Chapter nine

NOISE

INTRODUCTION

9.1 This chapter provides an assessment of the noise effects of the proposed development. The noise assessment has been carried out according to the Energy Technology Support Unit (ETSU) report ETSU-R-97[1] which is the approved assessment method stated in Scottish Government online planning guidance[2]. The ETSU guidance advises on noise limits for wind turbines which are thought to *"offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development"*.

9.2 To set the noise limits, baseline noise measurements over a 19-day period were carried out at five locations near the site. Predictions of the turbine noise have been carried out to ensure that the noise limits can be met.

9.3 The proposed development is approximately 7.5km from Farr Wind Farm which comprises 40 operational Bonus 2.3MW turbines. A proposed RWE scheme known as Glen Kyllachy Wind Farm lies immediately to the south of the Farr Wind Farm. The proposed Glen Kyllachy Wind Farm has been refused permission by the Highland Council and is currently the subject of an appeal to the Scottish Ministers. There is also proposal for two small turbines at Hillcroft, some 3.5km to the north-east of the proposed development.

9.4 ETSU-R-97 advises: "...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". Therefore, this assessment considers the noise impact of the proposed Carr development alone and the cumulative noise impact with the other operational and proposed schemes described above.

9.5 Noise during the construction phase could include construction activity on the wind farm site and noise from the transportation of construction materials and turbine components. Noise from on-site construction activity will be a short-term effect only and will be limited to hours agreed with Highland Council. Therefore it is not necessary to consider on-site construction noise as any impact will be insignificant. However an assessment of noise from construction traffic movements is included here.

9.6 A noise contour plot is provided in Figure 9.1 for the proposed development. This also shows the noise monitoring locations and other residential properties. A series of appendices provide further information on the methodologies and the data used in this assessment, including a glossary of noise terminology in Appendix 9-1 and a description of the ISO 9613-2 calculation parameters in Appendix 9-2. This noise impact assessment has been prepared by Ion Acoustics Ltd for Airvolution Energy.

1 ETSU-R-97 The Assessment and Rating of Noise from Wind Farms. ETSU for the DTI. Available online from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/49869/ETSU_Full_copy__Searchable_.pdf

2 Onshore Wind Turbines Scottish Government Updated May 28, 2014. Available online from: http://www.scotland.gov.uk/Resource/0045/00451413.pdf

Noise from wind turbines

9.7 Wind turbines are not noisy in absolute terms. It is possible to stand at the base of a turbine tower and hold a normal conversation. For the proposed development, noise levels will be limited to 41 dB L_{A90} (43 dB L_{Aeq}) for wind speeds up to 10 metres per second (m/s) at 10m height at the nearest third-party dwelling. This is put into context in Table 9.1 below, and by reference to the National Noise Incidence Survey carried out in 2000 / 2001 which indicated that 54% of the UK population were exposed to daytime noise levels at, or above 55 dB $L_{Aeq\ 16hr}$ and that 67% were exposed to night-time noise levels exceeding 45 dB $L_{Aeq\ 8hr}$. For these people, a wind farm would rarely be audible. However, away from major roads, there may be little other noise to mask noise from wind turbines. In these circumstances, a wind farm may be audible, and turbine noise must be controlled to provide acceptable conditions for those living in the vicinity.

Table 9.1 Noise from wind farms compared with other sources

Source/Activity	Indicative noise level dB (A)
Threshold of pain	140
Jet aircraft at 250 m	105
Pneumatic drill at 7m	95
Truck at 30 mph at 100 m	65
Busy general office	60
Car at 40 mph at 100 m	55
Wind farm at 500 m	35 – 45
Quiet Bedroom	20 – 35
Rural night-time background	20 – 40

9.8 Noise from wind turbines comprises: aerodynamic noise from the turbine blades turning in the wind, and mechanical noise from the gearbox (if present) and generator. Over recent years, turbine manufacturers have succeeded in substantially reducing the mechanical noise sources. Aerodynamic noise is characterised as a broadband sound not unlike wind blowing through trees, but modulated, so it appears as a swishing sound at regular intervals. As the distance from the turbines increases, the swishing becomes less prominent.

9.9 Wind turbines typically operate above a 'cut-in' wind speed of around 3m/s (at hub height). The noise and power output then gradually increases with increasing wind speed until the rated power is reached. Above this, the noise levels generally flatten off and there is little or no increase in noise with wind speed as the turbine blades are pitched to shed energy and maintain constant electrical power. The turbines are shut down, typically at wind speeds above 25m/s (at hub height) to prevent damage.

METHODOLOGY AND GUIDANCE

Planning Advice Note 1/2011 – Planning and Noise

9.10 Scottish Government advice on noise issues for planning is provided in Planning Advice Note (PAN) 1/2011 'Planning and Noise'. In relation to wind turbines, the document states: *"Good acoustical design and siting of turbines is essential to minimise the potential to generate noise."* PAN 1/2011 then refers to web-based planning advice for renewable energy technologies.

Onshore Wind Turbines – Scottish Government Planning Advice

9.11 Scottish Government information and planning advice on the technologies for renewable energy is available in the form of a series web-based advice documents. The document Onshore Wind Turbines (last updated 28 May 2014) is applicable.

9.12 In respect of noise, the document 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. 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."

9.13 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'[3]. 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."

9.14 ETSU-R-97 is used for this assessment together with the Institute of Acoustics' Good Practice Guide in accordance with the Scottish Government advice.

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

9.15 ETSU-R-97 published in September 1996, was the result of the deliberations of the Working Group on Noise from Wind Turbines, which was set up in 1993 by the Department of Trade and Industry to derive guidelines for assessing wind turbine noise. ETSU-R-97 is the assessment method stipulated by Scottish Government advice.

9.16 ETSU-R-97 provides a method for assessing wind turbine noise and in particular, the setting of external noise limits which are either:

- relative to the background noise (L_{A90} dB), or
- fixed when background noise levels are otherwise very low.

9.17 In most rural locations, the background noise depends on the wind speed. For rural environments, the "fixed" part of the ETSU-R-97 limit usually applies at low wind speeds. At high wind speeds, noise from wind in the trees and flowing over local features such as roofs can be considerable, and is often sufficient to mask the sound of

3 Institute of Acoustics 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' http://www.ioa.org.uk/publications/good-practice-guide

wind turbines. Therefore, it is often at lower wind speeds that the turbines are more audible.

9.18 The ETSU-R-97 limits are set in terms of the L_{A90} noise parameter. This is defined as the noise level exceeded for 90% of the measurement time. It is taken to represent the 'background noise', that is the underlying noise level in the absence of short-term events. This unit was chosen to describe turbine noise as it is fairly steady and because extraneous short-term events such as discrete car passes and aircraft do not usually affect the L_{A90} parameter. For wind turbine noise, the L_{A90} noise parameter is typically 2 dB less than the L_{Aeq} parameter. The L_{Aeq} can be regarded as an average noise level over a time period.

9.19 The ETSU-R-97 limits set relative to the background noise are derived separately for 'amenity hours' daytime periods and for the night-time periods, defined as 11pm to 7am. The amenity hours daytime periods are chosen to reflect periods when people might be outside in their gardens and are defined as:

- All evenings from 6pm to 11pm
- Saturday afternoons from 1pm to 11pm and
- All day Sunday (7am to 11pm)

9.20 For the daytime amenity hours periods, the suggested noise limits are 35 to 40 dB L_{A90} or 5 dB above the prevailing background, whichever is the greater. A degree of judgment is required in determining the fixed limit within the 35 to 40 dB L_{A90} range and ETSU-R-97 states that this will depend on:

- The number of dwellings in the neighbourhood of the wind farm
- The effect of noise limits on the number of kWh generated
- The duration and level of exposure

9.21 In the Scoping Opinion, Highland Council has advised that the lower fixed limit will be applied to the proposed development. Therefore the proposed daytime limit is set on the basis of 35 dB L_{A90} or the prevailing background noise + 5dB whichever is the greater.

