Knockcronal Wind Farm.

Technical Appendix 10.1 - Environmental Noise Assessment.

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AUTHOR: MARK JIGGINS MSc MIOA

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Contents.

Non-Technical Summary

Hoare Lea (HL) have been commissioned by Statkraft UK Ltd to undertake a noise assessment for the construction and operation of the proposed Knockcronal Wind Farm (the Proposed Development). Noise will be emitted by equipment and vehicles used during construction and decommissioning of the Proposed Development and by the wind turbines during operation. The level of noise emitted by the sources and the distance from those sources to the receiver locations are the main factors determining levels of noise at receptor locations.

Construction Noise

Construction noise has been assessed by a desk study of a potential construction programme and by assuming the Proposed Development is constructed using standard and common methods. Noise levels have been calculated for receiver locations closest to the areas of work and compared with guideline and baseline values. Construction noise, by its very nature, tends to be temporary and highly variable and therefore much less likely to cause adverse effects. Various mitigation methods have been suggested to reduce the effects of construction noise, the most important of these being suggested restrictions of hours of working. It is concluded that noise generated through construction activities will have a minor effect that is not significant in EIA terms.

Decommissioning is likely to result in less noise than the construction of the Proposed Development. The construction phase has been considered to have minor noise effects, therefore decommissioning will, in the worst case, also have minor noise effects in EIA terms.

Operational Noise

Operational wind turbines emit noise from the rotating blades as they pass through the air. This noise can sometimes be described as having a regular 'swish'. The amount of noise emitted tends to vary depending on the wind speed. When there is little wind the turbine rotors will turn slowly and produce lower noise levels than during high winds when the turbine reaches its maximum output and maximum rotational speed. Background noise levels at nearby properties will also change with wind speed, increasing in level as wind speeds rise due to wind in trees and around buildings, etc.

Noise levels from operation of the turbines have been predicted for those locations around the site most likely to be affected by noise. Noise surveys for the previous Linfairn Wind Farm application have already sufficiently established existing baseline noise levels at a number of these properties. Noise limits have been derived from data about the existing noise environment following the method stipulated in national planning guidance. Predicted noise levels take full account of the potential combined effect of the noise from the Proposed Development along with Dersalloch Windfarm (operational), Hadyard Hill Wind Farm (operational), Craiginmoddie Wind Farm (proposed) and Carrick Windfarm (in scoping). Other, more distant wind farms were not considered as they do not make an acoustically relevant contribution to cumulative noise levels.

Predicted operational noise levels have been compared to the limit values to demonstrate that turbines of the type and size which would be installed can operate within the limits so derived. It is concluded therefore that operational noise levels from the wind turbines will be within levels deemed, by national guidance, to be acceptable for developments with wind turbines, therefore the effects of operational wind turbine noise are considered not significant in EIA terms.

The Proposed Development would also include a substation and an energy storage facility, which would emit some noise during operation. Based on experience of similar installations and professional judgement, in conjunction with the large separation distances to the nearest receptor locations, the associated levels of operational noise would be negligible and are considered not significant in EIA terms.

This Non-Technical Summary contains an overview of the noise assessment and its conclusions. No reliance should be placed on the content of this Non-Technical Summary until this report has been read in its entirety.

1. Introduction

1.1.1 This report presents an assessment of the potential construction and operational noise effects of the Knockcronal Wind Farm (the Proposed Development) on the residents of nearby dwellings. The assessment considers both the construction and operation of the Proposed Development and also the likely effects of its decommissioning. Assessment of the operational noise effects accounts for the cumulative effect of the Proposed Development as well as other wind farms nearby. Other wind farms considered were: Dersalloch Windfarm (operational and approximately 4.5 km to the north east), Hadyard Hill Wind Farm (operational and approximately 7 km to the west) and Craiginmoddie Wind Farm (proposed and approximately 3.6 km to the west). This is illustrated on Figure B1 in Annex B. We are aware that Carrick Windfarm is at scoping stage and is adjacent to the south west and south but the application has not yet been submitted. However, we understand that Carrick is likely to be submitted at a similar time to the Proposed Development, therefore Carrick Windfarm has also been considered in this assessment, based on the information available at the time of this assessment (Aug 2021). Other, more distant wind turbines or wind farms were not considered because their potential noise contribution was not considered acoustically important[1].

1.1.2 Noise and vibration which arises from the construction of a wind farm is a factor which should be taken into account when considering the total effect of the Proposed Development. However, in assessing the effects of construction noise, it is accepted that the associated works are of a temporary nature. The main work locations for construction of the wind turbines are distant from nearest noise sensitive residences and are unlikely to cause significant effects. The construction and use of access tracks may, however, occur at lesser separation distances. Assessment of the temporary effects of construction noise is primarily aimed at understanding the need for dedicated management measures and, if so, the types of measures that are required.

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

1.1.4 The Proposed Development would also include a substation and an energy storage facility. These facilities would emit noise during operation (e.g. electrical plant and air conditioning systems).

1.1.5 An overview of environmental noise assessment and a glossary of noise terms are provided in Annex A.

1 The IOA GPG suggests that cumulative noise effects need not be considered where differences between existing and proposed wind farm noise levels are 10 dB(A) or more.

2. Policy and Guidance Documents

2.1 Planning Policy and Advice Relating to Noise

2.1.1 Scottish Planning Policy (SPP)[i] provides advice on how the planning system should manage the process of encouraging, approving and implementing renewable energy proposals including onshore wind farms. Whilst SPP suggests noise impacts are one of the aspects that will need to be considered it provides no specific advice. Planning Advice Note PAN1/2011[ii] provides general advice on the role of the planning system in preventing and limiting the adverse effects of noise without prejudicing investment in enterprise, development and transport. PAN1/2011 provides general advice on a range of noise related planning matters, including references to noise associated with both construction activities and operational wind farms. In relation to operational noise from wind farms, Paragraph 29 states that:

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

2.1.2 The Scottish Government's online renewables planning advice on wind turbines[iii] provides further advice on noise, and confirms that the recommendations of 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97)[iv] "*should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments*". The aim of ETSU-R-97 is:

> *'This document describes a framework for the measurement of wind farm noise and gives 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. The suggested noise limits and their reasonableness have been evaluated with regard to regulating the development of wind energy in the public interest. They have been presented in a manner that makes them a suitable basis for noise-related planning conditions or covenants within an agreement between a developer of a wind farm and the local authority.'*

2.1.3 The recommendations contained in ETSU-R-97 provide a robust basis for assessing the noise implications of a wind farm. ETSU-R-97 has become the accepted standard for such developments within the UK. Guidance on good practice on the application of ETSU-R-97 has been provided by the Institute of Acoustics (IOA Good Practice Guide or GPG)[v]. This was subsequently endorsed by the Scottish Government[vi] which advised in the web based planning advice note that this *'should be used by all IOA members and those undertaking assessments to ETSU-R-97',* The methodology of ETSU-R-97 and the IOA GPG has therefore been adopted for the present assessment and is described in greater detail below.

2.1.4 With regard to infrasound and low-frequency noise, the above-referenced online planning advice note (Onshore wind turbines: planning advice) refers to a report for the UK Government which concluded that *'there is no evidence of health effects arising from infrasound or low frequency noise generated by the wind turbines that were tested'*.

2.1.5 PAN1/2011 and the Technical Advice Note[vii] accompanying PAN1/2011 note that construction noise control can be achieved through planning conditions that limit noise from temporary construction-sites, or by means of the Control of Pollution Act (CoPA) 1974[viii]. The CoPA provides two means of controlling construction noise and vibration. Section 60 provides the Local Authority with the power to impose at any time operating conditions on the development site. Section 61 allows the developer to negotiate a prior consent for a set of operating procedures with the Local Authority before commencement of site works.

2.1.6 For detailed guidance on construction noise and its control, the Technical Advice Note refers to British Standard BS 5228[ix] 'Noise control on construction and open sites' Parts 1 to 4, but confirms that the updated version of this standard (Jan 2009) is relevant when used within the planning process. The 2009 version consolidates all previous parts of the standard into BS 5228-1: 2009 (amended 2014)[x] (BS 5228-1) for airborne noise and BS 5228-2: 2009 (amended 2014)[xi] (BS 5228-2) for ground-borne vibration. These updated versions have therefore been adopted as the relevant versions upon which to base this assessment.

2.1.7 BS 5228-1 provides guidance on a range of considerations relating to construction noise including the legislative framework, general control measures, example methods for estimating construction noise levels and example criteria which may be considered when assessing effect significance. Similarly, BS 5228-2 provides general guidance on legislation, prediction, control and assessment criteria for construction vibration.

2.1.8 Planning Advice Note PAN50[xii] "Controlling the Environmental Effects of Surface Mineral Workings" gives guidance on the environmental effects of mineral working. The main document summarises the key issues with regard to various environmental effects relating to surface mineral extraction and processing such as road traffic, blasting, noise, dust, visual intrusion etc. In addition, several annexes to the main document have been published which consider specific aspects in more detail: Annex A, "The Control of Noise at Surface Mineral Workings" and Annex D "The Control of Blasting at Surface Mineral Workings". BS 5228-1 and BS 5228-2 also provide guidance relating to surface mineral extraction including the assessment of noise and vibration effects associated with quarry blasting. BS 6472-2 2008[xiii] gives similar guidance on assessing vibration from blasting associated with mineral extraction.

3. Scope and Methodology

3.1 Methodology for Assessing Construction Noise

3.1.1 Construction works include both moving sources and static sources. The moving sources normally comprise mobile construction plant and Heavy Goods Vehicles (HGVs). The static sources include construction plant temporarily placed at fixed locations and in some instances, noise arising from blasting activities where rock is to be worked through.

3.1.2 The analysis of construction noise has been undertaken in accordance with BS 5228-1 which provides methods for predicting construction noise levels on the basis of reference data for the emissions of typical construction plant and activities. These methods include for the calculation of construction traffic along access tracks and haul routes and also for construction activities at fixed locations such as the bases of turbines, site compounds or sub stations.

3.1.3 The BS 5228 calculated levels are then compared with absolute noise limits for temporary construction activities which are commonly regarded as providing an acceptable level of protection from the short-term noise levels associated with construction activities.

3.1.4 Separate consideration is also given to the possible noise impacts of construction related traffic passing to and from the site along local surrounding roads. In considering potential noise levels associated with construction traffic movement on public roads, reference is made to the accepted UK prediction methodology provided by 'Calculation of Road Traffic Noise'[xiv] (CRTN).

3.1.5 The nature of works and distances involved in the construction of a renewable energy development with wind turbines are such that the risk of significant effects relating to ground borne vibration are very low (excluding blasting). Occasional momentary vibration can arise when heavy vehicles pass dwellings at very short separation distances, but again this is not sufficient to constitute a risk of significant impacts in this instance. Accordingly, vibration impacts do not warrant detailed assessment and are therefore not discussed further in this assessment.

3.1.6 It is anticipated that some rock extraction from borrow pits by means of blasting operations could be required in some instances. The analysis of the related potential impacts has been made in accordance with PAN50, BS 6472-2 2008 and BS 5228.

3.2 Methodology for Assessing Operational Wind Turbine Noise

3.2.1 The ETSU-R-97 assessment procedure specifies that noise limits should be set relative to existing background noise levels at the nearest properties and that these limits should reflect the variation in both turbine source noise and background noise with wind speed. The wind speed range which should be considered is between the cut-in speed (the speed at which the turbines begin to operate) for the turbines and 12 m/s (43.2 km/h), where all wind speeds are referenced to a ten metre measurement height.

3.2.2 Separate noise limits apply for the day-time and night-time. Day-time limits are chosen to protect a property's external amenity whilst outside their dwellings in garden areas and night-time limits are chosen to prevent sleep disturbance indoors. Absolute lower limits, different for day-time and night-time, are applied where the line of best-fit representation of the measured background noise levels equates to very low levels (< 30 dB(A) to 35 dB(A) for day-time, and < 38 dB(A) during the night).

3.2.3 The day-time noise limit is derived from background noise data measured during the 'quiet periods of the day' defined in ETSU-R-97: these comprise weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00). Multiple samples of ten-minute background noise levels using the $L_{A90,10min}$ measurement index are measured contiguously over a wide range of wind speed conditions (a definition of the $L_{A90,10min}$ index is given in Annex A). The measured noise levels are then plotted against the simultaneously measured wind speed data and a 'best-fit' curve is fitted to the data to establish the background noise level as a function of wind speed. The ETSU-R-97 day-time noise limit is then set to the greater of either: a level 5 dB(A) above the best-fit curve to the background noise data over a 0-12 m/s wind speed range <u>or</u> a fixed level in the range 35 dB(A) to 40 dB(A). The precise choice of the fixed lower limit within the range 35 dB(A) to 40 dB(A) depends on a number of factors: the number of noise affected properties, the likely duration and level of exposure and the consequences of the choice on the potential power generating capability of the wind farm.

3.2.4 ETSU-R-97 clearly indicates that the day-time limit is intended to lie within the range from 35 dB(A) to 40 dB(A). Therefore one can conclude that there must be projects where 35 dB(A) is appropriate and conversely, projects where 40 dB(A) is appropriate. Within ETSU-R-97 there is a specific example: *"A single wind turbine causing noise levels of 40 dB(A) at several nearby residences would have less planning merit (…) than 30 wind turbines also causing the same amount of noise at several nearby residences"*. Therefore, where a project offers relatively low power generating potential, the day-time limit should naturally tend towards the lower end of the range, unless the number of noise affected properties and the extent to which those properties would be affected by the higher noise levels is sufficiently low to justify noise limits tending towards the upper end of the range. Conversely, sites with relatively large power generating capacity should naturally justify limits towards the upper end of the range. Given the relatively large energy generating potential of the Proposed Development (particularly when compared to the range of wind farm generating capacities considered at the time ETSU-R-97 was prepared) and the relatively low number of surrounding properties in the immediate vicinity of the scheme, the limit should not be at the lowest choice within the 35 dB(A) to 40 dB(A) range. The appropriate choice of value is considered subsequently in this Report.

3.2.5 The night-time noise limit is derived from background noise data measured during the night-time periods (23:00 to 07:00) with no differentiation being made between weekdays and weekends. The ten minute $L_{A90,10min}$ noise levels measured over these night-time periods are again plotted against the concurrent wind speed data and a 'best-fit' correlation is established. As with the day-time limit, the night-time noise limit is also set as the greater of: a level 5 dB(A) above the best-fit background curve or a fixed level of 43 dB(A). This fixed lower night-time limit of 43 dB(A) was set in ETSU-R-97 on the basis of World Health Organization (WHO) guidance[xv] for the noise inside a bedroom and an assumed difference between outdoor and indoor noise levels with windows open. In the time since ETSU-R-97 was released, the WHO guidelines were revised to suggest a lower internal noise level, but conversely, a higher assumed difference between outdoor and indoor noise levels. Notwithstanding the WHO guideline revisions, the ETSU-R-97 limit remains consistent with current national planning policy guidance with respect to night-time noise levels. In addition, following revision of the night-time WHO criteria, ETSU-R-97 has been incorporated into planning guidance for Wales, England and Scotland and at no point during this process was it felt necessary to revise the guidance within ETSU-R-97 to reflect the change in the WHO guideline internal levels. The advice contained within ETSU-R-97 remains a valid reference on which to continue to base the fixed limit at night.

3.2.6 The exception to the setting of both the day-time and night-time lower fixed limits occurs in instances where a property occupier has a financial involvement in the development. Where this is the case then the lower fixed portion of the noise limit at that property may be increased to 45 dB(A) during both the day-time and the night-time periods alike.

3.2.7 The noise limits defined in ETSU-R-97 relate to the total noise occurring at a dwelling due to the combined noise of all operational wind turbines. The assessment will therefore need to consider the combined operational noise of the Proposed Development with operational, consented and proposed wind farms in the area to be satisfied that the combined cumulative noise levels are within the relevant ETSU-R-97 criteria. ETSU-R-97 also requires that the baseline levels on which the noise limits are based do not include a contribution from any existing turbine noise, to prevent unreasonable cumulative increases.

3.2.8 To undertake the assessment of noise effects in accordance with the foregoing methodology the following steps are required:

- specify the number and locations of the wind turbines on all wind farms;
- identify the locations of the nearest, or most noise sensitive, neighbours;
- determine background noise levels as a function of site wind speed at the nearest neighbours, or at least at a representative sample of the nearest neighbours;
- determine the day-time and night-time noise limits from background noise levels at the nearest neighbours;
- specify the type and noise emission characteristics of the wind turbines;
- calculate the noise immission levels due to the operation of the wind turbines on the Proposed Development and cumulatively in combination with other wind energy schemes as a function of site wind speed at the nearest neighbours; and
- compare the calculated wind turbine noise immission levels with the derived noise limits and assess in the light of planning requirements.

3.2.9 The foregoing steps, as applied to the turbines of the Proposed Development, are set out subsequently in this assessment.

3.2.10 Note that in the above, and subsequently in this assessment, the term 'noise emission' relates to the sound power level actually radiated from each wind turbine, whereas the term 'noise immission' relates to the sound pressure level (the perceived noise) at any receptor location due to the combined operation of all wind turbines on the Proposed Development.

3.3 Construction Noise Criteria

3.3.1 BS 5228-1 indicates a number of factors are likely to affect the acceptability of construction noise including site location, existing ambient noise levels, duration of site operations, hours of work, attitude of the site operator and noise characteristics of the work being undertaken.

3.3.2 BS 5228-1 informative Annex E provides example criteria that may be used to consider the significance of any construction noise effects. The criteria do not represent mandatory limits but rather a set of example approaches intended to reflect the type of methods commonly applied to construction noise. The example methods are presented as a range of possible approaches (both facade and free field noise levels, hourly and day-time averaged noise levels) according to the ambient noise characteristics of the area in question, the type of development under consideration, and the expected hours of construction activity. In broad terms, the example criteria are based on a set of fixed limit values which, if exceeded, may result in a significant effect unless ambient noise levels (i.e. regularly occurring levels without construction) are sufficiently high to provide a degree of masking of construction noise.

3.3.3 Based on the range of guidance values set out in BS 5228 Annex E, and other reference criteria provided by the World Health Organization (WHO) and PAN50 Annex A: The Control of Noise at Surface Mineral Workings (1996), the following significance criteria have been derived. The values have been chosen in recognition of the relatively low ambient noise typically observed in rural environments. The presented criteria have been normalised to free-field day-time noise levels occurring over a time period, T, equal to the duration of a working day on-site. BS 5228-1 Annex E provides varied definitions for the range of day-time working hours which can be grouped for equal consideration. The values presented in Table 1 have been chosen to relate to day-time hours from 07:00 to 19:00 on weekdays, and 07:00 to 13:00 on Saturdays. If noise-generating works occur outside of these hours, this may increase the significance of the impact in some cases.

Table 1 - Free-field noise criteria against which construction noise effects are assessed.

Significance	Noise Level dB $L_{Aeq,T}$		Description
	4 weeks or more	up to 4 weeks	
Major	> 75	> 85	Trigger level for noise insulation works, or costs thereof, as set out in E.4 of BS 5228-1.
Moderate	> 65 ≤ 75	> 75 ≤ 85	Most stringent threshold values for potential significant effects given in Annex E of BS 5228-1 for example methods relevant to proposed development is exceeded.
Minor	> 55 ≤ 65	> 65 ≤ 75	Noise is likely to be audible, but unlikely to change behaviour. BS 5228-1 thresholds not exceeded.
Negligible	≤ 55	≤ 65	At least 10 dB below the most stringent criteria provided in of BS 5228-1.

3.3.4 When considering the impact of short-term changes in traffic, associated with the construction activities, on existing roads in the vicinity of the Proposed Development, reference can be made to the criteria set out in the Design Manual for Roads and Bridges (DMRB[xvi]). A classification of magnitudes of changes in the predicted traffic noise level calculated using the CRTN methodology is set out: for short-term changes such as those associated with construction activities, changes of less than 1 dB(A) are considered negligible, 1 to 3 dB(A) is minor, 3 to 5 dB(A) moderate and changes of more than 5 dB(A) constitute a major impact. This classification can be considered in addition to the criteria of Table 1.

3.3.5 Blasting operations can generate airborne pressure waves or “air overpressure”. This covers both those pressure waves generated which are in the frequency range of human audibility (approximately 20 Hz to 20 kHz) as well as infrasonic pressure waves (those with a frequency of below 20 Hz), which, although outside the range of human hearing, can sometimes be felt.

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

3.3.7 The relevant guidance documents advise controlling air overpressure (and hence noise from blasting) through the use of good practices during the setting and detonation of charges as opposed to absolute limits on the levels produced, therefore no absolute limits for air overpressure or noise from blasting will be presented in this assessment.

3.3.8 In accordance with the guidance in BS 6472-2: 2008 / PAN50 Annex D, ground vibration caused by blasting operations will be considered acceptable if peak particle velocity (PPV) levels, at the nearest sensitive locations, do not exceed 6 mm/s for 95% of all blasts measured over any 6 month period, and no individual blast exceeds a PPV of 12 mm/s.

3.4 Operational Noise Criteria

3.4.1 The acceptable limits for wind turbine operational noise are clearly defined in the ETSU-R-97 document and these limits should not be breached. Consequently, the test applied to operational noise is whether or not the calculated wind turbine noise immission levels at nearby noise sensitive properties lie below the noise limits derived in accordance with ETSU-R-97. Depending on the levels of background noise the satisfaction of the ETSU-R-97 derived limits can lead to a situation whereby, at some locations under some wind conditions and for a certain proportion of the time, wind turbine noise may be audible. However, noise levels at the properties in the vicinity of the Proposed Development will still be within levels considered acceptable under the ETSU-R-97 assessment method.

