE COTTAGE, EAST LINNBRIDGEFORD	34.1
POKESKINE VIEW, LAURIES CLOSE	33.3
LAURIES CLOSE CHURCH	33.3
KIRTLE KNOWE	33.3
CARVANNE, LAURIES CLOSE	33.4
LAURIES CLOSE COTTAGE	33.4
KIRTLETON FARM COTTAGE	33.1
KIRTLETON LODGE	33.3
CROWDIEKNOWE COTTAGE	31.4
KIRTLETON HOUSE	33.9
DUNRAGIT	33.0
BARR COTTAGE, WATERBECK	33.4
FALFORD LODGE	33.0
SETTHORNS	33.2
MEGSFIELD	34.9
2 BIGHOLMS COTTAGES	31.7
1 BIGHOLMS COTTAGES	31.7
BLOCH FARM	28.6
COLLIN	33.2
HOLMFOOT	32.9
CALLISTERHALL	34.7
OLD SCHOOLHOUSE	29.3
WINTERHOPE COTTAGE	32.6
WINTERHOPE FARM	32.8
FILTERMANS COTTAGE	32.8
WESTWATER COTTAGE	32.2
WESTWATER FARM	32.3
1 CLEUCHFOOT COTTAGES	29.0
2 CLEUCHFOOT COTTAGES	28.8
GREENCLEUCH	31.4

13.130 As ETSU-R-97 considers a 35 dB(A) level in itself to provide sufficient protection of amenity it is therefore concluded that for all properties considered within this chapter and in the vicinity of the proposed Solwaybank wind farm, there is either an appropriate low noise level due to cumulative impact of existing, consented or proposed wind farms or negligible cumulative impact.

Cumulative Construction Noise Assessment

13.131 There is no cumulative construction noise impact with Craig and Minsca Wind Farms as they are already operational. Any noise due to the construction of Craig Extension, Ewe Hill or Ewe Hill Extension Wind Farms is not likely to be ongoing at the same time as the construction of Solwaybank Wind Farm. However, if this is the case the distances between the proposed wind farms and Solwaybank are such that the site activities are far enough away from each other so as not to have a cumulative impact.

13.132 Construction of the Gretna to Ewe Hill overhead line is not likely to be ongoing at the same time as the construction of Solwaybank Wind Farm. If construction does take place at the same time, the low levels of overhead line construction noise are not expected to have a significant impact on the results of the assessment.

13.133 Should the construction of Craig Extension, Ewe Hill, Ewe Hill Extension Wind Farms or the Gretna to Ewe Hill overhead line be ongoing at the same time as Solwaybank Wind Farm, cumulative construction traffic noise will be taken into account in the design of an appropriate Traffic Management Plan to be agreed with Dumfries and Galloway Council and the appropriate authorities.

Summary

13.134 The acoustic effect for the operation of the proposed Solwaybank wind farm on nearby neighbours has been assessed in accordance with the guidance on wind farm noise as issued in the DTI publication 'The Assessment and Rating of Noise from Wind Farms' (ETSU, 1996) as recommended for use by relevant planning policy.

13.135 To establish baseline conditions, background noise surveys were carried out at 4 nearby properties and the measured background noise levels used to determine appropriate noise limits, as specified by ETSU-R-97.

13.136 Operational noise levels were predicted using a noise propagation model, the proposed wind farm layout, terrain data and assumed turbine emission data.

13.137 The predicted noise levels are within derived appropriate noise limits at all considered wind speeds.

13.138 The proposed wind farm therefore complies with the relevant guidance on wind farm noise and the effect on the amenity of all nearby properties would be regarded as acceptable.

13.139 A construction noise assessment has been carried out in accordance with BS 5228-1:2009 'Noise control on construction and open sites' Part 1 – Noise, and, with due regard to mitigation outlined, indicates that predicted noise levels likely to be experienced at representative critical properties are below relevant construction noise criteria.

13.140 A cumulative operational noise assessment was completed for the potential effect of Solwaybank wind farm alongside the operational Craig and Minsca wind farms, the consented Craig Extension and Ewe Hill wind farms, and the proposed Ewe Hill Extension.

13.141 The predicted noise levels are within derived appropriate noise limits at all considered wind speeds. Therefore the cumulative noise effect on the amenity of all nearby properties should be regarded as acceptable.