9.22 For night-time periods, the ETSU-R-97 noise limit is 43 dB L_{A90} or 5 dB above the background, whichever is the greater. The 43 dB L_{A90} limit was derived from a sleep disturbance limit of 35 dB L_{Aeq} (internally) with an allowance of 10 dB for the attenuation of an open window to derive the corresponding external noise level and with 2 dB subtracted to account for the use of the L_{A90} noise index rather than the L_{Aeq}.

9.23 The ETSU-R-97 night-time limit was based on the old World Health Organisation (WHO) internal noise standard of 35 dB L_{Aeq}. Since the publication of ETSU-R-97, a later WHO document 'Guidelines for Community Noise', has reduced the internal night-time noise standard to 30 dB L_{Aeq} *"to avoid negative effects on sleep"*. The same WHO guidelines recommend that *"at night-time, outside sound levels about 1 metre from facades of living spaces should not exceed 45 dB L_{Aeq}, so that people may sleep with bedroom windows open"*. This was based on a reduction of 15 dB for the sound level difference between the inside and outside with an open window. The WHO 45 dB L_{Aeq} external noise limit at 1m from a façade translates to a limit of 42 dB L_{Aeq} in free-field conditions, away from the façade, or 40 dB L_{A90}. Therefore, there is an argument for reducing the ETSU-R-97 external noise limit to 40 dB L_{A90}.

9.24 In the Scoping Opinion, Highland Council has stated that a lower night-time limit of 38 dB L_{A90} or the background noise + 5dB shall be applied to the proposed development. The proposed development has been designed to meet this lower limit.

9.25 ETSU-R-97 allows for a higher limit where the residents are financially involved with the wind farm development. The suggested limit is 45 dB L_{A90} for both the quiet day and night-time periods and *"that consideration should be given to increasing the permissible margin above background"*. Dinichean House is occupied by landowners associated with the development. Therefore, the financially involved limit will apply at this location.

9.26 Where audible tones are present in the noise spectrum, ETSU-R-97 recommends that a tonal penalty be added based on the level of the tone above the masking noise. Modern wind turbines do not usually have significant tonal characteristics because noise control techniques have improved, particularly in reducing noise from the gearbox. Nevertheless, it is advisable to ensure that any planning condition noise limits are set in terms of the 'rating level' of the noise, that is the wind turbine noise level plus any tonal penalty derived according to the ETSU-R-97 rating system.

Institute of Acoustics Good Practice Guide to ETSU-R-97

9.27 In May 2013, the Institute of Acoustics (IoA) published the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'. The document was prepared with the purpose of agreeing current good practice in the application of the ETSU-R-97 methodology to wind turbine schemes. The document was prepared by a specialist working group and reviewed by a peer group of professionals working in a variety of relevant disciplines. A discussion of ETSU-R-97 noise limits was excluded from the remit of the working group as these are a matter of UK Government policy.

9.28 The Scottish Government has formally endorsed the IoA Good Practice Guide (GPG) and the planning advice recommends that it be used for wind turbine noise assessments. Since May 2013, a number of supplementary guidance notes have also been published providing further detail. The IoA GPG and the supplementary guidance notes should be regarded as a refinement of the ETSU-R-97 guidance to ensure consistency and this noise assessment follows the guidelines stated therein.

9.29 The Good Practice Guide (GPG) provides general advice on noise monitoring and data processing for noise surveys. It also clarifies a number of issues including the following:

- The background noise survey should be of sufficient duration that no fewer than 200 valid data points are obtained for each of the amenity hours and night-time periods with no fewer than five valid points in any 1 m/s wind speed bin.
- That ISO 9613-2[4] is to be used for wind turbine noise predictions, with certain stipulations and limitations.
- The background noise measurements (and thereby noise limits) should preferably be corrected for wind shear by correlating the background noise measurements with the standardised wind speed at 10m height. The

4 International Standards Organisation ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation

standardised wind speed is defined as the wind speed at 10m height which is derived from the hub height wind speed using a standard equation.

ISO 9613-2 Calculation Method

9.30 ETSU-R-97 does not prescribe a calculation method for predicting wind turbine noise. However, the IoA GPG, described above, recommends that ISO 9613-2 should be used for turbine noise predictions with certain stipulations and limitations.

9.31 The propagation model, described in Part 2 of the ISO 9613 Standard, allows noise levels to be predicted for short-term downwind conditions, i.e. for wind blowing from the proposed turbine towards the houses. This provides a typical worst case in terms of propagation because when the wind is blowing in the opposite direction, noise levels will be significantly reduced compared with the downwind case.

9.32 Noise from wind turbines is reduced by distance, atmospheric losses, screening effects (if present) and other 'miscellaneous' losses. Noise levels can be increased or reduced by the interaction of the sound waves with the ground. The ISO propagation model calculates the predicted sound pressure level at a specified distance by taking the sound power level in octave frequency bands and subtracting a number of attenuation factors according to the various losses and the ground effect as described above. The noise level in each octave band can be represented by equation 1 below:

9.33 Predicted Level $L_{90} = L_{W(eq)} + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc} - 2dB$ .....(1)

9.34 The predicted octave band levels from each of the turbines are then summed together to give the overall 'A' weighted predicted sound level from all the turbines acting together. The correction of 2dB is used to convert the L_{eq} levels, as used to describe the turbine sound power, to the L_{90} parameter, used in the ETSU assessment. The attenuation factors in the calculation (A_{geo} etc) are described in Appendix 9-2.

9.35 In accordance with the IoA GPG, the following input parameters and assumptions have been used:

- Downwind propagation
- Turbine sound power levels include an allowance for uncertainty
- G=0.5 "mixed ground" assumption and a receiver height of 4m
- Air absorption calculated using a temperature of 10°C and 70% relative humidity
- Screening losses are limited to 2dB.

Local Authority Consultation

9.36 The assessment methodology and noise monitoring positions were discussed with Mr Robin Fraser, an Environmental Health Officer with Highland Council. Five noise monitoring positions were agreed including properties to the east of the B861 as requested by Mr Fraser.

9.37 The Scoping Opinion dated 17th November 2014 by Highland Council set out other requirements for the assessment including the applied noise limits set out as above. It also stated that construction noise activity on site need not be assessed, provided that construction activity is limited to Highland Council's suggested working hours and that an assessment of construction traffic and 'access formation' was made. This is provided as a stand-alone section after the assessment of the operational noise effects.

BASELINE CONDITIONS

9.38 A baseline noise survey was carried out over a 19-day period from 30th October to 17th November 2014 to determine baseline noise conditions at five receptors and set noise limits for the scheme.

Survey Details

9.39 Five noise monitoring positions were identified and agreed with Mr Robin Fraser from Highland Council. These represent the nearest properties to the wind turbines.

9.40 The monitoring locations are described in Table 9.2 along with Ordnance Survey grid coordinates determined with a GPS and the distance to the nearest turbine. Photographs of the noise monitoring locations are provided in Appendix 9-3.