3.5 Consultation

3.5.1 Prior to undertaking the noise assessment, a detailed Scoping Report[xvii] was submitted to South Ayrshire Council (SAC), which presented the results of a baseline background noise level monitoring exercise and described the approach to how noise from the Proposed Development would be assessed. Through this consultation, it was proposed to utilise baseline data which had previously been gathered for the Linfairn Wind Farm application and about which SAC’s consultants (ACCON UK Ltd.) were consulted in relation to agreement of the methodology as well as witnessing and agreement of each of the measurement positions. The results of this survey were not submitted to SAC prior to the Scoping Report and are discussed further below. SAC responded[xviii] to the consultation and provided the advice from their consultants ACCON, which is summarised below:-

- ACCON were content with the methodology used for the noise surveys and that the background noise results have been determined in accordance with good practice guidance. The baseline background noise levels obtained were considered in line with ACCON’s experience of background noise levels of the local area.
- ACCON agreed with the proposed methodology for assessment of noise from the Proposed Development.
- ACCON agreed that assessment of ground-borne vibration (from construction and operation of the turbines) and low frequency noise from operation of the turbines can be scoped out of the assessment.

- ACCON agreed that operational noise from the substation and routine maintenance visits can be scoped out of the assessment provided the substation is located at least 500 m from any noise sensitive receptor.
- ACCON recommended operational wind turbine noise limits should be consistent with SAC policy[xix] of choosing the lowest value of 35 dB(A) for the day-time threshold, at the lowest end of the range of 35 dB(A) to 40 dB(A) set out in ETSU-R-97, regardless of the site-specific factors which ETSU-R-97 recommends as needing consideration when setting a value within this range, and that during the night-time to have the fixed part of the noise limit set at 38 dB(A), instead of 43 dB(A) as prescribed in ETSU-R-97.

3.6 Matters Scoped-out of the Assessment

3.6.1 Ground-borne vibration resulting from the operation of wind turbines is imperceptible at typical receptor separation distances (as discussed in Annex A) and is therefore scoped out from the noise assessment and is not discussed further, as agreed through consultation with SAC.

3.6.2 The proposed substation and energy storage system are located between turbine K06 and turbine K07, which are more than one kilometre from the nearest noise sensitive receptor location. Accordingly, operational noise from these elements of the Proposed Development, as well as routine maintenance visits during the lifetime of the Proposed Development, are scoped out from the noise assessment and not discussed further, as agreed through consultation with SAC.

4. Baseline & Assessment Criteria

4.1 General Description

4.1.1 The Proposed Development is located within the administration boundary of SAC in an area of relatively low population density. The noise environment in the surrounding area is generally characterised by ‘natural’ sources, such as wind disturbed vegetation, birds, farm animals and water flow sounds. Other sources of noise include agricultural vehicle movements in the area, occasional road traffic on minor roads and distant aircraft.

4.1.2 There are a number of other wind energy developments in the area around the Proposed Development. Each of these other wind energy developments were required to consider baseline information in order to derive noise limits in accordance with ETSU-R-97 and undertake an appropriate noise assessment.

4.2 Details of the Baseline Background Noise Environment

4.2.1 The area of the Proposed Development is similar to the previous Linfairn Wind Farm[xx] proposal, for which a detailed survey of baseline background noise levels was completed at six locations in 2018. These 2018 baseline survey results remain applicable and appropriate for assessment of the Proposed Development. These baseline were submitted to and agreed by SAC to be suitable for the purpose of assessing the Proposed Development through their scoping response (see Consultation section above). The methodology and results of this survey are set out in detail in the Scoping Report and are therefore not repeated in the present report.

4.2.2 A number of noise-sensitive receptor locations, which are closest to the Proposed Development, have been considered, the majority of which were directly surveyed during the baseline assessment. Six assessment locations are shown on the plan in Figures B1 and B2 of Annex B and listed in Table 2. The baseline survey location of Tairlaw Toll Cottage has been included as an assessment location instead of Tairlaw Toll House, as it is marginally closer to the Proposed Development. However baseline noise levels measured at Tairlaw Toll House (immediately across the lane from Tairlaw Toll Cottage) have been used in the assessment at Tairlaw Toll Cottage (as proposed in the Scoping Report) because of reduced influence from water flow sounds at that measurement position (further from Tairlaw Burn which runs adjacent to Tairlaw Toll Cottage). Tallaminnoch has also been represented by baseline measure at Tairlaw Toll House, as proposed in the baseline report.

Table 2 - Assessment locations in the vicinity of the Proposed Development

Receptor Location	Easting	Northing	Approximate Distance to Closest Turbine (m)	Closest Turbine (ID)	Baseline Survey Location
Genoch Cot.	239049	600791	1493	K04	Genoch Cot.
Knockskae	237279	601396	1544	K02	Knockskae
Linfairn Farm*	238159	601207	1328	K04	Linfairn Farm
Tairlaw Toll Cot.	239762	599541	1615	K06	Tairlaw Toll House
Tallaminnoch	240021	598257	2021	K06	Tairlaw Toll House
Glenalla Farm	234681	600218	2159	K01	Glenalla Farm
* Linfairn Farm is financially involved with the Proposed Development and has higher noise limits for a financially involved location.					

4.2.3 The list of assessment locations is not intended to be exhaustive but sufficient to be representative of noise levels typical of those receptors closest to the Proposed Development. Those receptor locations which are further from the Proposed Development would be less exposed to noise from the Proposed Development, with consequently reduced effects, and are not considered further. This approach is consistent with the guidance provided by ETSU-R-97 and current good practice as set out in the IOA GPG.

4.3 ETSU-R-97 Assessment Criteria

4.3.1 The ETSU-R-97 assessment method requires baseline data, and consequently noise limits, to be related to wind speed data at a height of 10 m, with wind speeds either directly measured at a height of 10 m or by calculation from measurement at other heights, the appropriate choice being determined by practitioner judgement and the available data sources. Since the publication of ETSU-R-97, the change in wind speed with increasing height above ground level has been identified as a potential source of variability when carrying out wind farm noise assessments.

4.3.2 The effect of site specific wind shear can be appropriately addressed by implementing the ETSU-R-97 option of deriving ten metre height reference data from measurements made at taller heights. It is this method that was referenced in the baseline noise assessment (see Scoping Report[xvii])for the Proposed Development to account for the potential effect of site-specific wind shear, by utilising wind speeds at hub height and converting these to 10 m height assuming reference wind shear conditions, consistent with the preferred method described in the IOA GPG. Wind speeds are therefore referred to as 'standardised' ten metre wind speeds to reflect the methodology used.

4.3.3 The wind speed reference for baseline data and consequently noise limits were related to a hub height of 132 m, which was a potential maximum for the Proposed Development. Tip heights of the turbines on the Proposed Development will be either 180 m or 200 m, resulting in hub heights of either 105 m or 125 m for the candidate wind turbine used for the noise assessment. Comparison of operational noise immission levels for turbines with hub heights lower than the 132 m wind speed reference used for the baseline data and noise limits represents a precautionary approach.

4.3.4 Noise limits required by ETSU-R-97 that apply during the day-time and night-time periods up to 12 m/s have been derived for this assessment and are shown in Table 3 for the day-time and Table 4 for the night-time. The two nearby operating wind farms of Dersalloch Windfarm and Hadyard Hill Wind Farm were granted consent on the basis of a choice of 37.5 dB(A) and 38 dB(A) respectively, within the range from 35 dB(A) to 40 dB(A) allowed by ETSU-R-97 during day-time periods, and with the fixed part of the limit set at 43 dB(A) during night-time, consistent with ETSU-R-97 (see Annex C). These noise limits are therefore not in line with SAC's general preferences, which were expressed in the SAC consultation response, but are consistent with Scottish Government planning guidance which is to use ETSU-R-97. SAC responded[xxi] to the scoping request for the Carrick Windfarm, providing comments from their noise consultants ACCON, which included a recommendation on the choice of the fixed part of the limit during the day-time:-

> *"ACCON would recommend the daytime fixed lower limit of 38 dB LA90 is applied in the cumulative noise assessment for the proposed assessment. This would recognise the aim of the 'Wind Turbine Development: Submission Guidance Note' (SGN issued by South Ayrshire Council Environmental Health) that new wind farms operating in isolation have a lower limit of 35 dB LA90, while also taking account of the noise limits set for the nearby consented wind farms."*

4.3.5 These existing consents, and the basis of their noise limits, could represent noise limits which could be applicable to other wind farms when considering cumulative noise immission levels. The SAC preference for choices of these fixed thresholds which are lower than those which already exist could in many cases leave no margin in which to operate other wind farm developments and would therefore be unreasonably restrictive. It is proposed the fixed part of the noise limits are chosen as 38 dB(A) during the day-time, within the range between 35 dB(A) to 40 dB(A) allowed by ETSU-R-97 and during the night-time set at 43 dB(A) consistent with ETSU-R-97. These choices would therefore be consistent with existing consents and SPP.

4.3.6 The choice of 38 dB(A) for the day-time would be consistent with ACCONs recommendation to SAC for assessing cumulative effects. For some baseline noise survey locations (Genoch Cottage & Tairlaw Toll House) the choice of the fixed part of the noise limits is of less relevance, at these locations the noise limits are determined primarily by the element which is related to 5 dB above typical background noise levels rather than the fixed thresholds. Further discussion is included below (Section 5.7) for the choice of the fixed threshold during the day-time.

4.3.7 The choice for the night-time limit of 43 dB(A) is not consistent with SAC's recommendation, but is stipulated by ETSU-R-97, the use of which is required when assessing wind turbine noise according to Scottish Government guidance.

4.3.8 For financially involved locations the lower absolute fixed threshold element of the noise limits becomes 45 dB(A) day-time and night-time, applicable at the receptor location Linfairn Farm. Noise limits derived from baseline data measured at Linfairn Farm may need to be used for other non-financially involved locations, therefore non-financially involved noise limits have also been provided at Linfairn Farm.

4.3.9 We are aware that some of the locations surveyed for the Proposed Development have also been surveyed separately by others for the assessment of Carrick Windfarm. The results of this survey, which were provided to us, are set out in Annex B for the three survey locations in common. These background noise levels were related to wind speeds measured at a different position and mast elevation compared to the wind sensor used for background noise levels surveyed for the Proposed Development. With a different wind speed reference, it is expected the relationships of background noise levels to wind speed at these three survey locations would differ from those presented previously for the Proposed Development. In order to consider whether differences in background noise levels might alter the assessment outcomes, these alternate limits are considered further in this assessment and are also included in Table 3 and Table 4.

Table 3 – Day-time $L_{A90,T}$ dB noise limits derived from baseline noise data according to ETSU-R-97, based upon a choice of 38 dB(A) for the fixed threshold and used to assess cumulative levels of noise, which include operation of the Proposed Development. Separate noise limits shown for Linfairn Farm including for financially involved status (FI). Also shown (indicated by 'CR' after the name) are noise limits derived from baseline noise data obtained for Carrick Windfarm.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	39.3	39.3	39.4	39.7	40.2	40.8	41.5	42.2	43.1	44.2	45.6	47.5
Knockskae	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.4	41.0	42.1
Linfairn Farm	38.0	38.0	38.0	38.0	38.0	38.4	39.7	40.9	42.1	43.2	44.3	45.6
Linfairn Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.6
Tairlaw Toll Cot.	40.0	40.0	40.0	40.2	40.6	41.4	42.6	44.0	45.8	47.7	49.6	51.2
Tallaminnoch	40.0	40.0	40.0	40.2	40.6	41.4	42.6	44.0	45.8	47.7	49.6	51.2
Glenalla Farm	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.7	40.6	42.5	44.2	45.7
Genoch Cot. (CR)	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.4	39.8	41.2	42.8	44.5
Tairlaw Toll Cot. (CR)	38.7	38.7	38.9	39.2	39.7	40.3	41.2	42.2	43.3	44.6	46.0	47.5
Tallaminnoch (CR)	38.7	38.7	38.9	39.2	39.7	40.3	41.2	42.2	43.3	44.6	46.0	47.5
Glenalla Farm (CR)	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.7	40.4	42.3	44.6

Table 4 – Night-time $L_{A90,T}$ dB noise limits derived from baseline noise data according to ETSU-R-97, based upon a 43 dB(A) fixed lower threshold, used to assess cumulative levels of noise, which include operation of the Proposed Development. Also shown (indicated by 'CR' after the name) are noise limits derived from baseline noise data obtained for Carrick Windfarm.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	45.9
Knockskae	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1
Linfairn Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.2
Linfairn Farm (FI)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Tairlaw Toll Cot.	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.4	46.4	48.7	51.0
Tallaminnoch	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.4	46.4	48.7	51.0
Glenalla Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	45.0
Genoch Cot. (CR)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.9
Tairlaw Toll Cot. (CR)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	44.3	45.6
Tallaminnoch (CR)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	44.3	45.6
Glenalla Farm (CR)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	44.8

5. Predicted Noise Effects

5.1 Predicted Construction Noise Levels

5.1.1 The level of construction noise that occurs at the surrounding properties will be highly dependent on a number of factors such as the final site construction programme, equipment types used for each process, and the operating conditions that prevail during construction. It is not practically feasible to specify each and every element of the factors that may affect noise levels, therefore it is necessary to make reasonable allowance for the level of noise emissions that may be associated with key phases of the construction.

5.1.2 In order to determine representative emission levels for this study, reference has been made to the scheduled sound power data provided by BS 5228. Based on experience of the types and number of equipment usually associated with the key phases of constructing this type of development, the scheduled sound power data has been used to deduce the upper sound emission level over the course of a working day. In determining the rating applicable to the working day, it has generally been assumed that the construction plant and machinery will operate for between 75% and 100% of the working day. In many instances, the plant would actually be expected to operate for a reduced percentage, thus resulting in noise levels lower than predicted in this assessment.

5.1.3 To relate the sound power emissions to predicted noise levels at surrounding properties, the prediction methodology outlined in BS 5228 has been adopted. The prediction method accounts for factors including screening and soft ground attenuation. The size of the site and resulting separation distances to surrounding properties allows the calculations to be reliably based on positioning all the equipment at a single point within a particular working area (for example, in the case of turbine erection, it is reasonable to assume all associated construction plant is positioned at the base of the turbine under consideration). In applying the BS 5228 methodology, it has been conservatively assumed that there are no screening effects, and that the ground cover is characterised as 50% hard / 50% soft.

5.1.4 Table 5 lists the key construction activities, the associated types of plant normally involved, the expected worst-case sound power level over a working day for each activity, the property which would be closest to the activity for a portion of construction, and the predicted noise level. It must be emphasised that these predictions only relate to the noise level occurring during the time when the activity is closest to the referenced property. In many cases such as access track construction and wind turbine erection, the separation distances will be considerably greater for the majority of the construction period and the predictions are therefore the worst-case periods of the construction phase.

5.1.5 Comparing the predicted construction noise levels (Table 5) to typical background noise levels measured around the Proposed Development suggests that the noisier construction activities would be audible at various times throughout the construction phase. However, comparing the levels to the significance criteria presented previously indicates that the majority of construction activities will have effects of negligible significance. The activity closest to Knockskae is related to construction of one of the access track route options, and it is predicted to have noise levels that could be categorised as being of moderate significance. However, this activity is likely to be present for a very short term period of less than one week, when activity is closest to this receptor. Noise levels will quickly diminish as construction progresses, quickly moving the activity further from the property and reducing noise levels. The short-term nature (shorter than the 4 weeks normally allowed for periods of noisier activity) of this activity consequently categorises the effects to be of minor significance.

5.1.6 In addition to onsite activities, construction traffic passing to and from the site will also represent a potential source of noise to surrounding properties. The traffic statement for the Proposed Development presented in Chapter 12, has assessed a worst-case scenario where all aggregate and concrete are sourced off site with the worst-case assumed for the purposes of this noise assessment. The highest volume of traffic generated by construction is expected to occur in months three to nine of the eighteen month construction program with similar levels of vehicle movements over this seven month period. The most intense period of activity is projected to be within month eight of construction. Data for traffic flows have been used to ascertain the projected traffic flows for the worst case scenarios with and without the Proposed Development.

Table 5 - Predicted construction noise levels

Task Name	Plant/Equipment	Upper Collective Sound Emission Over Working Day $L_{WA,T\ dB}$(A)	Nearest Receiver	Minimum Distance to Nearest Receiver (m)	Predicted Upper Day-Time $L_{Aeq\ dB}$
Upgrade Access Track	excavator / dump trucks / tippers / dozers / vibrating rollers	120	Glenalla Farm	310	60
Construct temporary site compounds (nearest)	excavator / dump truck / tippers / rollers/ delivery trucks	120	Bennan (237850,604550)	680	52
Construct site tracks	excavators / dump trucks / tippers / dozers / vibrating rollers	120	Knockskae	95	71
Construct Sub-Station	excavator / concrete truck / delivery truck	110	Tairlaw Toll Cot.	1500	35
Construct crane hardstandings	excavators / dump trucks	120	Linfairn Farm	1250	46
Construct turbine / met mast foundations	Piling Rigs / excavators / tippers / concrete trucks / mobile cranes / water pumps / pneumatic hammers / compressors / vibratory pokers	120	Linfairn Farm	1300	46
Excavate and lay site cables	excavators / dump trucks / tractors & cable drum trailers / wacker plates	110	Linfairn Farm	1300	36
Erect turbines	cranes / turbine delivery vehicles / artics for crane movement / generators / torque guns	120	Linfairn Farm	1300	46
Reinstate crane bases	excavator / dump truck	115	Linfairn Farm	1300	41
Borrow Pit Quarrying (BP-B)	Primary and secondary stone Crushers / excavators / screening systems / pneumatic breakers / conveyors	125	Knockskae	410	62

5.1.7 The above-referenced projected changes in traffic flows are summarised in Table 6. On this basis, the methodology set out in CRTN has been used to determine the associated maximum total changes in the average day-time traffic noise levels at any given location due to construction of the Proposed Development (see Table 6).

5.1.8 Table 6 indicates a maximum potential increase of 0.6 dB(A) in the day-time average noise level during the most intense phases of the construction programme at locations adjoining the B7023, north of Crosshill. Based on the criteria set out in the DMRB, the predicted short term change in traffic noise level would correspond to negligible impact. The predicted construction traffic flow value for some of the roads used by construction traffic fall well below the minimum flow volume of 1000 vehicles per day that is required by the CRTN methodology to enable reliable predictions. However, based on the predicted noise levels that CRTN suggests for the lowest flow value, it can be deduced that the associated $L_{Aeq,T}$ for the working day would be below 60 dB L_{Aeq} and would correspond to a temporary minor effect at most.

Table 6 - Projected two way traffic flows and CRTN predicted increase in day-time average traffic noise levels ($L_{A10,18hour}$)

Road	Without Development (2024)		With Development (2024)		Maximum Change in Traffic Noise Level, dB(A)
	Annual Average Daily Traffic Flow	% Heavy Goods Vehicles	Annual Average Daily Traffic Flow	% Heavy Goods Vehicles	
Western Access Option					
Hill Road, near Western Access	55	40.0%	164	58.5%	Low flow*
Unclassified road, near Northern Access (unofficially signed as Bennan's Farm)	30	43.3%	30	43.3%	No change (low flow*)
B7023, north of Crosshill	2378	18.5%	2487	20.7%	0.6
B7045, north of Grimmet	2535	17.2%	2627	19.5%	0.5
B741, east of Cloyntie	616	8.1%	616	8.1%	No change (Low flow*)
A77, near Nether Auchendrane	14110	8.9%	14202	9.3%	0.1
Northern Access Option					
Hill Road, near Western Access	55	40.0%	55	40.0%	No change (Low flow*)
Unclassified road, near Northern Access (unofficially signed as Bennan's Farm)	30	43.3%	139	62.6%	Low flow*
B7023, north of Crosshill	2378	18.5%	2487	20.7%	0.6
B7045, north of Grimmet	2535	17.2%	2627	19.5%	0.5
B741, east of Cloyntie	616	8.1%	725	17.1%	Low flow*
A77, near Nether Auchendrane	14110	8.9%	14202	9.3%	0.1
* Values indicated as 'Low flow' are below the minimum flow defined in CRTN for use of the CRTN prediction methodology (see further discussion in paragraph 5.1.8). Where there is no change for low flow cases, this is indicated.					

5.1.9 The most sensitive receiver locations in respect of vehicle movements are properties which are relatively close to the access tracks. Knockskae is the closest of these receptors and is at a distance of approximately 95 m at the closest point to one of the two access track route options. Large vehicles can generate noise levels in the region of 108 dB (sound power level) when in motion. However, these types of plant usually pass a receiver location quite quickly. Based on the prediction methodology in BS 5288, once vehicles are travelling on this haul road this will give rise to a maximum predicted noise level of 48 dB(A) $L_{eq,1hr}$ based on six heavy vehicles per hour[2] travelling at 35 km/hr[3]. The construction program indicates this intensity of heavy vehicle movements could be similar for months three to nine. At this location, in terms of significance criteria noise effects are considered to be of negligible significance.

5.1.10 In conclusion, noise from construction activities has been assessed and is predicted to result in a minor effect.

2 The traffic assessment reports a maximum of 74 HGV vehicle movements per day for the most intense period (month eight of the construction programme). This is a total of approximately 6.2 vehicles per hour for the twelve hour construction day.

3 A speed of 35 km/hr is estimated based on our experience of this type of activity and considered reasonably representative.

5.2 Construction Noise & Vibration Levels – Blasting

5.2.1 Because of the difficulties in predicting noise and air overpressure resulting from blasting operations, these activities are best controlled following the use of good practice during the setting and detonation of charges, as set out earlier in this report. The transmission and magnitude of ground vibrations associated with blasting operations at borrow pits are subject to many complex influences including charge type and position, and importantly, the precise nature of the ground conditions (material composition, compaction, discontinuities) at the source, receiver, and at every point along all potential ground transmission paths. Clearly any estimation of such conditions is subject to considerable uncertainty, thus limiting the utility of predictive exercises. Mitigation of potential effects of these activities is best achieved through onsite testing processes carried out in consultation with SAC.