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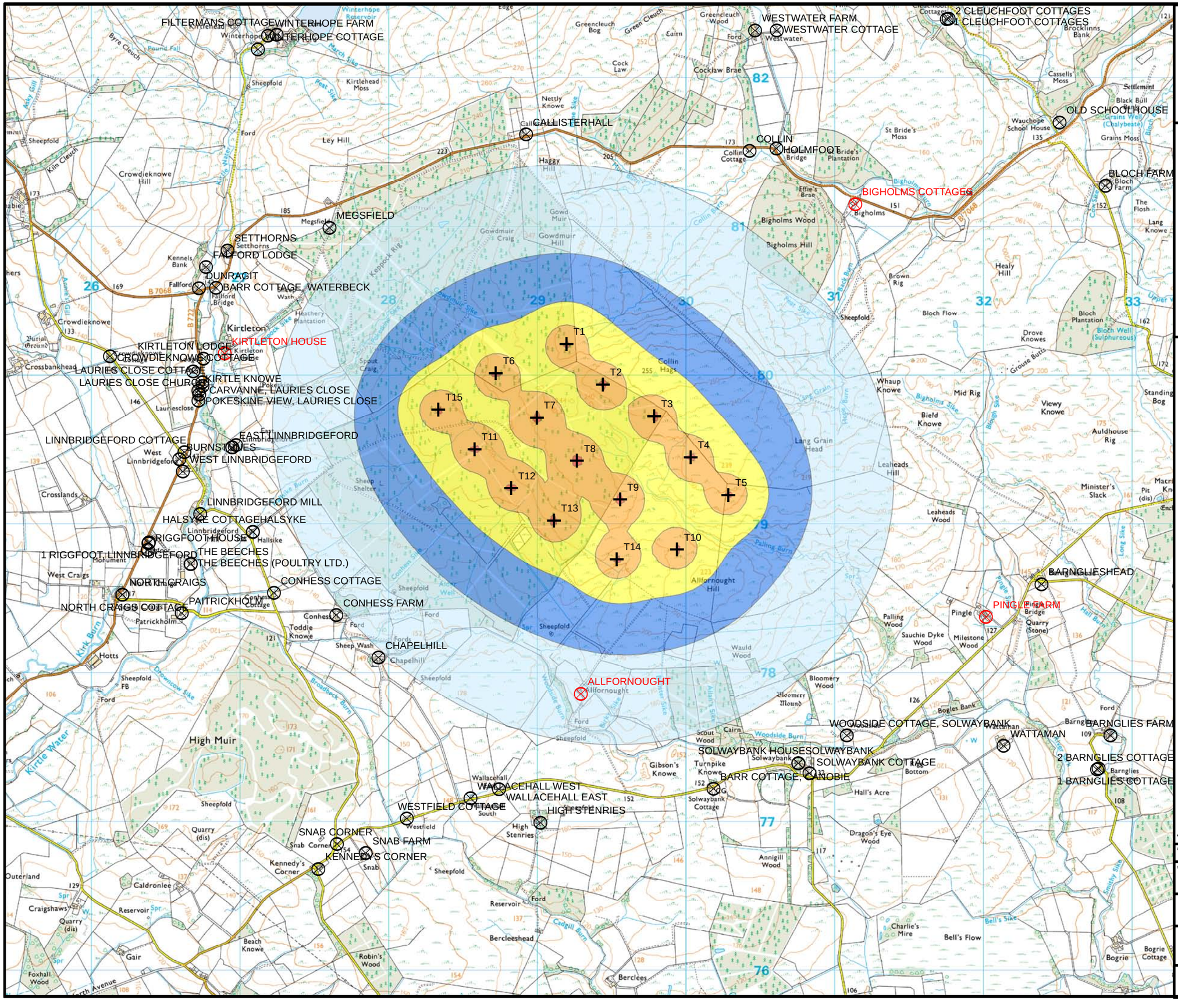

SOLWAYBANK

FIGURE 13.1

PREDICTED NOISE FOOTPRINT FOR PROPOSED SOLWAYBANK WIND FARM

Legend

- Receiver Locations
- Survey Locations
- Turbine location
- >35dB(A)
- >40dB(A)
- >45dB(A)
- >50dB(A)
- >55dB(A)

Grid intervals at 1 km

The LA90,10min descriptor has been used

The noise footprint has been calculated at a wind speed of 8m/s at 10m height using the ISO:9613:2 propagation model with all barrier attenuation (i.e. shielding by hills) removed. The figure may therefore show slightly more conservative results than those numerically calculated and presented in the acoustic chapter and should be considered illustrative only.

Red receiver icons indicate background noise measurements made at those locations

N

LAYOUT DWG	T-LAYOUT NO.
01307D0007-08	PSCOswb052

DRAWING NUMBER

01307D6901-02

SCALE - 1:24,000

ENVIRONMENTAL STATEMENT

Ewehill Extension Wind Farm

Craig Extension Wind Farm

Craig Wind Farm

Ewehill Wind Farm

Minsca Wind Farm

Solwaybank Wind Farm

SOLWAYBANK

FIGURE 13.2

PREDICTED CUMULATIVE NOISE FOOTPRINT

Legend

- Survey Location
- Receiver Location
- Turbine Location
- > 35dB(A)
- >40dB(A)
- >45dB(A)
- >50dB(A)
- >55dB(A)

Grid intervals at 1 km

The LA90,10min descriptor has been used

The noise footprint has been calculated at a wind speed of 8m/s at 10m height using the ISO:9613:2 propagation model with all barrier attenuation (i.e. shielding by hills) removed. The figure may therefore show slightly more conservative results than those numerically calculated and presented in the acoustic chapter and should be considered illustrative only.

Turbines prefixed "T" are the proposed Solwaybank wind farm. Turbines prefixed "C" are the operational and consented Craig wind farm. Turbines prefixed "M" are the operational Minsca wind farm. Turbine prefixed "E" are the consented Ewehill wind farm. Turbines prefixed "W" are the proposed Ewehill Extension wind farm.

Red receiver icons indicate background noise measurements made at those locations

N

LAYOUT DWG	T-LAYOUT NO.
01307D0007-10	PSCOswb051, 54 & 56-59

DRAWING NUMBER

01307D6903-04

SCALE - 1:40,000

ENVIRONMENTAL STATEMENT