Table 9.2 Description of Noise Monitoring Locations

Location	Easting	Northing	Distance* to Nearest Turbine (m)	Description
Cloughmor	267607	836094	749	The noise monitor was installed to the south of the house. The area to the west of the house is forestry but to the south and east there are open fields.
Ardelve	267856	836217	1016	The noise monitor was installed to the south of the house on a small area of grass by the drive way. There are large trees between the road and the house.
Monadhliath	268151	835707	1310	Monadhliath has a large garden extending to the south of the house. The noise monitor was installed at the far southern end of the garden in accordance with the wishes of the resident who wanted to ensure that the monitor was out of the way of her children.
Blar Buidhe	267455	834364	1160	Blar Buidhe is an isolated house set amongst trees with a view to the south. The monitor was set in the front garden in discussion with the resident.
Tom's Croft	265758	834695	1315	Tom's Croft is a residential care home for children and young people with large grounds. The noise monitor was set up to the east of the house at the bottom of the garden in a dip in the terrain. This position was requested to ensure that the monitor was out of

				view from the house.

* The distance shown is the distance from the nearest turbine to the noise monitoring location as determined by the GPS device (typically ± 5m). The distances to the houses and those used in calculations may differ slightly.

9.41 Four Larson-Davis Type LD-820 sound level meters and a Rion NL-52 sound level meter were used. The microphones of the Larson-Davis sound level meters were fitted with a double-skin windshields designed in line with the recommendations of ETSU report W/13/00386/REP. The Rion sound level meter was fitted with a Rion Type WS-15 wind shield. The microphones and windshields were mounted on tripods at a height of 1.2 - 1.5m above ground level. The sound level meters were configured to measure noise levels in 10-minute periods and calibrated with a Brüel & Kjær Type 4231 sound level calibrator. A tipping bucket rain gauge was set up at Cloughmor to determine periods with rain fall.

9.42 Table 9.3 shows the meters used, the deviation in the calibration levels between the start and end of the survey and a description of the noises heard at set up and collection.

Table 9.3 Noise Monitoring Equipment and Description of Noises Heard

Location	Meter Used	Deviation in Calibration Levels (dB) re initial	Noise heard at set up and collection
Cloughmor	LD-820 (ION 3)	0.2 dB	It was quiet during the setup of the equipment. Distant noise could be heard possibly from the A9 and other local roads and from chain saws. At collection, noise from distant reversing beepers and other activity could be heard from Mid Lairgs Quarry. Aircraft flyovers were noted. The residents reported that forestry operations had been taking place during the monitoring period.
Ardelve	LD-820 (ION 2)	-0.4 dB	During the set up the residents were cutting trees close to the house and building work was taking place to the house but both activities are only expected to take place during normal working hours which are excluded from the ETSU-R-97 analysis. Noise from the quarry could be heard at collection. This was variable in nature.
Monadhliath	LD-820 (ION 1)	+0.5 dB	At Monadhliath, noise from the quarry was again noted especially at collection. Noise from aircraft and from highland cattle were noted.
Blar Buidhe	NL-52	0.0 dB	The residents report hearing Farr Wind Farm occasionally although this was not audible during

			setup or collection. Instead the noise sources heard included distant traffic noise from the east.
Tom's Croft	LD-820 (ION 5)	0.0 dB	It was fairly still and quiet during the setup and collection of the equipment so noise could be heard from distant sources including possibly Mid Lairgs Quarry and distant chain saws. Occasional aircraft were noted.

9.43 The deviation in calibration levels are within acceptable tolerances. The meters and calibrator are calibrated to national standards biennially and annually respectively in line with standard recommendations. Appendix 9-4 provides calibration charts for the equipment used.

Measurement of Wind Speed

9.44 For the survey, wind speed and direction measurements were made using a Triton Sodar[5] unit installed on the site at Ordnance Survey grid reference 267016E, 836162N.

9.45 The Institute of Acoustics' Good Practice Guide requires that wind shear on the site be taken into account in noise assessments. Therefore, the use of the standardised wind speed at 10m height is preferred. This derived from the hub height wind speed according to the log law equation describing the variation in wind speed with height (Equation 2 below) with the ground roughness set at 0.05m.

$$v_{10} = v_{hh} \times \left(\frac{\ln\left[10/z_0\right]}{\ln\left[hh/z_0\right]} \right) \qquad \text{.....(2)}$$

9.46 Where v_{10} and v_{hh} are wind speeds at heights of 10m and hub height (73m) respectively, and z_0 is the ground roughness length (0.05m).

9.47 The Sodar provides measurements of wind speeds at various heights including 60m and 80m. For this site, the wind speed at the hub height (73m) was calculated by interpolation using the power law equation (Equation 3 below).

$$v_1 = v_2 \times \left(\frac{h_1}{h_2} \right)^m \qquad \text{.....(3)}$$

9.48 In equation 3, the measured wind speed at two heights, 60m and 80m allows the exponent 'm' to be calculated and hence the wind speed at the hub height, 73m. The log-law wind relationship (Equation 2) can then be used to standardise the wind speed measurements to 10m height as required by the IoA GPG.

9.49 The use of the standardised wind speed ensures that both the background noise measurements and predicted wind turbine sound levels are described with the same wind speed reference, ie at 10m height, but derived from the hub height wind speed using the same equation. This method allows for wind shear to be factored directly into the background noise measurements to reduce the uncertainties due to the

5 Sodar Sonic Detection and Ranging http://www.secondwind.com/Triton/Triton-Sodar.html

wind shear experienced on site. The wind speed and direction during the survey is shown in Appendix 9-5.

9.50 For each data sample, the Sodar unit reports a 'quality factor' relating to the accuracy of the data received. For this survey, data has been excluded where the quality factor was less than 90%. Similarly samples where the wind speed at 60m height was greater than the wind speed at 80m have been discounted. Therefore there are a few gaps in the wind speed data. Often this occurs due to rain when the readings are less reliable. Noise data with rain is excluded in any case for the ETSU-R-97 analysis.

Survey Results

9.51 The results of both surveys have been plotted as a series of time history charts showing the variation in noise with wind speed. These results are provided in graphical form in Appendix 9-6.

9.52 The extension cable between sound level meter and the microphone at Ardelve had somehow been disconnected at 9pm on Saturday 15th November. Therefore there is no data after that time. However, there are still 17 days of valid data logged at this position.

9.53 Some residents report hearing Farr Wind Farm on occasions although this was not audible during set up and collection. Predicted noise levels from the Farr Wind Farm in isolation indicate turbine noise levels at the various receptors between 17 and 20 dB L_{A90} for the Bonus 2.3MW turbines at a wind speed of 8 m/s and under downwind conditions. This is at, or below, the noise floor of the sound level meters and at least 10dB below the prevailing background noise levels at this wind speed. Predicted noise levels from far are also and more than 10dB below the lowest limit that would be applied, 35 dB L_{A90}. Therefore noise from Farr Wind Farm has a negligible effect on the measured noise levels and there has been no attempt to correct for this.

9.54 The noise data has then been filtered and analysed to obtain scatter plots showing the relationship between background noise levels and standardised wind speed at 10m height for night-time and daytime amenity hour periods as described above. Data has been removed when rain fall was logged. A 10-minute period before and after a rainfall event has been removed in accordance with the Institute of Acoustics Good Practice Guide. A few other data samples have been removed where spurious events were identified. The excluded samples are also shown on the scatter plots.

9.55 The scatter plots are presented in Appendix 9-7. Each scatter plot includes a best-fit trend line describing the prevailing background noise with wind speed. The background noise levels derived from the best-fit trendline are shown in Table 9.4 for wind speeds between 3 and 10 m/s at 10m height. At 10 m/s and above there is little noise data. The requirement of the Institute of Acoustics Good Practice Guide for five valid data points in the wind speed bin centred on 10 m/s is just met. There is insufficient data above 10 m/s, but the maximum turbine sound power level is already achieved at 9 m/s and therefore any noise limit for wind speeds above 10 m/s can be flattened to the value at 10 m/s.