5.3 Decommissioning Noise

5.3.1 Decommissioning is likely to result in less noise than the construction of the Proposed Development. The construction phase has been considered to have minor noise effects, therefore decommissioning will, in the worst case, also have minor noise effects.

5.4 Operational Wind Turbine Emissions Data

5.4.1 The exact model of turbine to be used at the site will be the result of a future tendering process and therefore an indicative candidate turbine model has been assumed for this noise assessment. This operational noise assessment is based upon the noise specification of the Vestas EnVentus V150-6.0 MW wind turbine. The wind turbines on the Proposed Development have been modelled using the layout as indicated on the map at Annex B (coordinates also provided). The candidate turbine is a variable speed, pitch-regulated machine with a rotor diameter of 150 m and a hub height which includes both 105 m and 125 m (see Annex B, Table B1). Its noise emissions are considered representative of turbines of this scale. Due to its variable speed operation, the sound power output of the turbine varies considerably with wind speed, being quieter at the lower wind speeds when the blades are rotating more slowly.

5.4.2 In addition to this general low noise characteristic at lower wind speeds, the candidate turbine also incorporates noise control technology. This allows the sound power output of the turbine to be reduced across a range of operational wind speeds, albeit with some loss of electrical power generation, to enable the best compromise to be achieved in any given situation between emitted noise and electrical power generation. Noise control of the candidate turbine is provided in a number of noise control modes with various noise/power output combinations. Similar noise reduction management systems are also offered by other wind turbine manufacturers. These systems are generally similar in that they rely on the turbine's computer based controller adjusting either the pitch of the blades or holding back the rotational speed of the blades to reduce emitted noise under selected wind conditions (direction, speed or some combination of the two). In this manner noise management only comes into play (and therefore potential power generation capacity is only lost) for those conditions under which it is required. For the purposes of the present assessment, the wind turbines on the Proposed Development have been modelled assuming standard operation.

5.4.3 Vestas have supplied specification noise emission data for the Vestas EnVentus V150-6.0 MW turbine which are values the manufacturer considers to be typical of this model of turbine. This turbine is as standard supplied with blades which have modifications (‘Serrated Trailing Edge Blades’), typically resulting in lower noise emission levels than turbines without this blade technology. A further correction factor of +2 dB was added to the Vestas specification data to allow for uncertainty in these data, which is consistent with advice in the IOA GPG and typically the largest allowance for uncertainty added to sound power levels suggested by the IOA GPG. Sound power data have been made available for a range of wind speeds at hub height, converted to standardised ten metre reference wind speeds for the range from 4 m/s to 12 m/s inclusive. These have been calculated for a hub height of 125 m and assumed to apply to the turbines on the Proposed Development at this height and at the lower hub height of 105 m. This assumption is precautionary and in practice for turbines with smaller hub heights, noise immission levels would be lower at some wind speeds[4]. In addition to the overall sound power data, reference has been made to the documentation from the manufacturer to derive a representative sound spectrum for the turbine. The overall sound power and spectral data are presented in Annex C.

5.4.4 Assessment of cumulative effects from operating the Proposed Development with other wind farms requires source information for the turbine types similar to that presented for the Proposed Development for each wind farm. For each of these adjacent wind farms, Annex C provides a detailed description of how appropriate sound power levels for the wind turbines were derived. In summary of the information presented therein, potential noise emission levels were considered in a robust way by considering the potential level of noise emission which would be allowed under the respective consent for each of the sites, allowing 'appropriate margins' in addition to uncertainty margins in the emission data for representative turbine models. This accords with good practice guidance as set out in the IOA GPG for assessing cumulative operational noise levels.

5.5 Choice of Wind Turbine Operational Noise Propagation Model

5.5.1 The ISO 9613-2 model[xxii] has been used to calculate the noise immission levels at the selected nearest residential neighbours as advised in the IOA GPG. The model accounts for the attenuation due to geometric spreading, atmospheric absorption, barrier and ground effects. All attenuation calculations have been made on an octave band basis and therefore account for the sound frequency characteristics of the turbines.

5.5.2 For the purposes of the present assessment, all noise level predictions have been undertaken using a receiver height of 4 m above local ground level, mixed ground (G=0.5) and an air absorption based on a temperature of 10 °C and 70% relative humidity. A receiver height of 4 m will be typical of first floor windows and result in slightly higher predicted noise levels than if a 1.2 to 1.5 metre receiver height were chosen in the ISO 9613 algorithm. The attenuation due to terrain screening accounted for in the calculations has been limited to a maximum of 2 dB(A). In situations of propagation above concave ground, a correction of +3 dB(A) was added. This method is consistent with the recommendations of the above-referenced IOA GPG which provides recommendations on the appropriate approach when predicting wind turbine noise levels. The propagation corrections applied are detailed in Annex B.

5.5.3 The IOA GPG also allows for directional effects to be taken into account within the noise modelling: under upwind propagation conditions between a given receiver and the wind farm the noise immission level at that receiver can be as much as 10 dB(A) to 15 dB(A) lower than the level predicted using the ISO 9613-2 model. However, predictions have been made assuming downwind propagation from every turbine to every receptor at the same time as a worst-case for assessing cumulative noise levels against the ETSU-R-97 criteria in the assessment.

5.6 Predicted Wind Turbine Operational Noise Immission Levels

5.6.1 Table 7 shows predicted noise immission levels at each of the assessment locations for each wind speed from 4 m/s to 12 m/s inclusive for the Proposed Development alone. All wind turbine noise immission levels in this report are presented in terms of the $L_{A90,T}$ noise indicator in accordance with the recommendations of the ETSU-R-97 report, obtained by subtracting 2 dB(A) from the calculated $L_{Aeq,T}$ noise levels, based on the turbine sound power levels discussed above.

4 For the part of the noise emission curve where noise emissions are increasing as wind speeds increase, noise emission levels would tend to be marginally lower for turbines with a shorter hub height relative to one with a taller hub height. Therefore, when there is a mix of hub heights to be considered, by assuming the turbines are all at a taller height provides more precautionary (greater) noise immission levels for a given wind speed for this part of the emission curve. Once turbine sound power levels reach a maxima, the difference between hub heights no longer results in any differences in predicted noise immission levels.

5.6.2 Similarly, Table 8 to Table 11 show predicted noise immission levels for the other wind farms, each operating alone, and which include robust allowances for their potential noise emissions in line with IOA GPG guidance, as detailed above.

Table 7 - Predicted $L_{A90,T}$ dB noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the Proposed Development (K) alone.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cott.	-	-	21.2	24.8	29.2	32.5	33.0	33.1	33.1	33.1	33.1	33.1
Knockskae	-	-	22.9	26.5	30.9	34.2	34.7	34.8	34.8	34.8	34.8	34.8
Linfairn Farm	-	-	22.7	26.3	30.7	34.0	34.5	34.6	34.6	34.6	34.6	34.6
Tairlaw Toll Cott.	-	-	21.5	25.1	29.5	32.8	33.3	33.4	33.4	33.4	33.4	33.4
Tallaminnoch	-	-	18.7	22.3	26.7	30.0	30.5	30.6	30.6	30.6	30.6	30.6
Glenalla Farm	-	-	18.7	22.3	26.7	30.0	30.5	30.6	30.6	30.6	30.6	30.6

Table 8 - Predicted $L_{A90,T}$ dB noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the built and operating Dersalloch Windfarm (D) alone.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cott.	-	-	-	17.7	22.5	27.6	29.5	30.3	30.3	30.3	30.3	30.3
Knockskae	-	-	-	19.3	24.1	29.2	31.1	31.9	31.9	31.9	31.9	31.9
Linfairn Farm	-	-	-	16.9	21.7	26.8	28.7	29.5	29.5	29.5	29.5	29.5
Tairlaw Toll Cott.	-	-	-	19.1	23.9	29.0	30.9	31.7	31.7	31.7	31.7	31.7
Tallaminnoch	-	-	-	12.1	16.9	22.0	23.9	24.7	24.7	24.7	24.7	24.7
Glenalla Farm	-	-	-	7.9	12.7	17.8	19.7	20.5	20.5	20.5	20.5	20.5

Table 9 - Predicted $L_{A90,T}$ dB noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the built and operating Hadyard Hill Wind Farm (HH) alone.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cott.	-	-	16.6	16.6	16.6	16.6	17.7	18.8	19.9	19.9	19.9	19.9
Knockskae	-	-	18.3	18.3	18.3	18.3	19.4	20.5	21.6	21.6	21.6	21.6
Linfairn Farm	-	-	17.4	17.4	17.4	17.4	18.5	19.6	20.7	20.7	20.7	20.7
Tairlaw Toll Cott.	-	-	16.2	16.2	16.2	16.2	17.3	18.4	19.5	19.5	19.5	19.5
Tallaminnoch	-	-	16.0	16.0	16.0	16.0	17.1	18.2	19.3	19.3	19.3	19.3
Glenalla Farm	-	-	22.2	22.2	22.2	22.2	23.3	24.4	25.5	25.5	25.5	25.5

Table 10 - Predicted $L_{A90,T}$ dB noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the proposed Carrick Windfarm (CR) alone.

Property	Standardised 10 m Wind Speed (m/s)										
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cott.	-	-	14.9	20.1	24.9	26.7	26.7	26.7	26.7	26.7	26.7	26.7
Knockskae	-	-	16.4	21.6	26.4	28.2	28.2	28.2	28.2	28.2	28.2	28.2
Linfairn Farm	-	-	15.1	20.3	25.1	26.9	26.9	26.9	26.9	26.9	26.9	26.9
Tairlaw Toll Cott.	-	-	19.7	24.9	29.7	31.5	31.5	31.5	31.5	31.5	31.5	31.5
Tallaminnoch	-	-	20.3	25.6	30.4	32.1	32.1	32.1	32.1	32.1	32.1	32.1
Glenalla Farm	-	-	23.9	29.1	33.9	35.7	35.7	35.7	35.7	35.7	35.7	35.7

Table 11 - Predicted $L_{A90,T}$ dB noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the proposed Craiginmoddie Wind Farm (CM) alone.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cott.	-	-	4.1	9.3	14.1	15.9	15.9	15.9	15.9	15.9	15.9	15.9
Knockskae	-	-	7.3	12.5	17.3	19.1	19.1	19.1	19.1	19.1	19.1	19.1
Linfairn Farm	-	-	5.6	10.8	15.6	17.4	17.4	17.4	17.4	17.4	17.4	17.4
Tairlaw Toll Cott.	-	-	3.1	8.3	13.1	14.9	14.9	14.9	14.9	14.9	14.9	14.9
Tallaminnoch	-	-	4.4	9.6	14.4	16.2	16.2	16.2	16.2	16.2	16.2	16.2
Glenalla Farm	-	-	18.6	23.8	28.6	30.4	30.4	30.4	30.4	30.4	30.4	30.4

5.6.3 When assessing cumulative noise levels, it is relevant to consider whether the contribution from more distant wind farms is sufficiently low that they make no acoustically relevant contribution. Inspection of predicted noise levels shown for individual wind farms presented above indicates:-

- At all receptor locations, predicted noise immission levels from Hadyard Hill Wind Farm are at least 10 dB(A) below[5] the lowest potential noise limit which could apply, and also at least 10 dB(A) below predicted noise immission levels from other more acoustically relevant wind farms. Consequently, the contribution from Hadyard Hill Wind Farm will not be included within the cumulative noise assessment.
- At Glenalla Farm, predicted nose immission levels from Dersalloch Windfarm are at least 10 dB(A) below the lowest potential noise limit which could apply, and also at least 10 dB(A) below predicted noise immission levels from other more acoustically relevant wind farms. The contribution from Dersalloch Windfarm will not be included within the cumulative noise assessment at Glenalla Farm.
- At all assessment locations <u>except</u> Glenalla Farm, predicted nose immission levels from Craiginmoddie Wind Farm are at least 10 dB(A) below the lowest potential noise limit which could apply, and also at least 10 dB(A) below predicted noise immission levels from other more acoustically relevant wind farms. The contribution from Craiginmoddie Wind Farm will <u>only</u> be included within the cumulative noise assessment at Glenalla Farm.

5.6.4 Table 12 shows cumulative predicted noise immission levels from the Proposed Development when operating together with the other adjacent wind farms, where relevant as discussed above. These

5 The IOA GPG suggests that where noise from adjacent developments differ by more than 10 dB(A) then this represents effectively negligible effects and that cumulative effects need not be considered. Two noise sources which differ by 10 dB(A) gives rise to total 0.4 dB(A) higher than the greater source. Accordingly it is generally assumed that increases of 0.4 dB(A) or less are not acoustically important.

predictions are cumulative assuming that all receptors are downwind of all wind turbines on the Proposed Development and these other wind farms at the same time. These cumulative noise levels are therefore unlikely to occur in practice and represent a conservative estimate of likely actual cumulative noise levels: both through the conservative nature of directional effects not being applied and the additional margins added to source sound power levels for each wind farm. Further consideration of directional effects is discussed below.

5.6.5 As discussed above, the cumulative totals shown include contributions from only relevant wind farms. For Glenalla Farm, the totals include contributions from the Proposed Development, Carrick Windfarm and Craiginmoddie Wind Farm, whereas for all other locations the cumulative totals include contributions from the Proposed Development, Dersalloch Windfarm and Carrick Windfarm.

Table 12 - Predicted $L_{A90,T}$ dB noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the cumulative total (assuming all receptors are downwind of all relevant wind farms and no directional propagation factors are included).

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cott.[1]	-	-	-	26.7	31.2	34.5	35.3	35.5	35.5	35.5	35.5	35.5
Knockskae[1]	-	-	-	28.3	32.8	36.2	36.9	37.2	37.2	37.2	37.2	37.2
Linfairn Farm[1]	-	-	-	27.6	32.2	35.4	36.1	36.3	36.3	36.3	36.3	36.3
Tairlaw Toll Cott.[1]	-	-	-	28.5	33.1	36.1	36.8	37.1	37.1	37.1	37.1	37.1
Tallaminnoch[1]	-	-	-	27.4	32.0	34.5	34.8	34.9	34.9	34.9	34.9	34.9
Glenalla Farm[2]	-	-	-	30.9	35.7	37.7	37.8	37.8	37.8	37.8	37.8	37.8

1. Includes contributions from the Proposed Development (K), Dersalloch Windfarm (D) and Carrick Windfarm (CR).
2. Includes contributions from the Proposed Development (K), Carrick Windfarm (CR) and Craiginmoddie Wind Farm (CM).

5.7 ETSU-R-97 Assessment

5.7.1 Table 13 and Table 14 show the difference between cumulative predicted noise immission levels and the cumulative ETSU-R-97 noise criteria applicable during day-time and night-time periods. These show that at all locations cumulative noise levels are within these cumulative ETSU-R-97 criteria.

5.7.2 The ETSU-R-97 noise limits assume that the wind turbine noise contains no audible tones. Where tones are present, a correction is added to the measured or predicted noise level before comparison with the recommended limits. The audibility of any tones can be assessed by comparing the narrow band level of such tones with the masking level contained in a band of frequencies around the tone called the critical band. The ETSU-R-97 recommendations suggest a tone correction which depends on the amount by which the tone exceeds the audibility threshold and should be included as part of the consent conditions. The wind turbines to be used for this site will be chosen to ensure that the noise emitted will comply with the requirements of ETSU-R-97 including any relevant tonality corrections.

Table 13 - Difference between the ETSU-R-97 derived day-time noise limits of Table 3 and the cumulative predicted $L_{A90,T}$ wind farm noise immission levels of Table 12 at each noise assessment location. Values are based on the fixed part of the day-time limit being 38 dB(A). For Linfairn Farm (FI) the comparison is with the financially involved limit (45 dB(A) lower threshold). Negative values indicate the noise immission level is below the limit and values in **bold** show excess above the criteria.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	-	-	-13.0	-9.0	-6.3	-6.2	-6.7	-7.6	-8.7	-10.1	-12.0
Knockskae	-	-	-	-9.7	-5.2	-1.8	-1.1	-0.8	-0.8	-2.2	-3.8	-4.9
Linfairn Farm	-	-	-	-10.4	-5.8	-3.0	-3.6	-4.6	-5.8	-6.9	-8.0	-9.3
Linfairn Farm (FI)	-	-	-	-17.4	-12.8	-9.6	-8.9	-8.7	-8.7	-8.7	-8.7	-9.3
Tairlaw Toll Cot.	-	-	-	-11.7	-7.5	-5.3	-5.8	-6.9	-8.7	-10.6	-12.5	-14.1
Tallaminnoch	-	-	-	-12.8	-8.6	-6.9	-7.8	-9.1	-10.9	-12.8	-14.7	-16.3
Glenalla Farm	-	-	-	-7.1	-2.3	-0.3	-0.2	-0.9	-2.8	-4.7	-6.4	-7.9
Genoch Cott. (CR)	-	-	-	-11.3	-6.8	-3.5	-2.7	-2.9	-4.3	-5.7	-7.3	-9.0
Tairlaw Toll Cot. (CR)	-	-	-	-10.7	-6.6	-4.2	-4.4	-5.1	-6.2	-7.5	-8.9	-10.4
Tallaminnoch (CR)	-	-	-	-11.8	-7.7	-5.8	-6.4	-7.3	-8.4	-9.7	-11.1	-12.6
Glenalla Farm (CR)	-	-	-	-7.1	-2.3	-0.3	-0.2	-0.2	-0.9	-2.6	-4.5	-6.8
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

Table 14 - Difference between the ETSU-R-97 derived night-time noise limits of Table 4 and the cumulative predicted $L_{A90,T}$ wind farm noise immission levels of Table 12 at each noise assessment location. Values are based on the fixed part of the night-time limit being 43 dB(A). For Linfairn Farm (FI) the comparison is with the financially involved limit (45 dB(A) lower threshold). Negative values indicate the noise immission level is below the limit and values in **bold** show excess above the criteria.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	-	-	-16.3	-11.8	-8.5	-7.7	-7.5	-7.5	-7.5	-8.3	-10.4
Knockskae	-	-	-	-14.7	-10.2	-6.8	-6.1	-5.8	-5.8	-5.8	-5.8	-5.9
Linfairn Farm	-	-	-	-15.4	-10.8	-7.6	-6.9	-6.7	-6.7	-6.7	-6.7	-7.9
Linfairn Farm (FI)	-	-	-	-17.4	-12.8	-9.6	-8.9	-8.7	-8.7	-8.7	-8.7	-8.7
Tairlaw Toll Cot.	-	-	-	-14.5	-9.9	-6.9	-6.2	-5.9	-7.3	-9.3	-11.6	-13.9
Tallaminnoch	-	-	-	-15.6	-11.0	-8.5	-8.2	-8.1	-9.5	-11.5	-13.8	-16.1
Glenalla Farm	-	-	-	-12.1	-7.3	-5.3	-5.2	-5.2	-5.2	-5.2	-5.4	-7.2
Genoch Cot. (CR)	-	-	-	-16.3	-11.8	-8.5	-7.7	-7.5	-7.5	-7.5	-7.5	-8.4
Tairlaw Toll Cot. (CR)	-	-	-	-14.5	-9.9	-6.9	-6.2	-5.9	-5.9	-6.1	-7.2	-8.5
Tallaminnoch (CR)	-	-	-	-15.6	-11.0	-8.5	-8.2	-8.1	-8.1	-8.3	-9.4	-10.7
Glenalla Farm (CR)	-	-	-	-12.1	-7.3	-5.3	-5.2	-5.2	-5.2	-5.2	-5.4	-7.0
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

5.7.3 Figures D1 to D22 (Annex D) show the calculated wind farm noise immission levels at the noise assessment locations and correspond to those already presented in the tables set out above, plotted as a function of standardised ten metre wind speed. The calculated noise immission levels are shown overlaid on the day-time and night-time noise limits. These limit curves have been derived from

ETSU-R-97 noise limits appropriate to each location, which were derived from background noise data already surveyed and presented in the Scoping Report, as discussed above.

5.7.4 As noted above, additional baseline surveys were completed for the Carrick Windfarm and have been referenced within this assessment, so that potential consequences of any differences between the Carrick baseline (and resulting noise limits) with those obtained for the survey for the Proposed Development can be considered. The tables above include assessment against ETSU-R-97 noise limits derived from the Carrick survey, which (along with Figures D15 to D22 in Annex D) show similar outcomes to the assessment based upon noise limits derived from baseline surveyed for the Proposed Development, at the relevant locations.

5.7.5 Also shown in the charts of Figures D1 to D22 (Annex D) are criteria set 10 dB(A) below the lowest potential noise limit. These were derived from background noise levels discussed above but with a choice of 35 dB(A) for the fixed threshold during the day-time, rather than 38 dB(A) used for the cumulative criteria; and with the night-time at 43 dB(A), the same as the cumulative criteria. Below these criteria, the contribution from distant wind farms is considered negligible and not considered further (see discussion in paragraph 5.6.3).

5.7.6 The ETSU-R-97 fixed part of the limit during the day-time should lie within the range from 35 dB(A) to 40 dB(A). As discussed above, setting this threshold to 35 dB(A) is a preference of SAC, within the 35 dB(A) to 40 dB(A) range allowed in accordance with ETSU-R-97. However, advice to SAC from their consultants ACCON is that 38 dB(A) would be appropriate when considering cumulative noise levels. The factors given in ETSU-R-97 to be used to determine where the limit should be set in this range have been discussed above and are discussed further below. It is important to recognise that these factors are not separate or individual criteria and will to some extent need to be considered jointly.