Table 9.4: Baseline Noise Levels, L_{A90} dB, derived from the Scatter Plots

Location	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Prevailing Background Noise Levels , L_{A90} dB							
Amenity Hours Daytime Periods								
Cloughmor	26.2	27.9	30.6	33.9	37.6	41.2	44.6	47.3
Ardelve	25.8	27.4	29.9	33.0	36.3	39.5	42.1	43.9
Monadhliath	28.6	29.5	31.1	33.0	35.3	37.8	40.3	42.7
Blar Buidhe	27.2	28.6	30.7	33.2	36.2	39.4	42.6	45.8
Tom's Croft	23.1	24.5	26.5	29.1	32.0	35.1	38.3	41.6
Night-time Periods								
Cloughmor	23.7	25.5	28.5	32.3	36.5	40.8	44.8	48.2
Ardelve	23.4	25.2	28.0	31.4	35.0	38.5	41.5	43.5
Monadhliath	26.6	27.5	29.4	31.9	34.8	37.8	40.5	42.6
Blar Buidhe	26.3	27.7	30.1	33.3	37.0	40.7	44.1	47.1
Tom's Croft	22.4	23.6	25.7	28.5	31.9	35.8	40.2	44.8

9.56 At all locations there is a consistent rising trend of background noise level with increasing wind speeds. Noise levels are fairly low at all locations and are lower still during the night-time. The lowest noise levels were logged at Tom's Croft. This was perhaps the most isolated position and was also further from forestry, the quarry and the A9.

Noise Limits

9.57 Noise limits for the proposed development can be set on the basis of the background noise results. The property Dinichean House is financially involved with the proposed development and therefore the noise limits are set on the basis of 45 dB L_{A90} for the daytime and night-time periods.

9.58 For the third-party properties, the daytime limits stipulated by Highland Council is the ETSU-R-97 lower absolute level of 35 dB L_{A90} or 5 dB above the background noise, whichever is the greater.

9.59 For the night-time period, the standard ETSU-R-97 limit would be 43 dB L_{A90}. However Highland Council have indicated that this is not appropriate and that a lower night-time limit of 38 dB L_{A90} is proposed. This is lower than the 40 dB L_{A90} limit which is consistent with the WHO advice (paragraph 9.23).

9.60 The proposed noise limits are set out in Table 9.5 below. The noise limits at Ardelve and Monadhliath can both be applied to represent properties around the B861. Ardelve has lower background noise levels at low wind speeds whereas Monadhliath has lower background noise levels at moderate to high wind speeds. In this case a composite limit is suggested which represents the lowest limit from either of the two properties. This can be applied to all properties off the B861 (except for Cloughmor). The noise limits at Tom's Croft will apply at Mains of Bunachton and other receptors in the immediate area.

Table 9.5: Proposed Noise Limits

Location	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Noise Levels , L_{A90} dB							
Amenity Hours Daytime Periods								
Cloughmor	35.0	35.0	35.6	38.9	42.6	46.2	49.6	52.3
Ardelve	35.0	35.0	35.0	38.0	41.3	44.5	47.1	48.9
Monadhliath	35.0	35.0	36.1	38.0	40.3	42.8	45.3	47.7
Blar Buidhe	35.0	35.0	35.7	38.2	41.2	44.4	47.6	50.8
Tom's Croft	35.0	35.0	35.0	35.0	37.0	40.1	43.3	46.6
Ardelve/Monadhliath composite limit	35.0	35.0	35.0	38.0	40.3	42.8	45.3	47.7
Night-time Periods								
Cloughmor	38.0	38.0	38.0	38.0	41.5	45.8	49.8	53.2
Ardelve	38.0	38.0	38.0	38.0	40.0	43.5	46.5	48.5
Monadhliath	38.0	38.0	38.0	38.0	39.8	42.8	45.5	47.6
Blar Buidhe	38.0	38.0	38.0	38.3	42.0	45.7	49.2	52.1
Tom's Croft	38.0	38.0	38.0	38.0	38.0	40.8	45.2	49.8
Ardelve/Monadhliath composite limit	38.0	38.0	38.0	38.0	39.8	42.8	45.5	47.6

POTENTIAL OPERATIONAL EFFECTS

Operational noise predictions

9.61 Predictions of wind turbine noise levels have been carried out to ensure that the scheme can comply with the above limits. The calculations have been carried out using a computer model "IMMI", which implements the ISO 9613-2 methodology with the input parameters from the Institute of Acoustics' Good Practice Guide, as described in paragraph 9.35. To carry out the modelling, the terrain information has been obtained from Ordnance Survey data at a 50m resolution and imported into the model.

9.62 A candidate turbine for this site is a Senvion 3.4M104 wind turbine with a 73m hub height. A Vestas V105 3.3MW turbine is also a possibility. The variation in sound power level with wind speed for these turbines is stated in Table 9.6, below. A 1dB margin for uncertainty has been added to the Senvion data to account for uncertainty in accordance with Senvion's recommendations. A 2dB margin for uncertainty is added to the Vestas data.

9.63 The Senvion data sheet is provided in Appendix 9-7. The datasheet values for a 78m to 80m hub height have been used (+1dB). Sound power levels at low wind speeds for the proposed 73m hub height would be slightly lower, although the difference is not significant. Both the Vestas and Senvion turbine can operate on reduced noise modes. Data for the unrestricted mode and reduced noise modes are presented in Table 9.6 including the applicable uncertainty margins. The Vestas V105 3.3MW is a relatively new turbine and information from Vestas received at the time of writing only refers to one sound-reduced mode (Mode 2). However, it is expected that other, lower, reduced noise modes will be available in the future.

Table 9.6 A-weighted Sound Power Levels for Senvion 3.4M104 & Vestas V105 3.3MW

Turbine	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Sound Power Level dB $L_{WA(eq)}$							
Senvion 3.4M104	96.0	97.4	100.8	104.6	106.3	106.6	106.1	105.8
Senvion 3.4M104 SMII Type A	96.0	97.4	99.7	102.8	103.6	104.0	106.3	105.8
Senvion 3.4M104 SMII Type B	96.1	96.6	97.8	99.1	100.3	104.0	106.5	105.8
Vestas V105 3.3MW Mode 0	94.0	96.6	101.6	105.4	107.8	108.5	108.5	108.5
Vestas V105 3.3MW Mode 2	94.4	96.7	101.6	104.8	106.3	106.5	106.5	106.5

9.64 For the ISO 9613 calculation, octave band sound power values are required. These have been taken from a Senvion measurement report *"WT 7360/09"* at 9 m/s at 10m height and are presented in Table 9.7, below.

Table 9.7 A-weighted Octave Band Sound Power Levels for Senvion 3.4M104 SMII Type B

Wind Speed (m/s) at 10m	Overall dB $L_{WA(eq)}$	A-Weighted Octave Band Sound Power Level dB $L_{WA(eq)}$ Including Uncertainty							
		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
9	106.5	91.9	95.9	98.5	100.7	101.4	97.0	90.7	83.1

9.65 The maximum sound power for the output occurs at between 8 m/s and 10 m/s at 10m height. Above this there is no increase in noise as the turbine blades are pitched to reduce energy and maintain the rated power output.

9.66 For this scheme, the Senvion 3.4M104 turbine operating at Sound Management Mode SMII Type B has been selected to meet the noise limits and other project criteria. Calculations using the Vestas V105 3.3MW turbine operating at Mode 2 indicate a small exceedance over the limits. However, other reduced noise modes for the Vestas V105 3.3MW turbine are likely to be available in the future which would be suitable and would meet the limits. Currently, there is no published noise data available for these modes.