Number of dwellings in the neighbourhood of the wind farm

- The area of the Proposed Development and its surroundings is generally of low population density, with a limited number of surrounding properties near to wind energy developments in the area. Where more receptors are present, these tend to be either further from the Proposed Development or exposed to lower levels of wind turbine noise.

Duration and level of exposure

- For the majority of receptors to the north and east of the Proposed Development, which would be most often downwind of the Proposed Development under typical prevailing wind conditions, their exposure to total cumulative noise levels would be towards the lower end of the 35 dB(A) to 40 dB(A) range of the ETSU-R-97 day-time criteria. Noise levels from the Proposed Development alone are below 35 dB(A) at all locations.
- The single receptor location of Glenalla Farm is potentially exposed to higher total cumulative noise levels, such that noise levels are at a maximum of 38 dB(A) within the 35 dB(A) to 40 dB(A) range of the ETSU-R-97 day-time criteria. Noise levels from the Proposed Development alone are well below the 35 dB(A) to 40 dB(A) range of the ETSU-R-97 and typically less than 31 dB(A) as a maximum.
- Cumulative predicted noise immission levels have been calculated without accounting for directional effects. In practice predicted noise levels are likely to be lower than the total shown, as the location could not be directly downwind from all turbines simultaneously.
- Although, the duration of exposure to wind turbine noise would be increased at some of the receptor locations considered, with turbine noise experienced in a wider range of wind directions, the contribution from each of the wind farms would be relatively low and at the lower end of the 35 dB(A) to 40 dB(A) range, and for properties located between different wind farms in opposite directions, the assumptions of simultaneous downwind propagation is particularly conservative. Considering conservative predictions in this way has effectively accounted for the increased duration of exposure in these cases.

Effect of noise limits on the number of kWh generated

- The generating capability of the Proposed Development is significant; more so when added to the generating potential of other schemes already present or proposed in the area near to the Proposed Development. Such large generating capacity suggests it would be appropriate to consider noise limits at the upper end of the range given in ETSU-R-97 i.e. at 40 dB(A).
- The power generating capacity of modern wind turbines has dramatically increased over that which was typical at the time the ETSU-R-97 guidelines were produced. For example, at the time the guide was produced, a wind farm site comprising around 90 turbines[6] would have been required to achieve a similar generating capacity to that of the Proposed Development, thus highlighting the significance of the scheme.
- With a day-time criteria based on a choice of 35 dB(A), and using non-directional predictions, the reduction in the number of turbines required to enable noise immissions to be within such limits can be estimated. Noise limits based on a choice of 35 dB(A) would be lowest at Knockskae, consequently 35 dB(A) based noise limits applied at Knockskae would primarily control noise immission levels from the Proposed Development. Stopping or removing the five northern turbines (out of nine total) from the Proposed Development would be required to bring noise within a 35 dB(A) based criteria for cumulative noise immission levels, with no mitigation applied to any other wind farm. Due to the less significant contribution to cumulative noise levels from the Proposed Development at Glenalla Farm, reductions would be required to Carrick Windfarm to meet 35 dB(A) based criteria and so is not considered further.

5.7.7 Overall, setting the day-time cumulative limit based upon a fixed threshold of 35 dB(A) cumulatively would have a disproportionate effect on potential energy generation relative to the level and duration of impact, and would also be inconsistent with noise limits already contained in the consents for Dersalloch and Hadyard Hill. It is considered that a choice of 38 dB(A) for the fixed part of the day-time criteria represents a reasonable choice compared with a choice of 35 dB(A).

5.8 Site-specific Noise Limits

5.8.1 Satisfactory control of cumulative noise immission levels can be achieved through the imposition of individual noise limits for each of the wind farms which are not already consented and operational. These individual site-specific noise limits can be determined through calculation, based upon the cumulative assessment criteria, taking into account the existing/consented schemes. For those receptor locations to the north and east of the Proposed Development, the cumulative assessment considered contributions from the Proposed Development (K), Dersalloch Windfarm (D), and Carrick Windfarm (CR). For these receptor locations the approach to determine apportioned noise limits is therefore:-

- Logarithmically subtract predicted noise immission levels due to operation of Dersalloch Windfarm from the cumulative criteria (given this wind farm is built and operating), resulting in a remaining ‘noise budget’ which will differ day-time and night-time.
- Take the ‘noise budget’ and apportion this between the Proposed Development (K) and Carrick Windfarm (CR) based on their individual contributions to total noise immission levels of these two wind farms combined.
- This apportionment will result in limit values which vary with wind speed, for each wind farm, for each receptor location and for the day-time and night-time. Where these apportioned limits rise

6 Based on typically 0.6 MW turbines being at the upper end of turbine capacities at the time of ETSU-R-97 was formulated and the candidate 6.0 MW turbine used for the noise assessment. The Development would be built using turbines of the type and size typical of the candidate used for the noise assessment.

again at lower wind speeds they have been maintained at a fixed value and extended to cover the lower wind speeds.

5.8.2 For the receptor location of Glenalla Farm to the west of the Proposed Development, to control cumulative noise levels the cumulative assessment considered contributions from the Proposed Development (K), Carrick Windfarm (CR) and Craiginmoddie Windfarm (CM). For this receptor location the approach to determine apportioned noise limits is therefore:-

- Take the total cumulative noise limit as the 'noise budget' and apportion this between the Proposed Development, Carrick Windfarm and Craiginmoddie Wind Farm based on their individual contributions to total noise immission levels of these three wind farms combined.
- This apportionment will result in limit values which vary with wind speed, for each wind farm and for day-time and night-time. Where these apportioned limits rise again at lower wind speeds they have been maintained at a fixed value and extended to cover the lower wind speeds.

5.8.3 Partial noise limits which could be applied to the Proposed Development in isolation at each assessment location are provided in Table E1 and E2 (Annex E) for the day-time and night-time respectively. Similarly, partial noise limits which could be applied to the Carrick Windfarm (Tables E4 and E5) and Craiginmoddie Wind Farm (Tables E5 and E6) are also provided in Annex E. These partial limits were derived by apportioning the relevant ETSU-R-97 limit in relation to the proportion of predicted noise levels between the Proposed Development and the other sites considered in the cumulative noise assessment as set out above. The resulting partial noise limits are such that compliance of the Proposed Development with these noise limits would maintain the conclusion of the cumulative assessment and result in cumulative levels which do not exceed the derived ETSU R 97 noise criteria.

5.8.4 Figures E1 to E22 (Annex E) show the calculated apportioned (site-specific) noise limits applicable to the relevant wind farms at each of the assessment locations and correspond to values presented in Tables E1 to E6 in Annex E. Also included in these charts are predicted noise immission levels as set out in Table 7, Table 10 and Table 11, which indicate that predicted noise levels are below these site-specific noise limits at all locations for all wind farms. Application of these site-specific noise limits would result in total predicted cumulative noise immission levels remaining within the ETSU-R-97 cumulative criteria / limits shown in Table 3 and Table 4.

5.8.5 Table 15 and Table 16 show the difference between predicted noise immission levels from the Proposed Development alone and the site-specific noise limits, which are to apply solely to the Proposed Development and are applicable during day-time and night-time periods. These show that at all locations, noise levels from the Proposed Development are within these site-specific noise limits.

Table 15 - Difference between the site specific noise limits to be applied to the Proposed Development during day-time periods (Table E1) and the predicted $L_{A90,T}$ wind farm noise immission levels for the Proposed Development (Table 7Table 12) at each noise assessment location. Negative values indicate the noise immission level is below the limit and values in **bold** show excess above the limit.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	-	-17.2	-13.6	-9.5	-7.1	-7.3	-7.9	-8.9	-10.0	-11.5	-13.4
Knockskae	-	-	-13.0	-9.4	-5.0	-1.7	-1.2	-1.1	-1.1	-2.9	-4.8	-6.0
Linfairn Farm	-	-	-14.6	-11.0	-6.6	-3.3	-4.2	-5.3	-6.6	-7.7	-8.9	-10.2
Linfairn Farm (FI)	-	-	-21.5	-17.9	-13.5	-10.2	-9.7	-9.6	-9.6	-9.6	-9.6	-10.2
Tairlaw Toll Cot.	-	-	-15.8	-12.2	-7.9	-6.0	-6.8	-8.2	-10.1	-12.0	-14.0	-15.6
Tallaminnoch	-	-	-16.6	-13.0	-8.7	-7.1	-8.1	-9.5	-11.3	-13.2	-15.1	-16.7
Glenalla Farm	-	-	-12.0	-8.4	-4.0	-0.7	-0.2	-0.9	-2.8	-4.7	-6.4	-7.9
Genoch Cott. (CR)	-	-	-15.2	-11.6	-7.2	-3.9	-3.4	-3.7	-5.3	-6.8	-8.5	-10.3
Tairlaw Toll Cot. (CR)	-	-	-14.8	-11.2	-7.0	-4.8	-5.3	-6.2	-7.4	-8.8	-10.3	-11.8
Tallaminnoch (CR)	-	-	-15.5	-11.9	-7.8	-6.0	-6.7	-7.7	-8.8	-10.1	-11.5	-13.0
Glenalla Farm (CR)	-	-	-12.0	-8.4	-4.0	-0.7	-0.2	-0.2	-0.9	-2.6	-4.5	-6.8
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

Table 16 - Difference between the site specific noise limits to be applied to the Proposed Development during night-time periods (Table E2) and the predicted $L_{A90,T}$ wind farm noise immission levels for the Proposed Development (Table 7Table 12) at each noise assessment location. Negative values indicate the noise immission level is below the limit and values in **bold** show excess above the limit.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	-	-20.6	-17.0	-12.6	-9.3	-8.8	-8.7	-8.7	-8.7	-9.6	-11.8
Knockskae	-	-	-18.9	-15.3	-10.9	-7.6	-7.1	-7.0	-7.0	-7.0	-7.0	-7.1
Linfairn Farm	-	-	-19.4	-15.8	-11.4	-8.1	-7.6	-7.5	-7.5	-7.5	-7.5	-8.8
Linfairn Farm (FI)	-	-	-21.5	-17.9	-13.5	-10.2	-9.7	-9.6	-9.6	-9.6	-9.6	-9.6
Tairlaw Toll Cot.	-	-	-19.0	-15.4	-11.0	-7.7	-7.2	-7.1	-8.6	-10.7	-13.1	-15.4
Tallaminnoch	-	-	-20.4	-16.8	-12.4	-9.1	-8.6	-8.5	-9.9	-11.9	-14.2	-16.5
Glenalla Farm	-	-	-17.0	-13.4	-9.0	-5.7	-5.2	-5.2	-5.2	-5.2	-5.4	-7.2
Genoch Cot. (CR)	-	-	-20.6	-17.0	-12.6	-9.3	-8.8	-8.7	-8.7	-8.7	-8.7	-9.7
Tairlaw Toll Cot. (CR)	-	-	-19.0	-15.4	-11.0	-7.7	-7.2	-7.1	-7.1	-7.3	-8.5	-9.9
Tallaminnoch (CR)	-	-	-20.4	-16.8	-12.4	-9.1	-8.6	-8.5	-8.5	-8.7	-9.8	-11.1
Glenalla Farm (CR)	-	-	-17.0	-13.4	-9.0	-5.7	-5.2	-5.2	-5.2	-5.2	-5.4	-7.0
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

5.9 Low Frequency Noise, Vibration and Amplitude Modulation

5.9.1 Low frequency noise and vibration resulting from the operation of wind farms are issues that have been attracting a certain amount of attention over recent years. Consequently, Annex A includes a detailed discussion of these topics. In summary of the information provided therein, the current recommendation is that ETSU-R-97 should continue to be used for the assessment and rating of operational noise from wind farms.

5.9.2 Annex A also discusses the most recently published research on the subject of wind turbine blade swish Amplitude Modulation (or AM). A penalty-type approach to account for instances of increased AM outside of what is expected from 'normal' blade swish has been proposed. This approach is a consequence of the combined results of this research and, in particular, the development by the IOA of an objective technique for identifying and quantifying AM noise, as well as a review of the subjective response to AM noise by a Government-commissioned research group. Some uncertainty remains at this stage over the application of such a penalty and this will be subject to a period of testing and review over the next few years.

5.10 Evaluation of Effects

Table 17 – Summary of effects

Potential Effect	Evaluation of Effect
Construction Noise	Noise levels have been predicted using the methodology set out in BS 5228. Based on assessment criteria derived and supported by a range of noise policy and guidance, overall construction noise levels are considered to represent a minor effect, and therefore considered not significant in EIA terms.
Operational Noise	Noise criteria have been established in accordance with ETSU-R-97. It has also been shown that these criteria are achievable with a commercially available turbine suitable for the Proposed Development. The basis of the ETSU-R-97 method is to define acceptable noise limits thought to offer reasonable protection to residents in areas around wind farm developments. At some locations under some wind conditions and for a certain proportion of the time, wind turbine noise may be audible; however, operational noise immission levels are acceptable in terms of the guidance recommended by planning policy for the assessment of wind farm noise, and therefore considered not significant in EIA terms. Operational noise from the substation and energy storage facility would be negligible and not significant in EIA terms.

6. Mitigation, Offsetting and Enhancement Measures

6.1 Proposed Construction Noise Mitigation Measures

6.1.1 To reduce the potential effects of construction noise, the following types of mitigation measures are proposed:

- Those activities that may give rise to audible noise at the surrounding properties and heavy goods vehicle deliveries to the site will be limited to the hours 07:00 to 19:00 Monday to Friday and 07:00 to 13:00 Saturdays. Turbine deliveries will only take place outside these times with the prior consent of the Council and Police Scotland. Some quieter activity (e.g. turbine installation) may occur outside the specified hours.
- All construction activities shall adhere to good practice as set out in BS 5228.
- All equipment will be maintained in good working order and any associated noise attenuation such as engine casing and exhaust silencers shall remain fitted at all times.
- Where flexibility exists, activities will be separated from residential neighbours by the maximum possible distances.
- A Construction Traffic Management Plan (CTMP) will be developed to control the movement of vehicles to and from the Proposed Development site.
- Construction plant capable of generating significant noise and vibration levels will be operated in a manner to restrict the duration of the higher magnitude levels.

6.1.2 The potential noise and vibration effects of blasting operations will be reduced according to the guidance set out in the relevant British Standards and PAN50 annex D and discussed below:-

- Blasting should take place under strictly controlled conditions with the agreement of the relevant authorities, at regular times within the working week, that is, Mondays to Fridays, between the hours of 10:00 and 16:00. Blasting out with these times should be a matter for negotiation between the contractor and the local authorities;
- Vibration levels at the nearest sensitive properties are best controlled through on-site testing processes carried out in consultation with the Local Authorities. This site testing based process would include the use of progressively increased minor charges to gauge ground conditions both in terms of propagation characteristics and the level of charge needed to release the requisite material. The use of onsite monitoring at neighbouring sensitive locations during the course of this preliminary testing can then be used to define upper final charge values that will ensure vibration levels remain within the criteria set out previously, as described in BS 5228-2 and BS 6472-2 2008;
- Blasting operations shall adhere to good practice as set out in BS 5228-2, and in PAN50, Annex D in order to control air overpressure.
- A scheme will be submitted to the mineral planning authority, for approval of blasting details, which will outline the mitigation measures to be adopted.

6.2 Proposed Operational Noise Mitigation Measures

6.2.1 The selection of the final turbine to be installed at the site would be made on the basis of enabling the relevant ETSU-R-97 based site-specific noise limits to be achieved at the surrounding properties.

7. Monitoring

7.1.1 It is proposed that if planning consent is granted for the Proposed Development, conditions attached to the planning consent should include the requirement that, in the event of a noise complaint, noise levels resulting from the operation of the Proposed Development are measured in order to demonstrate compliance with the conditioned noise limits. Furthermore, it is proposed that to provide a pragmatic approach to demonstrating compliance with site-specific noise limits that, should other wind farms be consented which contribute towards cumulative noise immission levels, measurements firstly demonstrate compliance with the overall cumulative ETSU-R-97 criteria. Subsequently should these cumulative criteria be exceeded only then would a more detailed assessment be required to determine noise attributable to operation of the Proposed Development alone (if considered likely to be a relevant contributor to the complaint). Such monitoring should be done in full accordance with ETSU-R-97 as well as good practice guidance and should include penalties for characteristics of the noise (if present).

8. Summary of Key Findings and Conclusions

8.1.1 This report has presented an assessment of the effects of construction and operational noise from the Proposed Development on the residents of nearby dwellings.

8.1.2 A number of residential properties lying around the Proposed Development have been selected as being representative of the closest located properties to the Proposed Development. The minimum separation distance between the nearest wind turbine and the closest located residential property is approximately 1.3 km. Noise assessments have been undertaken at these properties by comparing predicted construction and operational noise levels with relevant assessment criteria. In the case of construction noise, relevant assessment criteria are in the form of absolute limit values derived from a range of environmental noise guidance. In relation to operational noise, the limits have been derived from the existing background noise levels at surrounding properties, as derived from measurements undertaken previously.

8.1.3 The construction noise assessment has determined that associated levels are expected to be audible at various times throughout the construction programme, but remain with acceptable limits such that their temporary effects are considered minor.

8.1.4 Operational wind turbine noise from the Proposed Development has been assessed in accordance with the methodology set out in the 1996 DTI Report ETSU-R-97, 'The Assessment and Rating of Noise from Windfarms'. This document provides a robust basis for assessing the operational noise of a wind farm as recommended by SPP.

8.1.5 Applying the ETSU-R-97 derived noise limits at the assessment locations, it has been demonstrated that both the day-time and night-time noise criterion limits can be satisfied at all properties across all wind speeds. This assessment has been based on the use of the manufacturer's warranted sound power data for the Vestas V150-6.0 MW candidate wind turbine, which is typical of the type and size of turbine which may be considered for this site, and assuming worst case downwind propagation.

8.1.6 In summary, the overall levels of construction noise are considered to represent a minor effect, and therefore considered not significant in EIA terms. At some locations under some wind conditions and for a certain proportion of the time, wind turbine noise may be audible; however, operational noise immission levels are acceptable in terms of the guidance commended by planning policy for the assessment of wind turbine noise, and therefore considered not significant in EIA terms.

9. References

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xx Linfairn Wind Farm, (https://www.energyconsents.scot/ApplicationDetails.aspx?cr=EC00004192).

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Annex A - General Approach to Noise Assessment & Glossary

A.1 Some sound, such as speech or music, is desirable. However, desirable sound can turn into unwanted noise when it interferes with a desired activity or when it is perceived as inappropriate in a particular environment.

A.2 When assessing the effects of sound on humans there are two equally important components that must both be considered: the physical sound itself, and the psychological response of people to that sound. It is this psychological component which results in those exposed differentiating between desirable sound and unwanted noise. Any assessment of the effects of sound relies on a basic appreciation of both these components. This Annex provides an overview of these topics. A glossary of acoustic terminology is included at the end of this Annex.

A.3 The assessment of environmental noise can be best understood by considering physical sound levels separately from the likely effects that these physical sound levels have on people, and on the environment in general.

A.4 Physical sound is a vibration of air molecules that propagates away from the source. As acoustic energy (carried by the vibration back and forth of the air molecules) travels away from the source of the acoustic disturbance it creates fluctuating positive and negative acoustic pressures in the atmosphere above and below the standing atmospheric pressure. For most types of sound normally encountered in the environment these acoustic pressures are extremely small compared to the atmospheric pressure. When acoustic pressure acts on any solid object it causes microscopic deflections in the surface. For most types of sound normally encountered in the environment these deflections are so small they cannot physically damage the material. It is only for the very highest energy sounds, such as those experienced close to a jet engine for example, that any risk of physical damage exists. For these reasons, most sound is essentially neutral and has no cumulative damaging physical effect on the environment. The effects of environmental sound are therefore limited to its effects on people or animals.

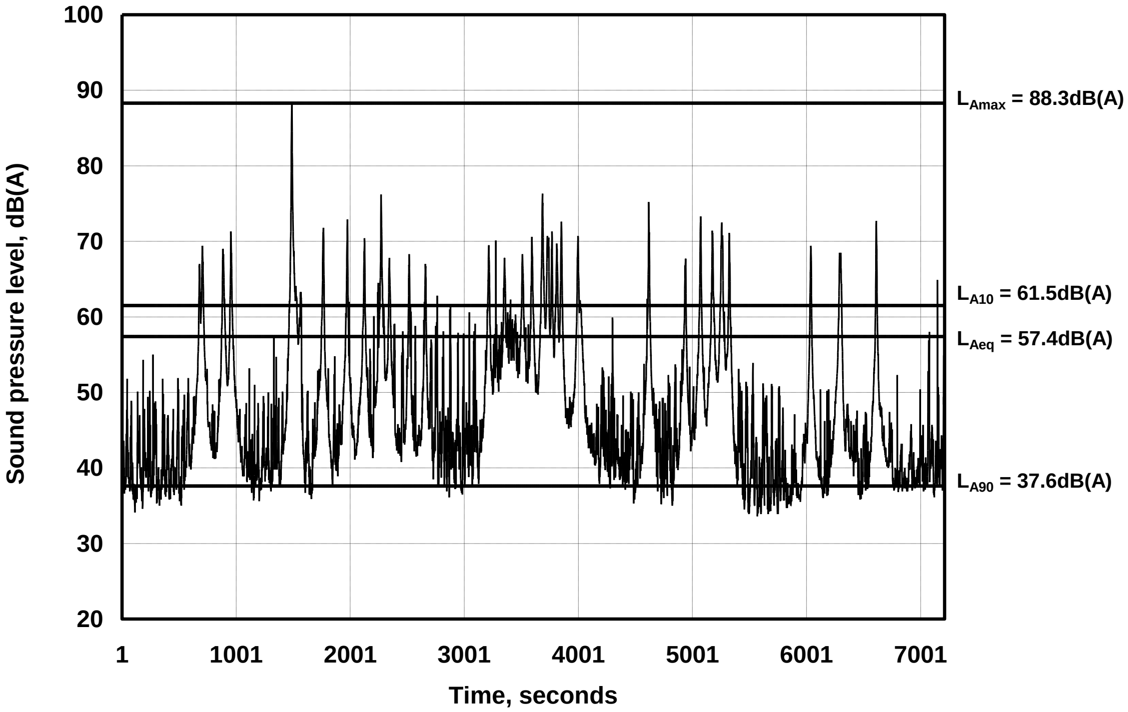
A.5 Before reviewing the potential effects of environmental sound on people, it is useful first to consider the means by which physical sound can be quantified.

Indicators of Physical Sound Levels

A.6 Physical sound is measured using a sound level meter. A sound level meter comprises two basic elements: a microphone which responds in sympathy with the acoustic pressure fluctuations and produces an electrical signal that is directly related to the incident pressure fluctuations, and a meter which converts the electrical signal generated by the microphone into a decibel reading. Figure A1 shows an example of the time history of the decibel readout from a sound level meter located approximately 50 m from a road. The plot covers a total time period of approximately 2 hours. The peaks in the sound pressure level trace correspond to the passage of individual vehicles past the measurement location.

A.7 Assigning a single value to the time varying sound pressure level presented in Figure A1 is clearly not straightforward, as the sound pressure level varies by over 50 dB with time. To overcome this, the measurement characteristics of sound level meters can be varied to emphasise different features of the sound that are thought to be most relevant to the effect under consideration.

Figure A1 Sample plot of the sound pressure level measured close to a road over a period of approximately two hours.



Objective measures of noise

A.8 The primary purpose of measuring environmental noise is to assess its effects on people. Consequently, any sound measuring device employed for the task should provide a simple readout that relates the objectively measured sound to human subjective response. To achieve this, the instrument must, as a minimum, be capable of measuring sound over the full range detectable by the human ear.

A.9 Perceived sound arises from the response of the ear to sound waves travelling through the air. Sound waves comprise air molecules oscillating in a regular and ordered manner about their equilibrium position. The speed of the oscillations determines the frequency, or pitch, of the sound, whilst the amplitude of oscillations governs the loudness of the sound. A healthy human ear is capable of detecting sounds at all frequencies from around 20 Hz to 20 kHz over a pressure amplitude range of approximately 1,000,000:1. Even relatively modest sound level meters are capable of detecting sounds over this range of amplitudes and frequencies, although the accuracy limits of sound level meters vary depending on the quality of the unit. When undertaking measurements of wind turbine noise, as with all other noise measurements, it is important to select a measurement system that possesses the relevant accuracy tolerances and is calibrated to a matching standard.

A.10 Whilst measurement systems exist that are capable of detecting the range of sounds detected by the human ear, the complexities of human response to sound make the derivation of a likely subjective response from a simple objective measure a non-trivial problem. Not only does human response to sound vary from person to person, but it can also depend as much on the activity and state of mind of an individual at the time of the assessment, and on the 'character' of the sound, as it can on the actual level of the sound. In practice, a complete range of responses to any given sound may be observed. Thus, any objective measure of noise can, at best, be used to infer the average subjective response over a sample population.

Sound Levels and Decibels

A.11 Because of the broad amplitude range covered by the human ear, it is usual to quantify the magnitude of sound using the decibel scale. When the amplitude of sound pressure is expressed using decibels (dB) the resultant quantity is termed the sound pressure level. Sound pressure levels are denoted by a capital 'L', as in L dB. The conversion of sound pressure from the physical quantity of Newton per square metre, or Nm-2, to sound pressure level in dB reduces the range from 0 dB at the threshold of hearing to 120 dB at the onset of pain. Both of these values are derived with respect to the hearing of the average healthy young person.

A.12 Being represented on a logarithmic amplitude scale, the addition and subtraction of decibel quantities does not follow the normal rules of linear arithmetic. For example, two equal sources acting together produce a sound level 3 dB higher than either source acting individually, so 40 dB + 40 dB = 43 dB and 50 dB + 50 dB = 53 dB. Ten equal sound sources acting together will be 10 dB louder than each source operating in isolation. Also, if one of a pair of sources is at least 10 dB quieter than the other, then it will contribute negligibly to the combined noise level. So, for example, 40 dB + 50 dB = 50 dB.

A.13 An increase in sound pressure level of 3 dB is commonly accepted as the smallest change of any subjective significance. An increase of 10 dB is often claimed to result in a perceived doubling in loudness, although the basis for this claim is not well founded. An increase of 3 dB is equivalent to a doubling in sound energy, which is the same as doubling the number of similar sources. An increase of 10 dB is equivalent to increasing the number of similar sources tenfold, whilst an increase of 20 dB requires a hundredfold increase in the number of similar sources and an increase of 30 dB requires a thousand times increase in the number of sources.

Frequency Selectivity of Human Hearing and A-weighting

A.14 Whilst the hearing of a healthy young individual may detect sounds over a frequency range extending from less than 20 Hz to greater than 20 kHz, the ear is not equally sensitive at all frequencies. Human hearing is most sensitive to sounds containing frequency components lying within the range of predominant speech frequencies from around 500 Hz to 4000 Hz. Therefore, when relating an objectively measured sound pressure level to subjective loudness, the frequency content of the sound must be accounted for.

A.15 When measuring sound with the aim of assessing subjective response, the frequency selectivity of human hearing is accounted for by down-weighting the contributions of lower and higher frequency sounds to reduce their influence on the overall reading. This is achieved by using an 'A'-weighting filter. Over the years, the A-weighting has become internationally standardised and is now incorporated into the majority of environmental noise standards and regulations in use around the world to best replicate the subjective response of the human ear. A-weighting filters are also implemented as standard on virtually all sound measurement systems.

A.16 Sound pressure levels measured with the A-weighting filter applied are referred to as 'A weighted' sound pressure levels. Results from such measurements are denoted with a subscripted capital A after the 'L' level designation, as in 45 dB LA, or alternatively using a bracketed 'A' after the 'dB' decibel designation, as in 45 dB(A).

Temporal Variation of Noise and Noise Indices

A.17 The simple A-weighted sound pressure level provides a snapshot of the sound environment at any given moment in time. However, as is adequately demonstrated by Figure A1, this instantaneous sound level can vary significantly over even short periods of time. A single number indicator is therefore required that best quantifies subjective response to time varying environmental noise, such as that shown in Figure A1. The question thus arises as to how temporal variations in level should be accounted for. This is most often achieved in practice by selecting a representative time period and calculating either the average noise level over that time period or, alternatively, the noise level exceeded for a stated proportion of that time period, as discussed below.

Equivalent Continuous Sound Level, $L_{Aeq,T}$

A.18 The equivalent continuous sound level, or $L_{Aeq,T}$ averages out any fluctuations in level over time. It is formally defined as the level of a steady sound which, in a stated time period 'T' and at a given location, has the same sound energy as the time varying sound. The $L_{Aeq,T}$ is a useful 'general' noise index that has been found to correlate well with subjective response to most types of environmental noise.

A.19 The equivalent continuous sound level is expressed $L_{Aeq,T}$ in dB, where the A–weighting is denoted by the subscripted 'A', the use of the equivalent continuous index is denoted by the subscripted 'eq', and the subscripted 'T' refers to the time period over which the averaging is performed. So, for example, 45 dB $L_{Aeq,1hr}$ indicates that A-weighted equivalent continuous noise level measured over a one hour period was 45 dB.

A.20 The disadvantage of the equivalent continuous sound level is that it provides no information as to the temporal variation of the sound. For example, an $L_{Aeq,1hr}$ of 60 dB could result from a sound pressure level of 60 dB(A) continuously present over the whole hour's measurement period, or it could arise from a single event of 96 dB(A) lasting for just 1 second superimposed on a continuous level of 30 dB(A) which exists for the remaining 59 minutes and 59 seconds of the hour long period. Clearly, the subjective effect of these two apparently identical situations (if one were to rely solely on the L_{Aeq} index) could be quite different.

A.21 The aforementioned feature can produce problems where the general ambient noise level is relatively low. In such cases the $L_{Aeq,T}$ can be easily 'corrupted' by individual noisy events. Examples of noisy events that often corrupt $L_{Aeq,T}$ noise measurements in situations of low ambient noise levels include birdsong or a dog bark local to a noise monitoring point, or an occasional overflying aircraft or a sudden gust of wind. This potential downside to the use of $L_{Aeq,T}$ as a general measurement index is of particular relevance to the assessment of ambient noise in quiet environments, such as those typically found in rural areas where wind farms are developed.

A.22 Despite these shortcomings in low noise environments, the $L_{Aeq,T}$ index is increasingly becoming adopted as the unit of choice for both UK and European guidance and legislation, although this choice is often as much for reasons of commonality between standards as it is for overriding technical arguments. In the Government's current planning policy guidance notes the $L_{Aeq,T}$ noise level is the index of choice for the general assessment of environmental noise. This assessment is undertaken separately for day time ($L_{Aeq,16hr}$ 07:00 to 23:00) and night time ($L_{Aeq,8hr}$ 23:00 to 07:00) periods. However, it is often the case for quiet environments, or for non-steady noise environments, that more information than can be gleaned from the $L_{Aeq,T}$ index may be required to fully assess potential noise effects.

Maximum, L_{Amax}, and percentile exceeded sound level, $L_{An,T}$

A.23 Figure A1 shows, superimposed on the time varying sound pressure level trace and in addition to the $L_{Aeq,T}$ noise level, examples of three well established measurement indices that are commonly used in the assessment of environmental noise impacts. These are the maximum sound pressure level, L_{Amax}, the 90 percentile sound pressure level, $L_{A90,T}$ and the ten percentile sound pressure level, $L_{A10,T}$.

A.24 The $L_{Amax,F}$ readings is suited to indicating the physical magnitude of the single individual sound event that reaches the maximum level over the measurement period, but it gives no indication of the number of individual events of a similar level that may have occurred over the time period.

A.25 Unlike the $L_{Aeq,T}$ index and the $L_{Amax,F}$ indices, percentile exceeded sound levels, percentage exceeded sound levels provide some insight into the temporal distribution of sound level throughout the averaging period. Percentage exceeded sound levels are defined as the sound level exceeded by a fluctuating sound level for n% of the time over a specified time period, T. They are denoted by $L_{An,T}$ in dB, where 'n' can take any value between 0% and 100%.

A.26 The $L_{A10,T}$ and $L_{A90,T}$ indices are the most commonly encountered percentile noise indices used in the UK.

A.27 The 10%'ile index, or $L_{A10,T}$ provides a measure of the sound pressure level that is exceeded for 10% of the total measurement period. It therefore represents the typical upper level of sound associated with specific events, such as the passage of vehicles past the measurement point. It is the traditional index adopted for road traffic noise. This index is useful because traffic noise is not usually constant, but rather it fluctuates with time as vehicles drive past the receptor location. The $L_{A10,T}$ therefore characterises the typical level of peaks in the noise as vehicles drive past, rather than the lulls in noise between the vehicles.

A.28 The $L_{A90,T}$ noise index is the noise level exceeded for 90% of the time period, T. It provides an estimate of the level of continuous background noise, in effect performing the inverse task of the $L_{A10,T}$ index by detecting the lulls between peaks in the noise. It is for this reason that the $L_{A90,T}$ noise index is the favoured unit of measurement for wind farm noise where, for the reasons discussed above, the generally low $L_{Aeq,T}$ noise levels are easily corrupted by intermittent sounds such as those produced by livestock, agricultural vehicles or the occasional passing vehicle on local roads. The $L_{A90,T}$ noise level represents the typical lower level of sound that may be reasonably expected to be present for the majority (90%) of the time in any given environment. This is usually referred to as the 'background' noise level.

Temporal Variations Outside the Noise Index Averaging Periods, 'T'

A.29 Averaging noise levels over the time period 'T' of the $L_{Aeq,T}$ and $L_{An,T}$ noise indices can successfully account for variations in noise over the time period, T. Some variations, however, exhibit trends over longer periods. At larger distances from noise sources meteorological factors can significantly affect received noise levels. At a few hundred metres from a constant level source of noise the potential variation in noise levels may be greater than 15 dB(A). To account for this variability consideration must be taken of meteorological conditions, particularly wind direction, when measurements and predictions are undertaken. As a general rule, when compared with the received noise level under neutral wind conditions, wind blowing from the source to the receiver can slightly enhance the noise level at the receiver (typically by no more than 3 dB(A)), but wind blowing from the receiver to the source can very significantly reduce the noise level at the receiver (typically by 15 dB(A) or more).

A.30 A similar effect occurs under conditions of temperature inversion, such as may exist after sunset when radiative cooling from the ground lowers the temperature of the air lying at low level more quickly than the air at higher levels, by loss of temperature through convective effects. This results in the air temperature increasing with increasing height above the ground. Depending on the source to receiver distance relative to the heights of the source and receiver, this situation can lead to sound waves becoming 'trapped' in the layer of air lying closest to the ground. The consequence is that noise levels at receptor locations can increase relative to those experienced under conditions of a neutral temperature gradient or a temperature lapse. The maximum increases compared to neutral conditions are similar to those experienced under downwind conditions of no more than around 3 dB(A). It is also worth noting that temperature lapse conditions, which is the more usual situation where temperature decreases with increasing height, can result in reductions in noise level at receptor locations by 15 dB(A) or more compared with the neutral conditions. The similarity between the magnitude of potential variations in noise levels for wind induced and temperature induced effects is not surprising, as the physical mechanisms behind the variations in level are the same for both situations: both variations result from changes in the speed of sound as a function of height above local ground level.

A.31 Temperature inversions on very still days can also affect noise propagation over much larger distances of several kilometres. These effects can produce higher than expected noise levels even at these very large distances from the source. A classic example that many people have experienced is the distant, usually inaudible, railway train that suddenly sounds like it is passing within a few hundred metres of a dwelling. However, these situations must generally be considered as rare exceptions to the usually encountered range of noise propagation conditions, especially in the case of wind farm noise as they rely on calm wind conditions under which wind turbines do not operate.

Effects of Sound on People

A.32 Except at very high peak acoustic pressures, the energy levels in most environmental sounds are too low to cause any physical disruption in any part of the body, just as they are too low to cause any direct physical damage to the environment. The main effects of environmental sound on people are therefore limited to possible interference with specific activities or to some kind of annoyance response. Some researchers have claimed statistical associations between environmental noise and various long-term health effects such as clinical hypertension or mental health problems, although there is no consensus on possible causative mechanisms. Evidence in support of health effects other than annoyance and some indicators of sleep disturbance is weak. However, the theory that psychological stress caused by annoyance might contribute to adverse health effects in otherwise susceptible individuals seems plausible. Health effects in the 'more usual' definition of physiological health therefore remain as a theoretical possibility which has neither been proved nor disproved. However, the World Health Organisation (WHO) defines health in the wider context of:

> *'a state of complete physical, mental and social well-being and not merely the absence of infirmity'.*

And within this wider context potential health effects of environmental noise are summarised by the World Health Organisation as:

- interference with speech communications;
- sleep disturbance;
- disturbance of concentration;
- annoyance; and
- social and economic effects.

Speech Interference

A.33 The instantaneous masking effects of unwanted noise on speech communication can be predicted with some accuracy by using specialist methods of calculation, but the overall effect of a small amount of speech interference on everyday life is harder to judge. The significance of speech masking depends on the context in which it occurs. For example, isolated noise events could interfere with telephone conversations by masking out particular words or parts of words but, because of the high redundancy in normal speech, the masking of individual words can often have no significant effect on the intelligibility of the overall message. Notwithstanding the above, noise levels from wind farms at even the closest located dwellings in otherwise quiet environments are usually no more than around 30 dB(A) indoors, even with windows open. This internal noise level is 5 dB(A) below the 35 dB(A) suggested by the World Health Organisation as the lowest potential cut-on level for issues relating to speech intelligibility.

Sleep Disturbance

A.34 Although sleep seems to be a fundamental requirement for humans, the most significant effect of sleep loss seems to be increased sleepiness the next day. Sleep normally follows a regular cyclic pattern from awake through light sleep to deep sleep and back, this cycle repeating several times during the night at around 90 minute intervals. Most people wake for short periods several times every night as part of the normal sleep cycle without necessarily being aware of this the next day. REM, or rapid eye movement, sleep is associated with dreaming and occurs several times each night during the lighter sleep stages.

A.35 Electroencephalography (EEG) and similar techniques can be used to detect transient physiological responses to noise at night. Transient responses can be detected by short bursts of activity in the recorded waveforms which often settle back down to the same pattern as immediately before the event.

Sometimes a transient response will be the precursor of a definite lightening of sleep, or even of an awakening, but often no discernible physical event happens at all.

A.36 These results suggest that at least parts of the auditory system remain fully operational even while the listener is asleep. The main purpose of this seems to be to arouse the listener in case of danger or in case some particular action is required which cannot easily be accomplished whilst remaining asleep. On the other hand, the system appears to be designed to filter out familiar sounds which experience suggests do not require any action. A very loud sound is likely to overcome the filtering mechanism and wake the listener, while intermediate and quieter sounds might only wake a listener who has a particular focus on those specific sounds. There is no evidence that the transient physiological responses to noise whilst asleep are anything other than normal. There is also considerable anecdotal evidence that people habituate to familiar noise at night, although some of the research evidence on this point is contradictory.

A.37 There is no consensus on how much sleep disturbance is significant. Some authorities take a precautionary approach, under which any kind of physiological response to noise is considered important, irrespective of whether there are any next day effects or not. Other studies suggest that transient physiological responses to unfamiliar stimuli at night are merely an indication of normal function and do not need to be considered as adverse effects unless they contribute to significant next-day effects. Recent World Health Organisation guidelines based mainly on laboratory studies suggest indoor limit values of 30 dB L_{Aeq} and 45 dB L_{AFmax} to avoid sleep disturbance, while other studies carried out in-situ, where habituation to the noise in question may have occurred, have found that much higher levels can be tolerated without any noticeable ill-effects.

Noise Annoyance

A.38 Noise annoyance describes the degree of 'unwantedness' of a particular sound in a particular situation. People's subjective response to noise can vary from not being bothered at all, through a state of becoming aware of the noise, right through to the point of becoming annoyed by the noise when it reaches a sufficiently high level. There is no statutory definition of noise annoyance.

A.39 Numerous noise annoyance surveys carried out over the last three decades have attempted to establish engineering relationships between the amount of noise measured objectively using sound level meters and the amount of community annoyance determined from questionnaires. The chief outcome of 'reported annoyance' has been measured using a very large range of different ideas. Both the wording of any questionnaire used and the context in which the question is put, and the manner in which it is therefore interpreted by respondents, can be very important. Some researchers are developing standardised questionnaire formats to encourage greater comparability between different studies, but this does not address the possibility of different contextual effects.

A.40 Notwithstanding these problems, there is a general consensus that average reported annoyance increases with aggregate noise level in long term static situations. However, there has been comparatively little research and consequently no real agreement on the effects of change. Some studies have found that even small changes in noise level can have unexpectedly large consequences on reported annoyance, while others have found the opposite. The most likely explanation for these apparent discrepancies is that underlying or true annoyance depends on many non-acoustic factors in addition to noise level alone, and that the extent to which reported annoyance actually represents underlying annoyance can be highly dependent on context. As a consequence, attempts to find a common relationship across all noise sources and listening situations have generally floundered. This task has been complicated by the great range of individual sensitivities to noise observed in the surveys, often affected as much by attitude as by noise level.

A.41 Whether or not an exposed individual has a personal interest in a given sound often has a significant bearing on their acceptance of it. For example, if recipients gain benefit from an association with the sound producer, or if they accept that the sound is necessary and largely unavoidable, then they are likely to be more tolerant of it. This is often the case even if they don't necessarily consider it desirable.

A good example of this is road traffic noise which is the dominant noise heard by over 90% of the population but results in relatively few complaints.

A.42 Notwithstanding the fact that attitudes may be as important as overall levels in determining the acceptance of a particular noise, there still remains a need to objectively quantify any changes in noise level. Whilst it may not be possible to attribute a particular degree of annoyance to a given noise level, an objective measure of noise that bears some relationship to annoyance is still useful. This objective measure enables an assessment of the effect of changes to be assessed on the basis that any reduction in overall noise level must be beneficial. Possible noise mitigation measures form a central consideration of any noise assessment, so an appropriate methodology must be adopted for assessing the effectiveness of any noise mitigation measures adopted.

A.43 When assessing the potential effects of any new source of noise, it is common practice to compare the A-weighted 'specific' noise level produced by the new source (usually measured using the $L_{Aeq,T}$ index) against the existing A-weighted 'background' noise level measured using the $L_{A90,T}$ index, as this is the typical level of noise that can be reasonably expected to be present the majority of the time to potentially 'mask' the new 'specific' noise. The assessment is therefore undertaken within the context of the existing noise environment. In some circumstances, it may prove equally instructive to compare the absolute level of a new specific noise against accepted absolute levels defined in standards or other relevant documents. The assessment is therefore undertaken against benchmark values, rather than against the context of the existing noise environment. Whatever approach is actually adopted for final assessment purposes, and often a combination of the two approaches is appropriate, it is important that the relevance of both contextual and benchmark assessments is at least considered in all cases.

A.44 Table 4.1 of the WHO Guidelines presents guideline benchmark values for environmental noise levels in specific environments. The noise levels relevant to residential dwellings are listed here in Table A1.