9.67 For commercial reasons, it is not possible to state that the Senvion turbine will definitely be used. The final choice of turbine for this site will depend on many factors, including the noise output. The options will be studied carefully by the developer and turbine supplier when the turbines are procured and will be selected to be compliant with the planning noise limits. In addition, the turbine will be required to be free from tonal components which would result in a tonal penalty.

Predicted Noise Levels

9.68 The noise predictions have been carried out in the first instance in the form of a noise contour plot for the candidate turbine, Figure 9.1. This shows downwind noise levels at a wind speed of 9 m/s at 10m height which represents the highest sound power level for this turbine in Sound Management Type B mode. The monitoring locations and other residential locations are also shown. The predicted turbine noise levels referenced to wind speeds at 10m height are shown for the closest properties in Table 9.8 at wind speeds between 4 and 10 m/s. Noise levels at wind speeds above 10 m/s are no higher than those reported at 10 m/s as the rated power is achieved.

Table 9.8 Predicted Downwind Noise Levels for Senvion 3.4M104 SMII Type B Turbines

Turbine	Easting	Northing	Standardised Wind Speed (m/s) at 10m Height						
			4	5	6	7	8	9	10
			Predicted Noise Levels dB L_{A90}						
Dinichean House	267339	837112	29.4	30.6	31.9	33.1	36.8	39.3	38.6
Cloughmor	267611	836123	30.9	32.1	33.4	34.6	38.3	40.8	40.1
Carr Ban	267830	836595	28.0	29.2	30.5	31.7	35.4	37.9	37.2
Bellforte	267870	836503	27.9	29.1	30.4	31.6	35.3	37.8	37.1

Turbine	Easting	Northing	Standardised Wind Speed (m/s) at 10m Height						
			4	5	6	7	8	9	10
			Predicted Noise Levels dB L_{A90}						
Belvedere	267832	836472	28.3	29.5	30.8	32.0	35.7	38.2	37.5
Ardelve	267868	836252	28.3	29.5	30.8	32.0	35.7	38.2	37.5
Gask House & Cottages	268034	836058	27.1	28.3	29.6	30.8	34.5	37.0	36.3
Mains of Gask Farmhouse	268073	836086	26.8	28.0	29.3	30.5	34.2	36.7	36.0
Monadhliath	268194	835819	25.9	27.1	28.4	29.6	33.3	35.8	35.1
The Arches	268260	835734	25.4	26.6	27.9	29.1	32.8	35.3	34.6
Bohanbeag Cottage	267857	835596	28.4	29.6	30.9	32.1	35.8	38.3	37.6
Knottywood Cottage	267896	835616	28.1	29.3	30.6	31.8	35.5	38.0	37.3
Grianach	267968	835470	27.2	28.4	29.7	30.9	34.6	37.1	36.4
Stroma	267894	835442	27.8	29.0	30.3	31.5	35.2	37.7	37.0
Blar Buidhe	267438	834408	25.5	26.7	28.0	29.2	32.9	35.4	34.7
Mains of Bunachton	265724	834850	26.9	28.1	29.4	30.6	34.3	36.8	36.1
Tom's Croft	265703	834749	26.2	27.4	28.7	29.9	33.6	36.1	35.4
Baile Na Creige	265602	834666	25.2	26.4	27.7	28.9	32.6	35.1	34.4

9.69 Dinichean House is occupied by landowners associated with the development and therefore, the 45 dB L_{A90} financially involved limit applies. This is comfortably met at all wind speeds. At the other receptors, an assessment must be made against the proposed noise limits which vary with wind speed as shown in Table 9.5.

9.70 The ETSU-R-97 assessments are shown in Tables 9.9 to 9.13 for Cloughmor, Mains of Bunachton, Blar Buidhe, Bohanbeag Cottage and Ardelve. These represent the closest properties for the applicable limits. Bohanbeag Cottage is assessed against the composite prevailing background noise levels determined at Monadhliath and Ardelve. At each integer wind speed the composite limit is derived from the lowest level of the two locations. Mains of Bunachton is assessed against limits derived from the background noise levels measured at Tom's Croft.

9.71 The margin below the noise limit is also given with a positive margin indicating compliance with the noise limit. The predicted turbine noise levels and limits are also plotted on the scatter plots (Appendix 9-7).

Table 9.9 ETSU-R-97 Assessment for Cloughmor

	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Noise Level, L_{A90} dB							
Predicted Turbine Noise dB L_{A90}	30.4	30.9	32.1	33.4	34.6	38.3	40.8	40.1
Day-time Assessment								
Daytime Background Noise dB L_{A90}	26.2	27.9	30.6	33.9	37.6	41.2	44.6	47.3
ETSU-R-97 Lower Daytime Limit dB L_{A90}	35.0	35.0	35.6	38.9	42.6	46.2	49.6	52.3
Margin below Limit dB	4.6	4.1	3.5	5.5	8.0	7.9	8.8	12.2
Night-time Assessment								
Night-time Background Noise dB L_{A90}	23.7	25.5	28.5	32.3	36.5	40.8	44.8	48.2
Highland Council Night-time Limit dB L_{A90}	38.0	38.0	38.0	38.0	41.5	45.8	49.8	53.2
Margin below Limit dB	7.6	7.1	5.9	4.6	6.9	7.5	9.0	13.1

9.72 Cloughmor is the closest property to the proposed development. However the use of the Senvion turbine with the low noise mode (Sound Management II Type B) results in low noise levels at low wind speeds which are a good fit to the prevailing background noise. The ETSU-R-97 limits are met comfortably with a minimum margin of 3.5 dB. Noise levels exceed the background noise at 6 m/s and below and therefore it is likely that turbine noise levels will be clearly audible under some conditions, albeit within the proposed noise limits.

9.73 The noise limits determined at Tom's Croft have been used to assess the closer property Mains of Bunachton. The results are shown in Table 9.10.

Table 9.10 ETSU-R-97 Assessment for Mains of Bunachton

	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Noise Level, L_{A90} dB							
Predicted Turbine Noise dB L_{A90}	26.4	26.9	28.1	29.4	30.6	34.3	36.8	36.1
Day-time Assessment								
Daytime Background Noise dB L_{A90} (Tom's Croft)	23.1	24.5	26.5	29.1	32.0	35.1	38.3	41.6
ETSU-R-97 Lower Daytime Limit dB L_{A90}	35.0	35.0	35.0	35.0	37.0	40.1	43.3	46.6
Margin below Limit dB	8.6	8.1	6.9	5.6	6.4	5.8	6.6	10.5
Night-time Assessment								
Night-time Background Noise dB L_{A90} (Tom's Croft)	22.4	23.6	25.7	28.5	31.9	35.8	40.2	44.8
Highland Council Night-time Limit dB L_{A90}	38.0	38.0	38.0	38.0	38.0	40.8	45.2	49.8
Margin below Limit dB	11.6	11.1	9.9	8.6	7.4	6.6	8.4	13.7

9.74 Again the use of the Senvion turbine with the low noise mode (Sound Management II Type B) results in low noise levels which follow the trend of the prevailing background noise. Predicted noise levels at Main of Bunachton are fairly low and do not exceed 35 dB L_{A90} until a wind speed of 9 m/s. Nevertheless, noise levels exceed the background noise at low wind speeds and therefore it is possible that turbine noise will be audible under certain wind conditions. In this case the noise limits are met by a minimum margin of 5.6 dB.