Table A1 Relevant Extracts from Table 4.1 'Guideline Values for Community Noise in Specific Environments'

Specific Environment	Critical Health Effects	$L_{Aeq,T}$	Time base (hrs)	L_{Amax} (dB)
Outdoor living area	Serious annoyance, day time and evening	55	16	-
	Moderate annoyance, day time and evening	50	16	-
Dwelling, indoors	Speech intelligibility and moderate annoyance, day time and evening	35	16	-
	Sleep disturbance, night time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoors)	45	8	60
School class rooms (included for potential effects on concentration)	Speech intelligibility, disturbance of information extraction, message communication	35	-	-

A.45 The text accompanying the Table in the WHO Guidelines explains that the levels given in the Table are set at the lowest levels at which the onset of any adverse health due to exposure to noise has been identified. The text continues:

'These are essentially values for the onset of health effects from noise exposure. It would have been preferred to establish guidelines for exposure-response relationships. Such relationships would indicate the effects to be expected if standards were set above the WHO guideline values and would facilitate the setting of standards for sound pressure levels (noise immission standards)'.

A.46 More recently, Environmental Noise Guidelines for the European Region (2018) were published and include general recommendations for wind turbine noise. However, they are designed to inform policy on noise, at the population and strategic level. They are based on the L_{den} noise indicator, which requires knowledge of the noise levels experienced over the course of a full year. This type of noise index is more suitable for general strategic studies and not appropriate for assessing the acceptability of noise produced by any specific development. Furthermore, these guidelines do not provide recommendations for indoor noise levels and the 2000 WHO Guidelines for Community Noise remain applicable in this regard. For these reasons, the 2018 guidelines will not be referenced any further.

A.47 In addition to consideration of the absolute A-weighted level of a new specific source of noise, other properties of the noise can heighten its potential effects when introduced into an existing background noise environment. Such properties of noise are commonly referred to as 'acoustic features' or the 'acoustic character'. These acoustic features can set apart the new source of noise from naturally occurring sounds. Commonly encountered acoustic features associated with transport and machinery sources, for example, can include whistles, whines, thumps, impulses, regular or irregular modulations, high levels of low frequency sound, rumbling, etc.

A.48 Due to the potential of acoustic features to increase the effects of a noise over and above the effects that would result from an otherwise 'bland' broad band noise of the same A-weighted noise level, it is common practice to add a 'character correction' to the specific noise level before assessing its potential effects. The resulting character corrected specific noise level is often referred to as the 'rated' noise level. Such character corrections usually take the form of adding a number of decibels to the physically measured or calculated noise level of the specific source. Typical character corrections are around +5 dB(A), although the actual correction depends on the subjective significance of the particular feature being accounted for.

A.49 The objective identification and rating of acoustic features can introduce a requirement to analyse sound in greater detail than has thus far been discussed. To this point all discussion has focussed on the use of the overall A-weighted noise level. This single figure value is derived by summing together all the acoustic energy present in the signal across the entire audible spectrum from around 20 Hz to 20,000 Hz, albeit with the lower and higher frequency contributions down-weighted in accordance with the A-weighting filter characteristics to account for the reduced sensitivity of the human ear at these frequencies.

A.50 However, in order to identify the presence of tones (which are concentrations of acoustic energy over relatively small bands of frequency), or in order to identify excessive levels of low frequency noise, it may be necessary to determine the acoustic energy present in the noise signal across much smaller frequency bands. This is where the concept of octave band analysis, fractional (e.g. 1/3, 1/12, 1/24) octave band analysis, or even narrow band Fast Fourier Transform (FFT) analysis is introduced. The latter enables signals to be resolved in frequency bandwidths of down to 1 Hz or even less, thereby enabling tonal content to be more easily identified and measured. As standard, noise emission data for wind turbines is supplied as octave band data, with narrow band tests also being undertaken to establish the presence of any tones in the radiated noise spectrum.

Low Frequency Noise and Vibration – Wind Farms

A.51 One issue that has increasingly been raised concerning potential noise effects of operational wind farms relates not to the overall noise levels, but to the specific issue of low frequency sound. However, confusion sometimes arises from the use of the generalised term 'low frequency sound' to describe specific effects that may, or sometimes may not, actually relate the low frequency character of the sound itself.

A.52 In this respect, there are three distinct characteristics of sound that should be clearly differentiated between:

- Low frequency sound in the range from around 20 Hz to 200 Hz, which therefore lies within the commonly referenced range of human hearing of around 20 Hz to 20,000 Hz;
- Very low frequency sound, or infrasound, below 20 Hz, which therefore lies below the commonly referenced lower frequency limit of human hearing;

– Amplitude modulated sound that characterises the 'swish, swish' sound sometimes heard from rotating wind turbine blades.

A.53 Looking at the first two of the three types of sound referred to in the preceding bullet points, a distinction is usually made between low frequency sound and very low frequency sound, otherwise termed infrasound. This distinction is based on the fact that the frequency range of audible noise is generally taken to be from 20 Hz to 20,000 Hz. Therefore, the range of frequencies from about 20 Hz to 200 Hz is usually taken to cover audible low frequency sound, whereas frequencies below 20 Hz are usually described as infrasound. The implication here is that low frequency sound is audible and infrasound is inaudible. However, this relatively arbitrary distinction between low frequency sound and infrasound can introduce some confusion in that frequencies below 20 Hz can still be heard provided they produce a sound pressure level at the ear of the listener that lies above the threshold of audibility of that listener to sound at that particular frequency.

A.54 The fact that low frequency sound and infrasound from wind farms has only relatively recently been highlighted as a potential problem by some groups does not mean that that the wind energy industry had not previously considered the issue. In fact, the issue of low frequency sound was one of the predominant technical hurdles associated with the some of the earliest larger scale wind turbines installed in the USA. These turbines were of the 'downwind' type, 'downwind' referring here to the fact that the rotor blades were located downwind of the turbine tower rather than upwind of it, as is the case for current machines. It was found that the interruption of wind flow past the tower resulted in a region of lower than average wind speed immediately in the wake of the tower. The passage of the blades into this region of lower wind speed in the wake of the tower, then back into the higher wind speed as they emerged from the wake of the tower back into the main wind stream, resulted in the generation of low frequency sound, often in the subjective form of a distinctive impulse, often referred to as a 'thump' or 'tower thump'. It was for this reason that modern day turbine configurations now have the blades upwind of the tower, as research and measurements demonstrated that low frequency sound radiation is reduced to sub-audible levels once the interaction of downwind tower wake effects with the rotating blades are removed from the design.

A.55 One of the problems inherent in the assessment of both low frequency sound and infrasound is the variability of hearing sensitivity across human subjects with otherwise healthy hearing. This threshold for sound below 200 Hz varies significantly more between different subjects than does the hearing threshold at higher frequencies. However, what is always true is that the perception threshold to lower frequency noise is much higher than the perception threshold for speech frequencies between around 250 Hz to 4,000 Hz. For example, the average person with healthy hearing is some 70 dB less sensitive to sounds at 20 Hz than to sounds that fall within the range of speech frequencies. An additional factor relevant to the perception of infrasound is that, although audibility remains below 20 Hz, tonality is lost below 16 Hz to 18 Hz, thus losing a key element of perception.

A.56 Both low frequency sound and infrasound are generally present all around us in modern life. They may be generated by many natural sources, such as thunder, earthquakes, waves and wind. They may also be produced by machinery including household appliances such as washing machines and air conditioning units, all forms of transport and by turbulence. The presence of low frequency sound and infrasound in our everyday lives is heightened by the fact that the attenuation of sound in air is significantly lower at low frequencies than at the mid to high frequencies. As a result, noise which has travelled over long distances is normally biased towards the low frequencies. However, the fact that human hearing naturally down-weights, or filters out, sounds of such low frequencies means we are generally not aware of its presence. It is only under circumstances when it reaches a sufficiently high level, for example in the 'rumble' of distant thunder or the sound of large waves crashing on a shore, that we become aware of its presence.

A-Weighting

A.57 It is because the human ear increasingly filters out sounds of lower frequencies that environmental noise measurements are undertaken as standard using sound level meters that apply the A-weighting curve, as it filters out lower frequency sounds to the same degree as the hearing of a healthy person with unimpaired hearing. The A-weighted sound level is used as a measure of subjective perception of sound unless there exists such a predominance of low frequency sound or infrasound relative to the level of sound at higher frequencies that the use of the A-weighting curve would down-weight the actual source of the problem to such a degree that the resultant objective noise levels do not truly reflect the potential subjective effects of the noise. It is for this reason that a number of alternative weighting curves have been developed, specifically aimed at better accounting for the assessment of low frequency sound and infrasound.

Alternative frequency weightings

A.58 One such curve is denoted C-weighting. Unlike the A weighting curve, which gradually reduces the significance of frequencies below 1000 Hz until at 10 Hz the attenuation is 70 dB, the C-weighting curve is flat to within 1 dB down to about 50 Hz and then drops by 3 dB at 31.5 Hz and 14 dB at 10 Hz. The C weighting curve was originally developed to reflect the fact that, at higher overall noise levels, low frequencies can have a greater subjective effect than at lower overall noise levels.

A.59 One relatively simple measure of undertaking a first-pass assessment as to whether low frequency sound is likely to be an issue is to determine the difference between the overall C weighted noise level and the overall A weighted noise level. The C weighted level includes contributions from low frequency sound, whereas the A weighted level filters it out. It has been suggested in that a level difference of more than 20 dB indicates that low frequency sound may be subjectively significant, but more detailed investigations are in practice required to determine whether or not this is actually the case.

A.60 Another curve, termed the G weighting curve, has been specifically derived to provide a measure of the audibility of infrasound when considered separately from higher frequency noise. The G weighting curve falls off rapidly above 20 Hz and below 20 Hz it follows assumed hearing contours with a slope of 12 dB per octave down to 2 Hz.

Wind-farm infrasound and vibration

A.61 Over the past few years there has been considerable attention paid to the possibility that operational wind farms may radiate sufficiently high levels of infrasound to cause health problems. It has, however, been the case that dedicated research investigations have shown this not to be the case.

A.62 As early as 1997 a report by Snow [2] gave details of a comprehensive study of infrasound and low frequency sound (up to around 100 Hz) and vibration measurements made in the vicinity of a wind farm. Measurements were made both on the wind farm site, and at distances of up to 1 kilometre. During the experiments a wide range of wind speeds and directions were recorded. 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. A similar comparison with recognised limits for assessing structural damage showed that the measured vibrations were a factor of 100 below the recommended guidelines at 100 m from the turbines.

A.63 Noise and vibration levels were found to comply with recommended residential criteria even on the wind turbine site itself. Although low level infrasonic (i.e. below 20 Hz) periodic noise from the wind farm was detected by instrumentation at distances up to 1 kilometre, the measuring instruments used were much more sensitive than human hearing. Based on his measurements Snow concluded that subjective detection of the wind turbines may be apparent at this distance, but if this is the case it will be due to higher frequency components (which are more readily masked by general ambient environmental noise) and not the low frequency components which lie below the threshold of audibility.

A.64 In 2003, findings on both low frequency sound and infrasound have been compiled into the previously referenced extensive review report commissioned by DEFRA and prepared by Dr G Leventhall [1]. Dr Leventhall notes that despite the numerous published studies there is little or no agreement about the biological effects of infrasound or low frequency sound on human health. Leventhall notes that direct evidence of adverse effects of exposure to low-intensity levels of infrasound (less than 90 dB) is lacking. He goes on to describe the low frequency hearing threshold i.e. the lowest levels which are audible to an average person with normal hearing. He notes the threshold at 4 Hz is about 107 dB, at 10 Hz it is about 97 dB and at 20 Hz it is 79 dB. As such, high levels of infrasound are required to exceed the hearing thresholds at such low frequencies. Leventhall therefore concluded that most people can be reassured that there will be no serious consequences to peoples' health from infrasound exposure.

A.65 Indeed, specifically in relation to wind farms and infrasound, Leventhall went further still with his statement of reassurance. This additional reassurance followed the voicing of concerns by some interested parties that, because infrasound and very low frequency vibrations could be measured from wind farms, then it must follow that these were a potential hazard and source of annoyance. In fact what those concerned observers failed to account for is that highly sensitive electronic measuring equipment designed solely to detect such infrasonic sounds and vibrations is orders of magnitude more sensitive than even the most sensitive human. Thus, whilst such measurement systems may be able to detect such low-level phenomena, the same stimuli can have no effect on humans. In the light of this, Leventhall issued an open statement:

> *'I can state quite categorically that there is no significant infrasound from current designs of wind turbines. To say that there is an infrasound problem is one of the hares which objectors to wind farms like to run. There will not be any effects from infrasound from the turbines'.*

A.66 In 2004/2005 researchers from Keele University investigated the effects of the extremely low levels of vibration resulting from wind farms on the operation of a seismic array installed at Eskdalemuir in Scotland. This is one of the most sensitive ground-borne vibration detection stations in the world. The results of this study have frequently been misinterpreted, as just discussed for the DEFRA/Leventhall report, in that if infrasonic vibrations from wind farms can be measured, then they must consequentially have some potential effect on humans. In order to clarify their position, the authors have subsequently explained that [3]:

> *'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'.*

A.67 They then continue:

> *'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'.*

A.68 In relation to airborne infrasound as opposed to ground-borne vibrations, the researchers are equally robust in their conclusions, stating:

> *'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 low frequency sound. There is no scientific evidence to suggest that infrasound [at such an extremely low level] has an impact on human health'.*

A.69 In 2006, the results of a study specifically commissioned by the UK Department of Trade and industry (DTI) to look at the effects of infrasound and low frequency noise (LFN) arising from the operation of wind farms have been published in what is commonly referred to as the DTI LFN Report [4]. This Report is quite categorical in its findings: infrasound is not the perceived health threat suggested by some observers, nor should it even be considered a potential source of disturbance. Quoting from the Executive Summary to the DTI LFN Report:

> *'Infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range. Even assuming that the most sensitive members of the population have a hearing threshold which is 12 dB lower than the median hearing threshold, measured infrasound levels are well below this criterion.*
>
> *The document "Community Noise" prepared for the World Health Organisation, states that "there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects". Other detection mechanisms of infrasound only occur at levels well above the threshold of audibility.*
>
> *It may therefore be concluded that infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour'.*

A.70 This has been subsequently confirmed by many international studies and reviews. For example, a study for the National Institute for Public Health and the Environment (RIVM) in the Netherlands [5] published in 2020 concluded in this regard that:

> *'Although low frequency sound and infrasound might have other effects than 'normal' sound has, these effects are highly unlikely at sound levels typical for wind turbines. Brain studies show that low frequency and infrasound are processed in the same parts of the brain as 'normal' sound and there is no evidence that infrasound elicits any reaction at sub-audible levels.'*

A.71 In conclusion, whilst is known that infrasound can have an adverse effect on people (potential adverse health impacts are listed by the World Health Organisation as stress, irritation, unease, fatigue, headache, possible nausea and disturbed sleep), these effects can only come into play when the infrasound reaches a sufficiently high level. This is a level above the threshold of audibility. However, all available information from measurements on current wind turbines reveals that the level of infrasound emitted by these wind turbines lies below the threshold of human perception.

Low Frequency Sound

A.72 A report prepared for DEFRA by Casella Stanger [6] lists wind farms as a possible source of audible low frequency sound (20 Hz to 200 Hz). However, this is one possible source in a list of many commonly encountered sources such as pumps, boilers, fans, road, sea and rail traffic, the wind, thunder, the sea, etc. The report only considers the general issues associated with low frequency sound and makes no attempt to quantify the potential problem associated with each of these sources. This is in contrast to other reports which have considered the specific situation associated with wind farms.

A.73 In respect of low frequency sound as opposed to infrasound, the DTI LFN Report identified that wind farm noise levels at the studied properties were, under certain conditions, measured at a level just above the threshold of audibility. The report therefore concluded that *'for a low frequency sensitive person, this may mean that low frequency sound associated with the operation of the three wind farms could be audible within a dwelling'*. This conclusion was, however, placed into some context with the qualifying statement that *'at all measurement sites, low frequency sound associated with traffic movements along local roads has been found to be greater than that from the neighbouring wind farm'*. In particular, it was concluded that, although measurable and under some conditions may be audible, levels of low frequency sound were below permitted night time low frequency sound criteria, including the latest UK criteria resulting from the 2003 DEFRA study into the effects of low frequency sound.

A.74 Based on the findings of the DTI LFN Report, low frequency sound in the greater than 20 Hz frequency range may, under some circumstances, be measured to be of a comparable or higher level than the threshold of audibility. On such occasions this low frequency sound may become audible to low frequency sensitive persons who may already be awake inside nearby properties, but not to the degree that it will cause awakenings. However, such noise should still be assessed for its potential subjective effects in the conventional manner in which environmental noise is generally assessed. In particular, the subjective effects of this audible low frequency sound should not be confused with the claimed adverse health effect arguments concerning infrasound which, in any event, have now been shown from the results of the DTI LFN Report to be wholly unsubstantiated.

A.75 In November 2006, the UK Government released a statement [7] concerning low frequency sound, reiterating the conclusion of the DTI LFN report that:

> *'there is no evidence of health effects arising from infrasound or low frequency sound generated by wind turbines'.*

A.76 The Government statement concluded the position regarding low frequency sound from wind farms with the definitive advice to all English Local Planning Authorities and the Planning Inspectorate that PPS22 and ETSU-R-97 should continue to be followed for the assessment of noise from wind farms.

Blade Swish (Amplitude Modulation)

A.77 The noise assessment methodology presented in ETSU-R-97, sets out noise limits which already account for typically encountered levels of blade swish. Notwithstanding the conclusions and advice presented in the preceding paragraphs concerning both infrasound and low frequency sound, the DTI LFN Report went on to suggest that, where complaints of noise at night had occurred, these had most likely resulted from an increased amplitude modulation of the blade passing noise, making the 'swish, swish, swish' sound (often referred to as 'blade swish') more prominent than normal. Whilst it was therefore acknowledged that this effect of enhanced amplitude modulation of blade aerodynamic noise may occur, it was also concluded that there were a number of factors that should be borne in mind when considering the importance to be placed on the issue when considering present and proposed wind farm installations:

- it appeared that the effect had only been reported as a problem at a very limited number of sites (the DTI report looked at the 3 out of 5 U.K. sites where it has been reported to be an issue out of the 126 onshore wind farms reported to be operational at the time in 2006);
- the effect occurred only under certain conditions at these sites (the DTI LFN Report was significantly delayed while those involved in taking the measurements waited for the situation to occur at each location);
- at one of the sites concerned it had been demonstrated that the effect can be reduced to an acceptable level by the introduction of a Noise Reduction Management System (NRMS) which controls the operation of the necessary turbines under the relevant wind conditions (this NRMS had to be switched off in order to gain the data necessary to inform the DTI LFN Report);
- whilst still under review, it appeared that the most likely cause of the increased amplitude modulation was related to an increase in the stability of the atmosphere during evening and night time periods, hence the increased occurrence of such an effect at these times, but this effect had been shown by measurement of wind speed profiles to be extremely site specific;
- internal noise levels were below all accepted night time criteria limits and insufficient to wake residents, it was only when woken by other sources of a higher level (such as local road traffic) that there were self-reported difficulties in returning to sleep.

A.78 The Government then commissioned an independent research project to further investigate the prevalence of the impact of enhanced levels of amplitude modulation across UK wind farms. This research work was awarded to the University of Salford who reported on their findings in July 2007 [8].

The Salford study concluded that that the occurrence of increased levels of 'blade swish' was infrequent, but suggested it would be useful to undertake further work to understand and assess this feature of wind turbine noise.

A.79 As a consequence of the findings of the report by the University of Salford, the UK Department for Business, Enterprise and Regulatory Reform (BERR formerly the DTI) issued a statement in August 2007 [9] which concluded:

> *'A comprehensive study by Salford University has concluded that the noise phenomenon known as aerodynamic modulation (AM) is not an issue for the UK's wind farm fleet.*
>
> *AM indicates aerodynamic noise from wind turbines that is greater than the normal degree of regular fluctuation of blade swoosh. It is sometimes described as sounding like a distant train or distant piling operation.*
>
> *The Government commissioned work assessed 133 operational wind projects across Britain and found that although the occurrence of AM cannot be fully predicted, the incidence of it from operational turbines is low'.*

A.80 The statement then concludes with the advice:

> *'Government continues to support the approach set out in Planning Policy Statement (PPS) 22 – Renewable Energy. This approach is for local planning authorities to "ensure that renewable energy developments have been located and designed in such a way to minimise increases in ambient noise levels", through the use of the 1997 report by ETSU to assess and rate noise from wind energy development'.*

A.81 This represents an aspect of wind turbine noise which has become the subject of considerable research in the UK and abroad in the past years and the state of knowledge on the subject is rapidly evolving. An extensive research programme entitled 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' was published in 2013. This research, commissioned by RenewableUK (ReUK), was specifically aimed at identifying and explaining some of the key features of wind turbine AM noise.

A.82 Claims have emerged from different researchers that wind turbines were capable of generating noise with characteristics outwith that expected of them. This characteristic was an enhanced level of modulated aerodynamic noise that resulted in the blade swish becoming more impulsive in character, such that those exposed to it would describe it more as a 'whoomp' or 'thump' than a 'swish'. It could also become audible at distances from the wind turbines that were considerably greater than the distances at which blade swish could ordinarily be perceived. It has since emerged that this may be similar to the character of the noise identified in the DTI LFN study. Hence for the purposes of the ReUK project, any such AM phenomena with characteristics falling outside those expected of this "normal" AM (NAM) were therefore termed 'Other AM' (OAM).

A.83 The research identified the most likely cause of OAM noise is transient stall on the wind turbine blade (i.e. stall which occurs over a small area of each turbine blade in one part of the blade's rotation only). The occurrence of transient stall will be dependent on a combination of factors, including the air inflow conditions onto the individual blades, how these inflow conditions may vary across the rotor disc, the design of the wind turbine blades and the manner in which the wind turbine is operated. Variable inflow conditions may arise, for example, from any combination of wind shear, wind veer, yaw errors, turbine wake effects, topographic effects, large scale turbulence, etc. However, the occurrence of OAM on any particular site cannot be predicted at this stage.

A.84 As a consequence of the combined results of the ReUK research, and most notably the development of objective techniques for identifying and quantifying AM noise and the ability to relate such an objective measure to the subjective response to AM noise, ReUK has proposed an AM test [11] for implementation as a planning condition, although this was subject to discussion.

A.85 The Institute of Acoustics (IOA) published in 2016 a standardised methodology [12] for the assessment and rating of AM magnitude. The method provides a decibel level each 10 minute which represents the magnitude of the modulation in the noise, and minimises the influence of sources not related to wind turbines. The proposed method, unlike other methods that have previously been proposed, utilises as the core of its detection capability the fact that AM noise from wind turbines, by definition, exhibits periodicity at a rate that is directly related to the rotational speed of the source wind turbine. The IOA document does not, however, provide any thresholds or criteria methodology for using the resulting AM values.

A.86 The UK Government (DECC or Department of Energy and Climate Change, now obsolete) commissioned a review focused on the subjective response to AM with a view to recommend how this feature may be controlled. The outcome of this research has been published [13] in October 2016 by the Department for Business, Energy & Industrial Strategy (DBEIS). This report recommends the use of a "character penalty" approach, in which a correction is applied to the overall A-weighted noise level to account for AM in the noise in a manner similar to that used to assess tonality in the noise according to ETSU-R-97. This penalty is based on the above IOA methodology for detecting AM. The researchers make a number of recommendations for local authorities to consider and qualifications for the use of such controls, and note that the current state of knowledge on the subject and the implications of their proposed control is limited and that a period of testing and review over the next few years would be beneficial. However, the authors were unable to provide clarity on how exactly the recommendations would operate in practice for any particular wind farm. On publication of the report, DBEIS encouraged local authorities in England to consider the research but provided limited guidance on how the outcomes were to be accounted for within the planning system. The Scottish Government is currently reviewing this report in the context of the Scottish planning system.

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Glossary of Acoustics Terminology

Terminology	Description
A-weighting	a filter that down-weights low frequency and high frequency sound to better represent the frequency response of the human ear when assessing the likely effects of noise on humans
acoustic character	one or more distinctive features of a sound (e.g. tones, whines, whistles, impulses) that set it apart from the background noise against which it is being judged, possibly leading to a greater subjective effect than the level of the sound alone might suggest
acoustic screening	the presence of a solid barrier (natural landform or manmade) between a source of sound and a receiver that interrupts the direct line of sight between the two, thus reducing the sound level at the receiver compared to that in the absence of the barrier
ambient noise	All-encompassing noise associated with a given environment, usually a composite of sounds from many sources both far and near, often with no particular sound being dominant
annoyance	a feeling of displeasure in this case evoked by noise
attenuation	the reduction in level of a sound between the source and a receiver due to any combination of effects, including: distance, atmospheric absorption, acoustic screening, the presence of a building façade, etc.
audio frequency	any frequency of a sound wave that lies within the frequency limits of audibility of a healthy human ear, generally accepted as being from 20 Hz to 20,000 Hz
background noise	the noise level rarely fallen below in any given location over any given time period, often classed according to day time, evening or night time periods (for the majority of the population of the UK the lower limiting noise level is usually controlled by noise emanating from distant road, rail or air traffic)
dB	abbreviation for 'decibel'
dB(A)	abbreviation for the decibel level of a sound that has been A-weighted
decibel	the unit normally employed to measure the magnitude of sound
directivity	the property of a sound source that causes more sound to be radiated in one direction than another
equivalent continuous sound pressure level	the steady sound level which has the same energy as a time varying sound signal when averaged over the same time interval, T, denoted by $L_{Aeq,T}$
external noise level	the noise level, in decibels, measured outside a building
filter	a device for separating components of an acoustic signal on the basis of their frequencies
frequency	the number of acoustic pressure fluctuations per second occurring about the atmospheric mean pressure (also known as the 'pitch' of a sound)
frequency analysis	the analysis of a sound into its frequency components
ground effects	the modification of sound at a receiver location due to the interaction of the sound wave with the ground along its propagation path from source to receiver

Terminology	Description
hertz	the unit normally employed to measure the frequency of a sound, equal to cycles per second of acoustic pressure fluctuations about the atmospheric mean pressure
impulsive sound	a sound having all its energy concentrated in a very short time period
instantaneous sound pressure	at a given point in space and at a given instant in time, the difference between the instantaneous pressure and the mean atmospheric pressure
internal noise level	the noise level, in decibels, measured inside a building
L_{Aeq}	the abbreviation of the A-weighted equivalent continuous sound pressure level
L_{A10}	the abbreviation of the 10 percentile noise indicator, often used for the measurement of road traffic noise
L_{A90}	the abbreviation of the 90 percentile noise indicator, often used for the measurement of background noise
level	the general term used to describe a sound once it has been converted into decibels
loudness	the attribute of human auditory response in which sound may be ordered on a subjective scale that typically extends from barely audible to painfully loud
noise	physically: a regular and ordered oscillation of air molecules that travels away from the source of vibration and creates fluctuating positive and negative acoustic pressure above and below atmospheric pressure. Subjectively: sound that evokes a feeling of displeasure in the environment in which it is heard, and is therefore unwelcomed by the receiver
noise emission	the noise emitted by a source of sound
noise immission	the noise to which a receiver is exposed
noise nuisance	an unlawful interference with a person's use or enjoyment of land, or of some right over, or in connection with it
octave band frequency analysis	a frequency analysis using a filter that is an octave wide (the upper limit of the filter's frequency band is exactly twice that of its lower frequency limit)
percentile exceeded sound level	the noise level exceeded for n% of the time over a given time period, T, denoted by $L_{An,T}$
receiver	a person or property exposed to the noise being considered
residual noise	the ambient noise that remains in the absence of the specific noise whose effects are being assessed
sound	physically: a regular and ordered oscillation of air molecules that travels away from the source of vibration and creates fluctuating positive and negative acoustic pressure above and below atmospheric pressure subjectively: the sensation of hearing excited by the acoustic oscillations described above (see also 'noise')
sound level meter	an instrument for measuring sound pressure level

Terminology	Description
sound pressure amplitude	the root mean square of the amplitude of the acoustic pressure fluctuations in a sound wave around the atmospheric mean pressure, usually measured in Pascals (Pa)
sound pressure level	a measure of the sound pressure at a point, in decibels
sound power level	the total sound power radiated by a source, in decibels
spectrum	a description of the amplitude of a sound as a function of frequency
Standardised wind speed	Values of wind speed at hub height corrected to a standardised height of 10 m using the same procedure as used in wind turbine emission testing
threshold of hearing	the lowest amplitude sound capable of evoking the sensation of hearing in the average healthy human ear (0.00002 Pa)
tone	the concentration of acoustic energy into a very narrow frequency range

Annex B – Location Maps and Turbine Coordinates

Figure B1 - Map showing the Proposed Development turbine layout (dark red circles, prefixed 'K') and the other wind farms which have been considered in this assessment: Dersalloch Windfarm (blue circles, prefixed 'D'), Carrick Windfarm (orange circles, prefixed 'CR'), Craiginmoddie Wind Farm (purple circles, prefixed 'CM') and Hadyard Hill Wind Farm (green circles, prefixed 'HH'). Also shown are the nearby noise assessment locations at which baseline noise surveys were completed (green squares within green circles) as well as additional noise sensitive receptor locations considered in the assessment (orange square within red circles).

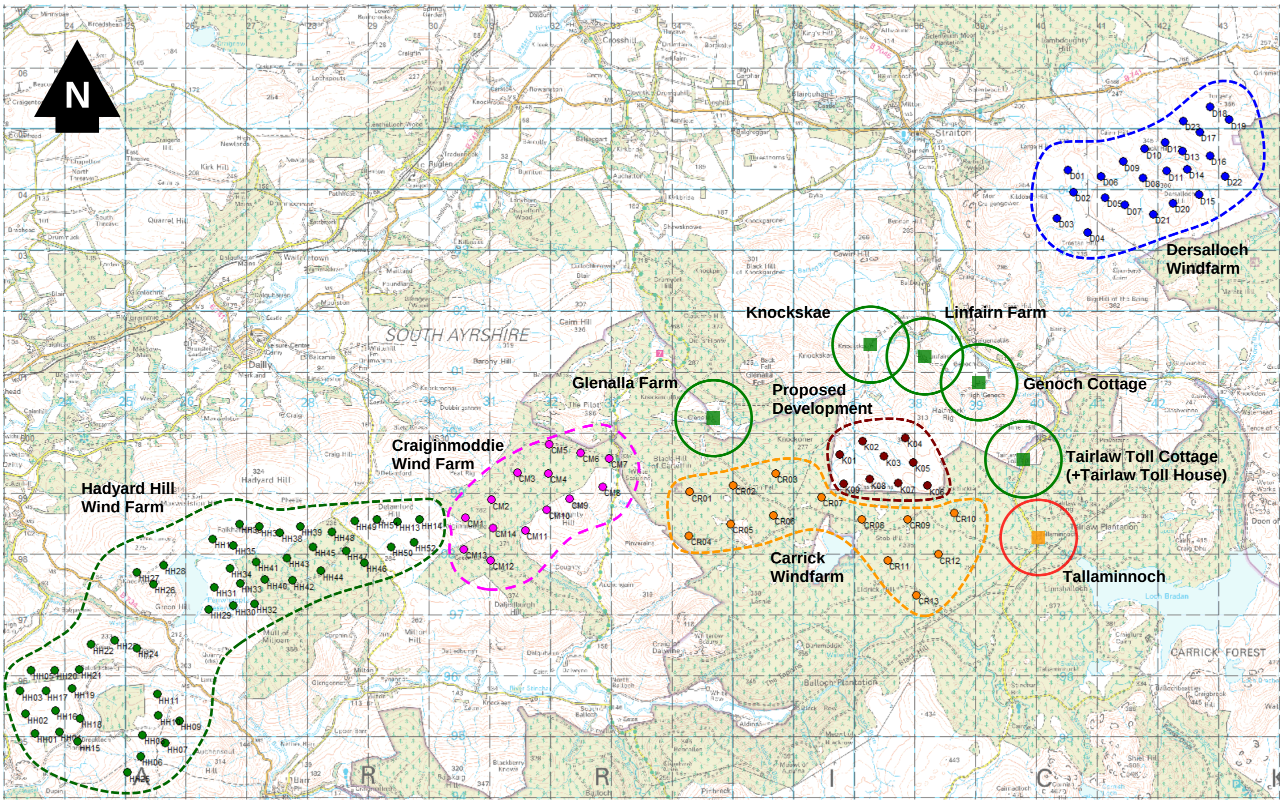
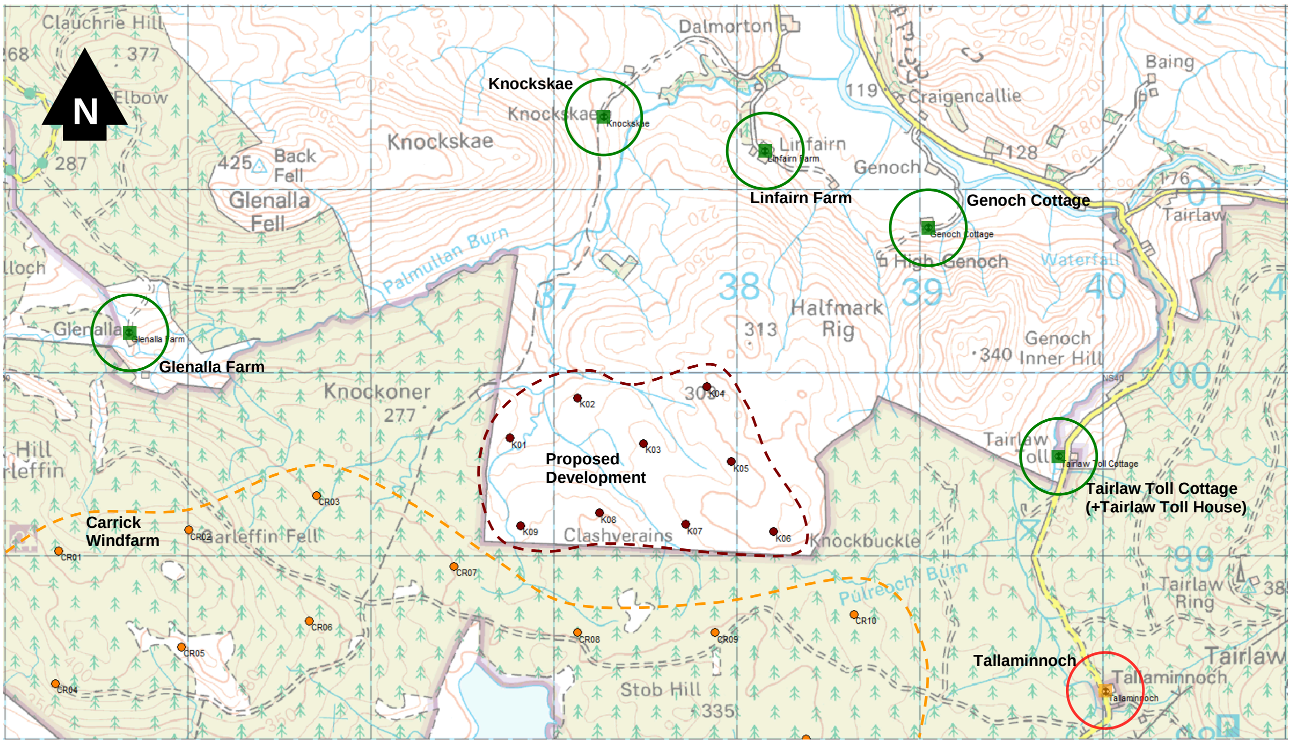


Figure B2 - Map showing a more detailed layout of the turbines on the Proposed Development (dark red circles, prefixed 'K') and the immediately adjacent Carrick Windfarm (orange circles, prefixed 'CR'). Also shown are the nearby noise assessment locations at which baseline noise surveys were completed (green squares within green circles) as well as additional noise sensitive receptor locations considered in the assessment (orange square within red circles).



Turbine & Propagation Details: the Proposed Development

Table B1 – Turbine coordinates – the Proposed Development

Turbine	Easting	Northing	Hub Height (m)	Turbine	Easting	Northing	Hub Height (m)
K01	236759	599643	125	K06	238202	599132	105
K02	237131	599863	125	K07	237720	599172	125
K03	237491	599614	125	K08	237249	599234	125
K04	237838	599922	105	K09	236820	599164	125
K05	237972	599514	105				
All turbines modelled operating in Mode PO6000 (6 MW) for the Vestas V150-6.0 MW with serrated trailing edge blades and sound power level data for a hub height of 125 metres. The hub heights given above are for noise propagation modelling purposes, calculated from the tip heights defined for the Proposed Development and accounting for the rotor diameter of the V150 wind turbine, used for noise prediction modelling only.							

Table B2-Propagation attenuation effects due to terrain (dB) – the Proposed Development – Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
K01	2	0	0	0	0	0
K02	2	0	0	0	0	0
K03	0	0	0	0	0	0
K04	0	0	0	0	0	-3
K05	2	0	2	0	0	0
K06	2	0	2	0	0	0
K07	2	0	2	0	0	0
K08	2	0	2	0	0	0
K09	2	0	2	0	0	0

Turbine & Propagation Details: Dersalloch

Table B3 – Turbine coordinates – Dersalloch Windfarm

Turbine	Easting	Northing	Turbine	Easting	Northing
D01	240518	604322	D13	242401	604639
D02	240606	603965	D14	242485	604335
D03	240334	603535	D15	242669	603918
D04	240848	603298	D16	242852	604557
D05	241130	603870	D17	242685	604953
D06	241068	604225	D18	242858	605357
D07	241456	603746	D19	243174	605150
D08	241758	604194	D20	242248	603779
D09	241424	604463	D21	241921	603597
D10	241782	604671	D22	243105	604221
D11	242145	604308	D23	242421	605129
D12	242120	604775			
All turbines modelled using a hub height of 80 m. The consent permits 16 turbines with a tip-height up to 125 m and 7 up to 115 m, which with a rotor diameter of 101 m (see next section) would give hub heights of 74.5 m and 64.5 m respectively. Use of an 80 m hub height is therefore slightly precautionary for propagation modelling.					

Table B4-Propagation attenuation effects due to terrain (dB) – Dersalloch Windfarm. Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
D01	2	-3	0	2	2	2
D02	2	-3	2	-3	2	2
D03	2	-3	2	2	2	2
D04	2	-3	2	-3	2	2
D05	2	-3	2	-3	2	2
D06	2	-3	2	-3	2	2
D07	2	-3	2	-3	2	2
D08	2	-3	2	-3	2	2
D09	2	-3	2	-3	2	2
D10	2	-3	2	-3	2	2
D11	2	0	2	-3	2	2
D12	2	-3	2	-3	2	2
D13	2	0	2	2	2	2
D14	2	0	2	2	2	2

Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
D15	2	2	2	0	2	2
D16	2	0	2	0	2	2
D17	2	0	2	2	2	2
D18	2	0	2	2	2	2
D19	2	0	2	0	2	2
D20	2	-3	2	-3	2	2
D21	2	0	2	-3	2	2
D22	2	2	2	0	2	2
D23	2	0	2	-3	2	2

Turbine & Propagation Details: Carrick Windfarm

Table B5 – Turbine coordinates – Carrick Windfarm

Turbine	Easting	Northing	Turbine	Easting	Northing
CR01	234298	599032	CR08	237132	598584
CR02	235006	599144	CR09	237885	598581
CR03	235701	599334	CR10	238642	598676
CR04	234272	598308	CR11	237546	597897
CR05	234967	598502	CR12	238380	598000
CR06	235666	598647	CR13	238032	597331
CR07	236449	598947			
All turbines modelled assuming a hub height of 122.5 m, with the coordinates provided by SPR 2021-08-31, rounded to one metre resolution.					

Table B6-Propagation attenuation effects due to terrain (dB) – Carrick Windfarm. Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
CR01	2	2	0	0	0	0
CR02	2	2	0	0	-3	0
CR03	2	2	0	0	0	0
CR04	2	2	2	0	0	0

Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
CR05	2	2	2	0	0	0
CR06	2	0	2	0	0	0
CR07	2	0	2	0	0	0
CR08	2	0	2	0	0	0
CR09	2	0	2	0	0	0
CR10	2	0	2	0	0	0
CR11	2	0	2	0	0	0
CR12	2	0	2	0	0	0
CR13	2	0	2	0	0	0

Turbine & Propagation Details: Craiginmoddie Wind Farm

Table B7 – Turbine coordinates – Craiginmoddie Wind Farm

Turbine	Easting	Northing	Turbine	Easting	Northing
CM1	230600	598605	CM8	232854	599111
CM2	231021	598899	CM9	232319	598909
CM3	231450	599350	CM10	231935	598735
CM4	231960	599330	CM11	231580	598394
CM5	231980	599815	CM12	231017	597903
CM6	232495	599675	CM13	230574	598083
CM7	232964	599581	CM14	231050	598435
All turbines modelled using a hub height of 122.5 m.					

Table B8-Propagation attenuation effects due to terrain (dB) – Craiginmoddie Wind Farm. Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
CM1	2	2	2	2	0	2
CM2	2	2	2	2	0	2
CM3	2	2	2	2	2	0
CM4	2	2	2	2	0	0
CM5	2	2	2	2	0	0
CM6	2	2	2	2	0	0

Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
CM7	2	2	2	2	0	0
CM8	2	2	2	2	0	0
CM9	2	2	2	2	0	0
CM10	2	2	2	2	0	2
CM11	2	2	2	2	2	2
CM12	2	2	2	2	0	2
CM13	2	2	2	2	0	2
CM14	2	2	2	2	0	2

Turbine & Propagation Details: Hadyard Hill Wind Farm

Table B9 – Turbine coordinates – Hadyard Hill Wind Farm

Turbine	Easting	Northing	Turbine	Easting	Northing	Turbine	Easting	Northing
HH01	223515	595059	HH19	224128	595790	HH37	227205	598457
HH02	223359	595374	HH20	223841	596094	HH38	227548	598361
HH03	223263	595751	HH21	224244	596106	HH39	227877	598460
HH04	223909	595078	HH22	224435	596519	HH40	227297	597583
HH05	223450	596094	HH23	224825	596591	HH41	227156	597878
HH06	225247	594675	HH24	225182	596463	HH42	227746	597570
HH07	225658	594891	HH25	225037	594410	HH43	227657	597946
HH08	225281	595031	HH26	225455	597511	HH44	228220	597729
HH09	225887	595264	HH27	225194	597710	HH45	228086	598122
HH10	225538	595348	HH28	225627	597827	HH46	228932	597867
HH11	225522	595697	HH29	226372	597100	HH47	228628	598059
HH12	226437	598255	HH30	226779	597157	HH48	228399	598369
HH13	229480	598543	HH31	226463	597463	HH49	228773	598557
HH14	229846	598573	HH32	227130	597185	HH50	229372	598125
HH15	224215	594918	HH33	226889	597529	HH51	229135	598580
HH16	223845	595436	HH34	226720	597770	HH52	229746	598201
HH17	223690	595749	HH35	226778	598150			
HH18	224249	595306	HH36	226882	598505			
All turbines modelled assuming a hub height of 60 m.								