9.75 The assessment for Blar Buidhe is shown below in Table 9.11.

Table 9.11 ETSU-R-97 Assessment for Blar Buidhe

	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Predicted Noise Level, L_{A90} dB							
Predicted Turbine Noise dB L_{A90}	25.0	25.5	26.7	28.0	29.2	32.9	35.4	34.7
Day-time Assessment								
Daytime Background Noise dB L_{A90}	27.2	28.6	30.7	33.2	36.2	39.4	42.6	45.8
ETSU-R-97 Lower Daytime Limit dB L_{A90}	35.0	35.0	35.7	38.2	41.2	44.4	47.6	50.8
Margin below Limit dB	10.0	9.5	9.0	10.3	12.0	11.5	12.2	16.1
Night-time Assessment								
Night-time Background Noise dB L_{A90}	26.3	27.7	30.1	33.3	37.0	40.7	44.2	47.1
Highland Council Night-time Limit dB L_{A90}	38.0	38.0	38.0	38.3	42.0	45.7	49.2	52.1
Margin below Limit dB	13.0	12.5	11.3	10.4	12.8	12.8	13.8	17.4

9.76 Predicted noise levels at Blar Buidhe are fairly low and are only marginally above 35 dB L_{A90} at the maximum wind speed. ETSU-R-97 states that a level of 35 dB L_{A90} is sufficiently low to protect amenity regardless of the background noise. In this case the noise limits are met by a minimum margin of 9 dB. Predicted noise levels are below the prevailing background noise at all wind speeds although it is possible that turbine noise will be audible under certain wind conditions.

9.77 Bohanbeag Cottage is the closest of four properties on the west side of the B861. Predicted noise levels at this location are assessed against a composite limit derived from the lowest noise levels at each wind speed taken from Ardelve and Monadhliath. The assessment is shown in Table 9.12 below.

Table 9.12 ETSU-R-97 Assessment for Bohanbeag Cottage

	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Predicted Noise Level, L_{A90} dB							
Predicted Turbine Noise dB L_{A90}	27.9	28.4	29.6	30.9	32.1	35.8	38.3	37.6
Day-time Assessment								
Daytime Background Noise dB L_{A90} (Composite Limit Ardelve / Monadhliath)	25.8	27.4	29.9	33.0	35.3	37.8	40.3	42.7
ETSU-R-97 Lower Daytime Limit dB L_{A90}	35.0	35.0	35.0	38.0	40.3	42.8	45.3	47.7
Margin below Limit dB	7.1	6.6	5.4	7.1	8.2	7.0	7.0	10.1
Night-time Assessment								
Night-time Background Noise dB L_{A90} (Composite Limit Ardelve / Monadhliath)	23.4	25.2	28.0	31.4	34.8	37.8	40.5	42.6
Highland Council Night-time Limit dB L_{A90}	38.0	38.0	38.0	38.0	39.8	42.8	45.5	47.6
Margin below Limit dB	10.1	9.6	8.4	7.1	7.7	7.0	7.2	10.0

9.78 The composite noise limit is met by a minimum margin of 5.4 dB. Predicted turbine noise levels are above the background noise at low wind speeds and therefore it is possible that turbine noise will be audible under some wind conditions, albeit well within the proposed noise limits.

9.79 Predicted noise levels at Ardelve are shown below in Table 9.13. Noise levels at Ardelve, Bohanbeag Cottage and Belvedere are very similar and represent the closest properties on the B861 with the exception of Cloughmor, which has been assessed separately. There is no need to assess the other properties as the nearest properties can comply with the composite noise limit.

Table 9.13 ETSU-R-97 Assessment for Ardelve

	Standardised Wind Speed (m/s) at 10m Height							
	3	4	5	6	7	8	9	10
	Predicted Noise Level, L_{A90} dB							
Predicted Turbine Noise dB L_{A90}	27.8	28.3	29.5	30.8	32	35.7	38.2	37.5
Day-time Assessment								
Daytime Background Noise dB L_{A90}	25.8	27.4	29.9	33.0	36.3	39.5	42.1	43.9
ETSU Daytime Limit dB L_{A90}	35.0	35.0	35.0	38.0	41.3	44.5	47.1	48.9
Margin below Limit dB	7.2	6.7	5.5	7.2	9.3	8.8	8.9	11.4
Night-time Assessment								
Night-time Background Noise dB L_{A90}	23.4	25.2	28.0	31.4	35.0	38.5	41.5	43.5
Highland Council Night-time Limit dB L_{A90}	38.0	38.0	38.0	38.0	40.0	43.5	46.5	48.5
Margin below ETSU Limit dB	10.2	9.7	8.5	7.2	8.0	7.8	8.2	11.0

9.80 Predicted noise levels at Ardelve are well within the ETSU-R-97 and Highland Council noise limits and below the prevailing background noise at 6 m/s and above. Nevertheless it is possible that turbine noise will be audible under certain conditions.

Other Operational Noise Issues - Tonal Noise

9.81 Modern wind turbines have been designed to reduce tones to levels below perception thresholds, even though tones are sometimes measurable. The selection of the final turbine type will include full compliance with ETSU-R-97 including the tonal output. Consequently, no correction for tonal components has been added to the predicted noise levels. Nevertheless, it is appropriate for a planning condition to be imposed on the development which states that the noise limits apply to the rating level of the noise including any tonal penalty applicable when assessed according to the method in ETSU-R-97.

Other Operational Noise Issues - Vibration

9.82 Vibration levels from wind turbines have been measured by extremely sensitive measuring equipment such as seismic arrays, but in terms of human perception, measured vibration levels are well below perception thresholds, even on wind farm sites. Therefore, there is no impact from vibration affecting residents.

Other Operational Noise Issues - Infrasound and Low Frequency Noise

9.83 Infrasound, low frequency noise and vibration are often reported as noise issues in press stories. Infrasound is usually defined as sound below 20 Hz, whereas the frequency range for low frequency sound is often taken to be from 10 Hz to 200 Hz. In 2004, following reports in local and national newspapers, the Department for Trade and Industry (DTI) commissioned Hayes McKenzie to investigate claims that infrasound or low frequency noise levels from wind turbines were causing adverse health effects. Of the 126 operational wind farms (at the time of the study), there were five with reported complaints due to low frequency noise. The DTI/Hayes McKenzie report, 'The measurement of low frequency noise at three UK wind farms'[6] reported detailed noise measurements from three UK wind farms and concluded that there was no evidence of adverse health effects arising from infrasound or low frequency noise from wind turbines.

9.84 Infrasound levels were well below perception thresholds even for the most sensitive persons and there is no evidence that noise below perception thresholds can cause health effects. Low frequency noise levels were audible in some locations, but below the night-time noise criterion proposed by the Department for Environment, Food and Rural Affairs (DEFRA) and below that from other sources, such as traffic noise.

9.85 Many of these issues were summarised in an article in the March / April 2009 issue of Acoustics Bulletin published by the Institute of Acoustics and written by leading authorities on wind farm noise and low frequency noise. The article also concludes: *"From examination of reports of the studies ... and other reports widely available on internet sites, we conclude that there is no robust evidence that low frequency noise (including 'infrasound') or ground-borne vibration from wind farms, generally has adverse effects on wind farm neighbours."*

6 http://www.berr.gov.uk/energy/sources/renewables/explained/wind/onshore-offshore/page31267.html

Other Operational Noise Issues - Amplitude Modulation

9.86 Amplitude modulation is described as a low frequency sound which varies in amplitude at, or above the blade passage frequency of the wind turbines, typically 1 Hz. Sometimes this is called Excess Amplitude Modulation or Other Amplitude Modulation (OAM) to distinguish the phenomenon from blade swish which is a part of normal wind turbine noise, but also a form of (normal) amplitude modulation (NAM) which is well understood and was taken into account when setting the ETSU-R-97 noise limits.

9.87 In July 2007, the Salford University Report[7] on (Other) Amplitude Modulation was published. The Salford study comprised a survey of local authorities to reveal the extent of the problem, a literature review and further detailed investigation of the complaint logs from four affected sites. The report concluded that the mechanism for other amplitude modulation was not fully understood, nor could it be predicted. However, at the time of the study there were only four confirmed cases causing complaints, and overall, the level of complaints from wind farms was low compared to other noise sources. Furthermore, of the four wind farms where amplitude modulation had occurred, the complaints at three of the sites had either subsided or had been resolved with noise control procedures.

9.88 Following this report, the UK Government stated that it did not consider there to be a need to assess this issue further, and confirmed that ETSU-R-97 should continue to be used to assess the noise of wind farms.

9.89 The wind industry trade body, Renewable UK (R-UK), has recently (December 2013) published research into Other Amplitude Modulation[8]. This included theoretical research on mechanisms causing the problem, subjective tests to determine a dose-response relationship and the development of a measurement and assessment rating method. A draft planning condition has been provided (although this is subject to ongoing refinement). The conclusions of the R-UK research are as follows:

- That OAM is caused by the tip of the rotor blade going into the stall at the highest point on its arc under certain conditions. This can result in a periodic 'whoomphing' or 'thumping' noise and, for a turbine with three blades rotating at 20 rpm, this will occur approximately once per second. The phenomenon is primarily a downwind effect with low frequencies prevalent.
- Stall occurs when the air flow becomes detached from the surface of the blade. These transient stall conditions primarily, but not exclusively, occur during high wind shear conditions, when the difference in the wind speed between the lowest part of the rotor's arc varies significantly from the wind speed at the highest point. In these circumstances, the blade pitch settings may not reflect the high wind speeds at the top of the blade.
- Therefore, OAM is more prevalent at night when wind shear tends to be higher. However, in general terms, even for sites where the effect has been documented, the general incidence of OAM is infrequent. The frequency will also depend on the location of the receptors relative to the prevailing wind direction.

7 Research into aerodynamic modulation of wind turbine noise Report by Salford University July 2007 Contract no NANR233.
8 http://www.renewableuk.com/en/publications/index.cfm/wind-turbine-amplitude-modulation

- Subjective tests undertaken at the University of Salford have indicated that the modulated sounds are subjectively more annoying than non-modulated sounds, although the overall level of the sound is still an important factor in the overall annoyance.
- From the Salford subjective tests, and by reference to other subjective research carried out in Japan, it is possible to develop a penalty mechanism for OAM based on the perceived additional annoyance caused by the modulation relative to an unmodulated signal of the same overall level. The proposed penalty has a value between 3 and 5 dB.
- The penalty applicable can be determined by objective measurements and data processing which focuses on the periodic nature of OAM. The penalty is then applied to the measured noise levels in a similar way to the tonal penalty (provided within ETSU-R-97). A draft planning condition is available, although this is subject to ongoing refinement and likely to be replaced following UK Government sponsored research.
- Although, at present it is not possible to assess the likelihood of OAM occurring at the planning stage, the provision of the draft planning condition and penalty mechanism provides some comfort that OAM, should it occur, can be controlled in planning.
- If OAM should occur, it will be possible to mitigate any problems by controlling the turbine, albeit with some loss of power.

POTENTIAL EFFECTS DURING THE CONSTRUCTION PHASE

9.90 Highland Council's Scoping Opinion requested an assessment of traffic noise during construction and including noise from 'access formation'. The assessment is set out below. In accordance with the Scoping Opinion there has been no assessment of on-site construction noise as the site is remote from residential locations and working hours will be agreed with Highland Council.

Increases in noise due to construction traffic

9.91 The change in noise levels during the peak month of the construction programme can be calculated and compared with the assumed traffic flow for the base year, 2016. Information on traffic has been taken from the Transport and Access Chapter (Chapter 12). The methodology described in the Calculation of Road Traffic Noise (CRTN)[9] is used. This provides two equations:

Increase due to increased flow: $$10\log(\frac{q_1}{q_0}) \quad \text{.....(4)}$$

Increase due to percentage HGVs: $$10\log(1+\frac{5p_1}{V})-10\log(1+\frac{5p_0}{V}) \quad \text{.(5)}$$

9.92 Where q_1 and q_0 are the flow with construction and the baseline flows respectively and p_1 and p_0 are the percentage of heavy vehicles for the construction traffic and baseline respectively and V, the traffic speed in km/h.

9.93 The above formulae allow the change in noise levels to be calculated according to the predicted changes in traffic flows for the base year with construction. The

9 Calculation of Road Traffic Noise (CRTN), Department of Transport Welsh Office 1988

calculation for the peak month is set out in Table 9.14. The traffic speeds are those reported in the traffic chapter, that is 59 and 60 km/h for the B851 and B861 respectively. The 12-hour baseline flows have been used.

Table 9.14 Noise Change on B851 & B861 During Peak Month of Construction Traffic

Baseline			Construction Traffic		Baseline + Construction			Increase in Noise (dB)		Total Increase (dB)
Vehicles	HGV	% HGV	Vehicles	HGV	Vehicles	HGV	% HGV	From Flow	From HGV	
B851 Road										
740	17	2.3%	7	74	821	91	11.1%	0.5 dB	2.1 dB	2.6
B861 Road										
531	10	1.9%	14	74	619	84	10.9%	0.7 dB	2.2 dB	2.8

9.94 The predicted change in noise levels on both roads are less than 3dB during the peak month of construction traffic. The Design Manual for Roads and Bridges (DMRB)[10], is Transport Scotland's approved method of assessing the impact of road noise changes. DMRB classifies a change of between 1dB and 2.9dB as a "minor" impact. Therefore, the increase in traffic noise for the peak month results in a minor noise impact, but is a short-term effect only. Strictly speaking the DMRB criteria would apply after the construction of a new permanent road. A lesser impact would be expected for temporary construction noise. In overall terms therefore any impact associated with construction traffic would not be regarded as significant.

Access Formation

9.95 It will be necessary to widen the existing access track at the junction with the B861. The closest property to these works is Carr Ban which is approximately 200m away. Noise levels at Carr Ban have been estimated from noise measurement data of typical plant provided in BS 5228-1:2009. A basic calculation is set out below in Table 9.15 assuming distance attenuation only.

10 The Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3 Transport Scotland

Table 9.15 Construction Noise Levels at Carr Ban during Access Formation

Plant	BS 5228 Reference	No. of Items	Noise Level at 10m (dB L_{Aeq})	Noise Level $L_{Aeq,\ 10\ Hr}$ at Carr Ban
Excavator 25t	C2 19	1	77	51
Dumper 5t	C4 7	1	78	52
Roller	C2 37	1	79	53
29t Dump Truck	C2 30	1	79	53
Dozer 20t	C2 12	1	81	55
Total Noise Level dB L_{Aeq}				60

9.96 The calculation in Table 9.15 assumes all the identified plant is operating for the entire day. In reality this would not happen and the actual noise level at Carr Ban would be lower.

9.97 There are no noise limits within the main text of BS 5228-1: 2009 and in fact, the preferred approach is to use 'best practicable means' to reduce noise rather than setting limits. This means that everything should be done to reduce noise subject to practicality, programme and cost. This strategy will be adopted here.

9.98 However, Annex E of BS 5228 Part 1 gives 'example criteria for the assessment of the significance of noise effects' e.g. for use in Environmental Statements. For quiet areas, where the existing ambient noise levels are low, a significant noise effect is deemed to occur if the construction noise (plus the ambient noise) exceeds the following threshold values:

- 65 dB L_{Aeq} Daytime (07.00–19.00) and Saturdays (07.00 – 13.00);
- 55 dB L_{Aeq} Evenings & Weekends (19.00–23.00 Weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays), and
- 45 dB L_{Aeq} Night-time (23.00–07.00).

9.99 The access formation will occur during the daytime normal working hours only and therefore the 65 dB L_{Aeq} significance threshold is applicable. Predicted noise levels are below this. The widening of the access track at the junction with the B861 is estimated to last no more than a few days. Applicable significance thresholds for construction noise are not exceeded and any disruption will be a short-term effect only and limited to daytime hours. Therefore, the noise impact of the access formation is not significant.

MITIGATION

9.100 Mitigation has already been considered in the design of the wind farm layout which has gone through several iterations to ensure that noise levels are generally low and within the noise limits. The turbines will operate at a reduce noise settings to limit noise levels. This also reduces the energy yield.

9.101 The manufacturer of the wind turbines procured for the site will be required to provide a warranty that sound power levels will not exceed those assessed in this chapter and that no tonal penalty will apply to the turbine noise when assessed according to the ETSU method.

9.102 Best practical means measures will be used to reduce construction noise levels to a minimum.

RESIDUAL EFFECTS

9.103 Turbine noise will be audible at the closest properties under certain wind conditions and the proposed development will cause an increase in the background noise at the nearest properties again for certain wind conditions. However, predicted noise levels are low in absolute terms and the proposed development can meet Highland Council noise limits designed to protect residential amenity and sleep disturbance such that further mitigation measures are not necessary.

CUMULATIVE NOISE ISSUES

9.104 There are several other operational and proposed wind farms within the vicinity of the proposed Carr Ban scheme. Those within 10km of the site are set out below.

Table 9.16 Details of Other Projects Considered in the Cumulative Assessment

Scheme	Status (Dec 2014)	Approximate Distance to Site Centre	Details	Sound Power Level dB L_{WA}
Farr	Existing Operational	7.5 km	40 Bonus 2.3MW Turbines	108.5 dB L_{WA} at 9 m/s
Glen Kyllachy	Proposed (Appeal)	9.2 km	20 Vestas V80 Turbines	107.0 dB L_{WA} at 9 m/s
Hillcroft	Proposed (In Planning)	3.7 km	2 x C&F50 50kW Turbines	C&F50 50kW 90 dB L_{WA}

9.105 Noise levels have been predicted from each of the schemes listed above for selected receptors. The results are shown in Table 9.17 for a wind speed of 9 m/s at 10m height.

Table 9.17 Summary of Cumulative Noise Levels at 8m/s at 10m height

Location	Predicted Noise Levels dB L_{A90} at 9 m/s at 10m Height				
	Carr Ban	Hillcroft	Farr	Glen Kyllachy	Cumulative
Dinichean House	39.3	6.1	16.6	13.2	39.4
Cloughmor	40.8	7.9	18.1	13.6	40.8
Carr Ban	37.9	9.1	17.5	13.8	38.0
Bellforte	37.8	9.1	17.7	13.8	37.8
Belvedere	38.2	9.0	17.7	13.8	38.2
Ardelve	38.2	8.8	18.0	13.5	38.3
Gask House	37.0	8.9	18.4	13.6	37.1
Mains of Gask	36.7	8.9	18.6	13.7	36.8

Monadhliath	35.8	8.9	19.0	14.1	35.9
The Arches	35.3	8.9	19.2	14.2	35.4
Bohanbeag Cottage	38.3	7.7	19.0	14.1	38.3
Knollywood Cottage	38.0	7.8	19.0	14.1	38.0
Grianach	37.1	7.7	19.3	14.4	37.2
Stroma	37.7	7.5	19.3	14.3	37.7
Blar Buidhe	35.4	4.8	20.4	16.1	35.5
Mains of Bunachton	36.8	2.6	18.7	13.5	36.9
Tom's Croft	36.1	2.5	18.4	13.1	36.2
Baile Na Creige	35.1	2.3	18.0	13.1	35.2

9.106 The cumulative assessment carried out indicates that there is a negligible cumulative effect for the receptors close to the Carr Ban proposed development. Predicted noise levels from the other schemes are 10dB below that predicted from the Carr Ban proposed development. Therefore the increase in noise due to all the above schemes is less than 1dB and no further cumulative assessment is required.

SUMMARY

9.107 An assessment has been made of the noise impact of the proposed development. The assessment is made according to ETSU-R-97 and the Institute of Acoustics' Good Practice Guide. These are the guidance documents recommended in Scottish Government online planning advice. In terms of operational noise, the proposed development can meet noise limits derived according to guidance document ETSU-R-97 and lower Highland Council night-time noise limits. The findings of the assessment are summarised in Table 9.18 below.

Table 9.18 Summary Assessment Table

Potential Effect	Mitigation	Residual Effect	Significance
Operational Effects			
Turbine noise at residential properties.	Embedded mitigation in the turbine selection and wind farm layout in order to meet approved noise limits. A low noise turbine is selected. The proposed scheme can meet ETSU-R-97 noise limits and the lower Highland Council noise limits.	Wind farm noise will be audible and above the background noise at the nearest properties. However the wind farm can meet noise limits designed to protect residential amenity.	Minor
Construction Effects			
Construction Noise	Best practical means as defined in BS 5228-1: 2009.	None for short-term noise	Negligible

Chapter ten

AVIATION AND TELECOMMUNICATIONS

INTRODUCTION

10.1 This chapter assesses the potential for the proposed wind turbines at the development site to affect communications links within the vicinity of the development site. A wind turbine is a structure that may affect electro-magnetic signals by reflecting them from the blades. The following communications links are considered within this chapter

- Electro-magnetic transmissions such as radio and microwaves which are used for a wide variety of communication purposes including radio, television and mobile phone links.

10.2 This chapter also assesses the potential for wind turbines to affect civil and military aviation operations and infrastructure in accordance with the guidance provided in Civil Aviation Authority (CAA) 'Policy and Guidelines on Wind Turbines' (CAA CAP764) and all other relevant documents. Turbines can affect radar transmissions used to detect and track moving objects such as aircraft which rely on reflected radio energy.

METHODOLOGY

10.3 Consultation as recommended by the Civil Aviation Authority and the Ministry of Defence (MOD) Defence Infrastructure Organisation (DIO) has taken place in respect of air traffic control and radar facilities.

10.4 Radar projections have been produced by WPAC Ltd using specialist propagation prediction software (Rview). Developed over a number of years, it has been designed and refined specifically for the task. RView uses a comprehensive systems database which incorporates the safeguarding criteria for a wide range of radar and radio navigation systems. RView models terrain using the Ordnance Survey (OS) Landform Panorama digital terrain model, which has a post spacing of 50 metres and has a root mean square (RMS) error of 3 metres. The results are verified using the Shuttle Radar Topography Mission (SRTM) dataset, a separate smoothed digital terrain model with data spacing of 3 arc seconds. By using two separate and independently generated digital terrain models, anomalies are identified and consistent results assured.

Civil Aerodromes

10.5 Consultation with airports and aerodromes has taken place in accordance with the guidance contained in CAP764 which recommends the following consultation distances:

- Airfield with a surveillance radar – 30 kilometres (km);
- Non radar licensed aerodrome with a runway of more than 1,100 metres – 17 km;
- Non radar licensed aerodrome with a runway of less than 1,100 metres – 5 km;