Table B10-Propagation attenuation effects due to terrain (dB) – Hadyard Hill Wind Farm. Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Noise Sensitive Receptor						Turbine	Noise Sensitive Receptor					
	Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm		Genoch Cottage	Knockskae	Linfairn Farm	Tairlaw Toll Cottage	Tallaminnoch	Glenalla Farm
HH01	2	2	2	2	2	2	HH27	2	2	2	2	2	2
HH02	2	2	2	2	2	2	HH28	2	2	2	2	2	2
HH03	2	2	2	2	2	2	HH29	2	2	2	2	2	2
HH04	2	2	2	2	2	2	HH30	2	2	2	2	2	2
HH05	2	2	2	2	2	2	HH31	2	2	2	2	2	2
HH06	2	2	2	2	2	2	HH32	2	2	2	2	2	2
HH07	2	2	2	2	2	2	HH33	2	2	2	2	2	2
HH08	2	2	2	2	2	2	HH34	2	2	2	2	2	2
HH09	2	2	2	2	2	2	HH35	2	2	2	2	2	2
HH10	2	2	2	2	2	2	HH36	2	2	2	2	2	2
HH11	2	2	2	2	2	2	HH37	2	2	2	2	2	2
HH12	2	2	2	2	2	2	HH38	2	2	2	2	2	2
HH13	2	2	2	2	2	2	HH39	2	2	2	2	2	2
HH14	2	2	2	2	2	2	HH40	2	2	2	2	2	2
HH15	2	2	2	2	2	2	HH41	2	2	2	2	2	2
HH16	2	2	2	2	2	2	HH42	2	2	2	2	2	2
HH17	2	2	2	2	2	2	HH43	2	2	2	2	2	2
HH18	2	2	2	2	2	2	HH44	2	2	2	2	2	2
HH19	2	2	2	2	2	2	HH45	2	2	2	2	2	2
HH20	2	2	2	2	2	2	HH46	2	2	2	2	2	2
HH21	2	2	2	2	2	2	HH47	2	2	2	2	2	2
HH22	2	2	2	2	2	2	HH48	2	2	2	2	2	2
HH23	2	2	2	2	2	2	HH49	2	2	2	2	2	2
HH24	2	2	2	2	2	2	HH50	2	2	2	2	2	2
HH25	2	2	2	2	2	2	HH51	2	2	2	2	2	2
HH26	2	2	2	2	2	2	HH52	2	2	2	2	2	2

Carrick Windfarm - Baseline

B.1 Baseline surveys were undertaken for Carrick Windfarm, with the charts of data plotted against wind speed provided to ourselves[7]. The equations of the best-fit lines fitted to the presented data were used to derive values at whole wind speed shown below in Table B11 and B12 for the three locations common to both surveys. These survey data were related to wind speeds measured on a metrological mast at Carrick Garleffin (235158, 598511). This mast location is approximately 3.3 kilometres south west of, and at a ground elevation approximately 100 metres higher than, the wind sensor position used for the noise survey for the Proposed Development. Wind speeds at 50.4 m and 81 m were used to calculate wind speeds at a height of 125 m following guidance on good practice (IOA GPG).

B.2 The survey location Tairlaw Toll House has been used to represent the receptor location of Tairlaw Toll Cottage, which is marginally closer to the Proposed Development (see main text).

Table B11 - Table of background noise levels at integer standardised ten metre wind speeds for each of the survey locations during quiet day-time periods for those Carrick Windfarm survey locations which are common with those surveyed for the Proposed Development.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla (CR)	25.9	26.6	27.4	28.2	29.0	29.9	31.0	32.2	33.7	35.4	37.3	39.6
Genoch Cottage (CR)	28.1	28.4	28.8	29.4	30.2	31.1	32.2	33.4	34.8	36.2	37.8	39.5
Tairlaw Toll House (CR)	33.8	33.7	33.9	34.2	34.7	35.3	36.2	37.2	38.3	39.6	41.0	42.5

Table B12 - Table of background noise levels at integer standardised ten metre wind speeds for each of the survey locations during quiet night-time periods for those Carrick Windfarm survey locations which are common with those surveyed for the Proposed Development.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla (CR)	27.8	27.4	27.5	28.0	28.9	30.1	31.5	33.1	34.8	36.5	38.2	39.8
Genoch Cottage (CR)	25.9	25.7	26.1	26.8	28.0	29.4	31.0	32.7	34.4	36.1	37.6	38.9
Tairlaw Toll House (CR)	32.8	33.4	34.0	34.5	35.0	35.5	36.0	36.6	37.3	38.2	39.3	40.6

7 Data Release Memo from Jim Poulson at WSP to Mark Jiggins at Hoare Lea, dated 25 August 2021. Indicated to be confidential but ScottishPower Renewables confirmed by e-mail 31st August 2021 that data presented in this memo could be referenced, as these data would subsequently be published in the Carrick Windfarm EIAR.

Annex C – Wind Turbine Source Emissions

C.1 For the Proposed Development a candidate wind turbine has been chosen which is typical of the type and size which would be installed, with relevant noise emission data shown below in Tables C1 and C2. Data provided by Vestas shows that there are different variants of the EnVentus turbine 'platform' with slightly differing power outputs from approximately 4.2 MW to 6.6 MW, all of which are offered with serrated trailing edge blades as standard and have the same overall sound power levels.

C.2 For assessment of the cumulative effects of the Proposed Development when operating with other wind farms nearby, source information is considered below. For operational wind farms, noise predictions were based on the actual installed turbine model. For sites which are proposed but not consented, the candidate turbine considered in the planning application was assumed. For each wind farm considered, details are provided below of the source of data used in the noise modelling.

Proposed Development

Table C1 - Wind turbine sound power levels (dB L_{Aeq}) used in the noise assessment - the Proposed Development

Turbine make / model	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Vestas V150-6.0 MW Mode PO6000	-	-	95.0	98.6	103.0	106.3	106.8	106.9	106.9	106.9	106.9	106.9
Derived from: 'General Description' Document no.: 0081-5017 V04 2020-09-09 and 'Performance Specification Vestas EnVentus™ V150-6.0 MW 50/60 Hz', Document no.: 0098-0749 V01 2020-10-13. Data for the turbine operating in 'Mode PO6000 (Blades with serrated trailing edge)'. Values here are converted from those specified at hub height for standardised ten metre wind speeds at a 125 m hub height. A further 2 dB was added to the values from the specification to account for uncertainties and provide the values shown above.												

Table C2 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v_{10} = 8 m/s) - the Proposed Development

Turbine make / model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	A
Vestas V150-6.0MW Mode PO6000	81.1	88.7	93.4	95.1	94.0	89.9	82.9	72.9	100.0
Derived from: 'Third octave noise emission EnVentus™ V150-6.0MW', Document no: 0095-3747_01, 2020-11-03. Values are for the V150 in Mode PO6000 converted to octave bands from one-third octave bands provided in the document at a hub height wind speed of 12 m/s, which is close to a standardised ten metre wind speed of 8 m/s. Octave band values were normalised to an overall sound power level of 100 dB(A).									

Dersalloch Windfarm

C.3 Operational noise limits for Dersalloch Windfarm are defined in the Dersalloch Consent[8] and are based upon background noise levels presented in the 2012 Addendum[9]. Condition 33 of the Dersalloch Consent is included in Figure C1. The three baseline measurement positions were Baing (240253, 601611), Gass (241193, 605601) and Grimmet (244672, 606340).

Figure C1 – Extract of the consent for Dersalloch Windfarm showing Condition 33 related to operational noise.

33. At wind speeds not exceeding 12 metres per second as measured and calculated at a height of 10 metres above ground level using the methods described in "Prediction and Assessment of Wind Turbine Noise" (published in IOA Bulletin March/April 2009), the noise emission levels of the wind farm measured at any dwelling existing at the date of this permission shall comply with the following:

(a) During night-time hours, as defined in ETSU-R-97 as 23.00 to 07.00 on all days, the Windfarm noise emission level shall not exceed 43dB LA90, 10 min or the ETSU-R-97 derived "night hours" noise limit based on the measured LA90, 10 min Background Noise Level plus 5dB(A), whichever is the greater.
(b) At all other times, the Windfarm noise emission level shall not exceed 37.5dB LA90, 10 min or the ETSU-R-97 derived "quiet waking hours" noise limit based on the measured LA90, 10 min Background Noise Level plus 5dB(A), whichever is the greater.
(c) The above noise emission limits may be increased to 45 dB LA90, 10 min or the relevant ETSU-R-97 derived "quiet waking hours" or "night hours" noise limit based on the measured LA90, 10 min noise level plus 5dB(A), whichever is the greater, when measured at any dwelling owned by persons with a financial involvement in the windfarm.
(d) Background Noise Levels referred to in this condition shall be those recorded by the regression lines in Appendix D3 forming part of the Dersalloch Windfarm 2012 Addendum produced by ScottishPower Renewables in February 2012.

C.4 Dersalloch Windfarm is built and operating and is understood to have been constructed using 23 Siemens D3 direct drive 3 MW turbines[10]. For the purposes of this assessment, Dersalloch Windfarm has been modelled assuming data for a Siemens SWT-3.0-101 DD wind turbine, with data provided by Siemens for a hub height of 89.5 m for the 'standard setting' i.e. without using any noise reduced modes of operation. Data provided by Siemens are stated to be 'warranted sound power levels' and therefore include an appropriate margin for uncertainties as required by good practice.

C.5 Review of the noise limits derived from the three baseline background noise survey locations for the Dersalloch Windfarm, indicates that large margins exist[11] between predicted noise immission levels at the three locations and the noise limits, with predictions based on the turbine actually installed, as discussed above.

C.6 In order to provide reasonably precautionary contributions in the cumulative assessment, an additional 2 dB margin has been added to the warranted values provided by Siemens to yield the values shown in Table C3. Also shown in Table C4 is the octave band frequency spectrum for the Siemens SWT-3.0-101 DD turbine. The overall sound power levels assumed on this basis are therefore considered to include an appropriate margin when assessing cumulative operational noise, as required by good practice guidance.

8 Consent under S36 of the Electricity Act 1989 and Deemed planning permission under S57(2) of the Town and Country Planning (Scotland) Act 1997 by Scottish Ministers for Construction and Operation of the Dersalloch Wind Farm, Located about 4km east of Straiton, in the council area of South Ayrshire. Head of Energy Consents and Deployments, for and on behalf of the Scottish Ministers, Energy and Climate Change Directorate, Energy Division, Scottish Government, 23 July 2014.

9 Dersalloch Windfarm Environmental Statement 2012 Addendum, ScottishPower Renewables, February 2012. Chapter 9.0 Noise: Regression Figure 1 to Regression Figure 8.

10 ReNews (https://renews.biz/39726/spr-delivers-dersalloch/) retrieved 2021-07-20 and ScottishPower Renewables (https://www.scottishpowerrenewables.com/pages/dersalloch_windfarm.aspx) retrieved 2021-07-20.

11 The margin is smallest at Gass, with a margin of at least 6.8 dB day-time and 5.8 dB night-time (both at 7 m/s wind speed). With the additional 2 dB added to sound power levels for precautionary source emission levels used in the cumulative assessment, these margins would also reduce by 2 dB.

Table C3 - Wind turbine sound power levels (dB L_{Aeq}) used in the noise assessment – Dersalloch Windfarm.

Turbine make / model	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Siemens SWT-3.0-101 DD	-	-	-	97.4	102.2	107.3	109.2	110.0	110.0	110.0	110.0	110.0
Derived from: 'Siemens SWT-3.0-101 DD, Hub Height 89.5 m Acoustic Emission', Document ID: E R WP SP EN-10-0000-0034-00, PE, BSN / 2010.03.04 for 'Standard Setting' and stated to be 'warranted sound power levels'.												

Table C4 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v_{10} = 8 m/s) – Dersalloch Windfarm.

Turbine make / model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	A
Siemens SWT-3.0-101 DD	74.8	86.7	93.4	96.7	93.4	85.5	74.6	71.3	100.0
Derived from: 'Siemens SWT-3.0-101 DD, Hub Height 89.5 m Acoustic Emission', Document ID: E R WP SP EN-10-0000-0034-00, PE, BSN / 2010.03.04. 'Typical, not warranted octave band spectrum' for a 8 m/s wind speed 'referenced to 10 m height' and normalised to 100 dB(A).									

Hadyard Hill Wind Farm

C.7 Hadyard Hill Wind Farm is built and has been operating for several years. We understand that the turbines are likely to be Bonus (Siemens) 2.3 MW with a rotor diameter of 80 metres. Sound power levels for Hadyard Hill were provided in the noise assessment for the proposed and withdrawn Hadyard Hill Extension[12]. The consent conditions for noise are included in Figure C2.

Figure C2 – Extract of the consent for Hadyard Hill Wind Farm showing the conditions related to operational noise.

7.11 At properties occupied by persons with a financial interest in the development, day and night time noise levels must not exceed an L_{A90} (10 minutes) of 45 decibels. At wind speeds above 5.5 metres per second the L_{A90} should not exceed I_{eq} (10 minutes) by more than 5 decibels.

Reason: to ensure operational noise levels do not affect the amenity of those living in the vicinity of the windfarm.

7.12 At residential properties with no such financial interest, for wind speeds of up to 5.5 metres per second the L_{A90}, (10 minutes) should not exceed 38dB (day time) and 43dB (night time) when measured at the external façade of the nearest residential properties.

C.8 Previous work undertaken by Hoare Lea for Assel Valley Wind Farm[13] included a detailed consideration of potential noise levels from operation of Hadyard Hill, based on measurements at two nearby receptor locations. Comparison of predicted noise levels at these two Assel Valley receptors[14] with predicted noise levels (using the TNEI sourced noise emission data) shows predicted noise levels are higher than those assumed and derived from the Hoare Lea measurements (see Table C5).

12 Hadyard Hill Extension Wind Farm Environmental Statement Technical Appendix 6: Noise, April 2015, TNEI. Values taken from table headed 'TNEI summary analysis of noise data for: Bonus-2.3MW-NA blade-Standard mode-80hub'.

13 Assel Valley Wind Farm Environmental Impact Assessment – Noise & Vibration, Mark Jiggins MSc MIOA, Hoare Lea v2.3 2011-05-03. Appendix F – Derivation of Hadyard Hill Noise Immission Levels. SAC reference 11/00564/APPM.

14 Tormitchell Farm (223019, 594549) and Tralodden Cottage (222733, 596254).

Table C5 – Consideration of noise immission levels for the Hadyard Hill Wind Farm at Assel Valley nearby receptors.

Description	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Derived Hadyard Hill noise immission levels at both Assel Valley receptors (dB L_{A90})	29.0	30.0	35.0	36.0	37.0	38.0	39.0	41.5	*45.0**	*48.5**
** Whilst values are included for wind speeds of 11 m/s and 12 m/s from the Assel Valley report, these values were highly uncertain and were likely influenced by non-wind turbine noise levels and were noted in the Assel Valley report as "likely to be unrealistically high".*										
Predicted noise immission levels at Tormitchell Farm assuming TNEI source emission levels (dB L_{A90})	39.0	39.0	39.0	39.0	40.1	41.2	42.3	42.3	42.3	42.3
Predicted noise immission levels at Tralodden Cottage assuming TNEI source emission levels (dB L_{A90})	40.1	40.1	40.1	40.1	41.2	42.3	43.4	43.4	43.4	43.4
The amount by which the Hadyard Hill noise immission levels derived in the Assel Valley assessment are lower, compared to predicted noise immission levels using the TNEI source emission data.										
Tormitchell Farm	10.0	9.0	4.0	3.0	3.1	3.2	3.3	0.8	*-2.7#*	*-6.2#*
Tralodden Cottage	11.1	10.1	5.1	4.1	4.2	4.3	4.4	1.9	*-1.6#*	*-5.1#*
# Whilst values are included for wind speeds of 11 m/s and 12 m/s, these values are unlikely to be representative as noted above.*										

C.9 The comparison shows that there are already reasonable margins incorporated within predictions based on the TNEI data, accordingly and in accordance with good practice, these values (as shown in Tables C6 and C7) have been assumed for modelling the contribution from operation of Hadyard Hill Wind Farm in the cumulative assessment for the Proposed Development.

Table C6 - Wind turbine sound power levels (dB L_{Aeq}) used in the noise assessment – Hadyard Hill Wind Farm.

Turbine make / model	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Bonus-2.3MW with 82 m rotor and 80 m hub height.	-	-	104.2	104.2	104.2	104.2	105.3	106.4	107.5	107.5	107.5	107.5
Derived from: TNEI noise assessment for Hadyard Hill Extension Wind Farm[12].												

Table C7 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v_{10} = 8 m/s) – Hadyard Hill Wind Farm.

Turbine make / model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	A
Bonus-2.3MW with 82 m rotor	91.0	97.7	98.7	98.5	97.3	97.3	92.6	81.4	105.4
Derived from: TNEI noise assessment for Hadyard Hill Extension Wind Farm[12].									

Craiginmoddie Wind Farm

C.10 The noise assessment for the proposed Craiginmoddie Wind Farm has been submitted[15] and provides detailed information about the sound power levels for the candidate turbine used for the noise assessment of that development. These data are derived from values considered to be 'typical' by the manufacturer. The Craiginmoddie noise assessment added an additional 2 dB margin to these values in order to account for uncertainties, as required by good practice. The data provided in the Craiginmoddie assessment have been adopted for the contribution from Craiginmoddie Wind Farm in the cumulative assessment of the Proposed Development and are shown in Table C8 and Table C9.

Table C8 - Wind turbine sound power levels (dB L_{Aeq}) used in the noise assessment – Craiginmoddie Wind Farm.

Turbine make / model	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Siemens Gamesa SG 6.0-155 6.6 MW with a 122.5 m hub height	-	-	95.2	100.4	105.2	107.0	107.0	107.0	107.0	107.0	107.0	107.0
Derived from: Noise assessment for Craiginmoddie Wind Farm[15].												

Table C9 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v_{10} = 8 m/s) – Craiginmoddie Wind Farm.

Turbine make / model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	A
Siemens Gamesa SG 6.0-155 6.6 MW	79.6	87.0	91.6	93.9	93.7	94.0	87.4	72.4	100
Derived from: Noise assessment for Craiginmoddie Wind Farm[15] and normalised to 100 dB(A).									

Carrick Windfarm

C.11 The noise assessment for the proposed Carrick Windfarm is expected to be submitted at an approximately similar time to that of the Proposed Development and has been included in this assessment for completeness. At the time of this assessment (Aug 2021) the candidate turbine to be used for Carrick Windfarm was not confirmed. In absence of confirmation of a specific candidate wind turbine, it has been assumed that the candidate used for Craiginmoddie Wind Farm would be typical of the type, size and noise emission levels suitable for Carrick Windfarm. Accordingly the data assumed for assessment of the contribution from Carrick Windfarm in the cumulative assessment are shown in Table C8 and Table C9, as used for Craiginmoddie Wind.

15 Craiginmoddie Wind Farm Environmental Impact Assessment Report – Volume I – Chapter 10: Noise. Wood on behalf of Energiekontor UK Ltd. December 2020. 'Table 10.11: Siemens Games SG 6.0-155 6.6 MW Apparent Sound Power Level (dB(A))' and 'Table 10.12: Siemens Gamesa SG 6.0-155 6.6 MW Apparent Sound Power Level Spectra (dB(A))'.

Annex D – Predicted Noise and Noise Limits/Criteria

Figure D1 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Genoch Cottage as well as background noise levels, during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential day-time noise limit (based on 35 dB(A)). Predicted noise immission levels are shown for the Proposed Development and other wind farms considered as well as the cumulative total.

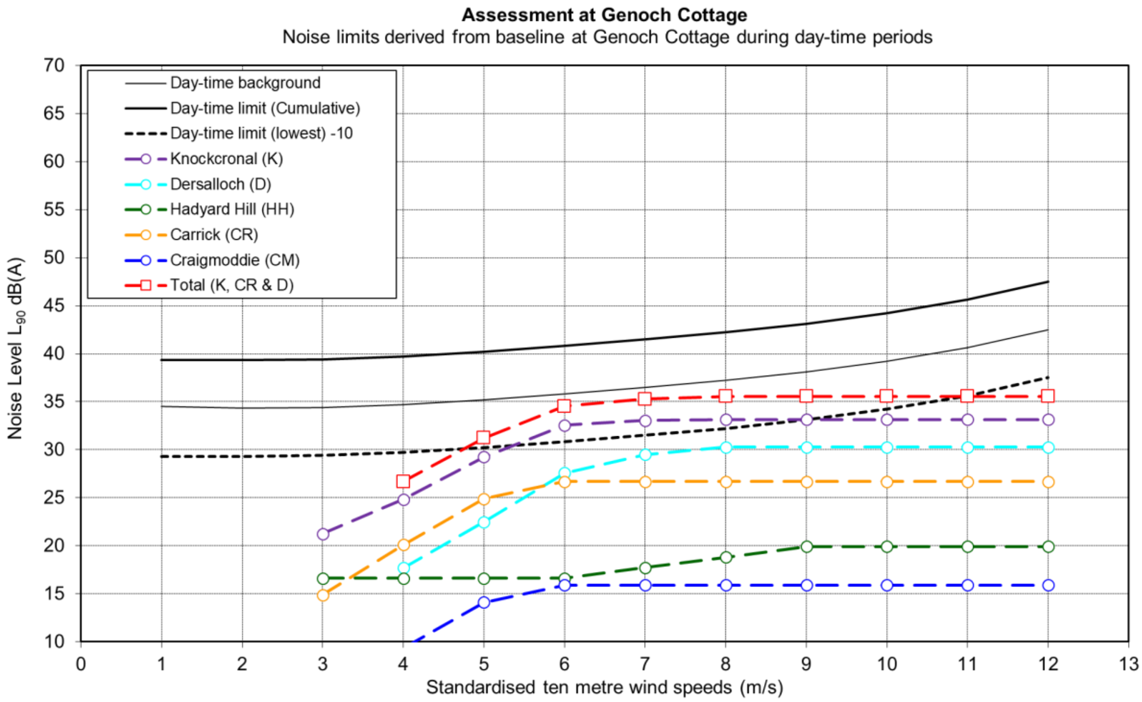


Figure D2 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Genoch Cottage as well as background noise levels, during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered as well as the cumulative total.

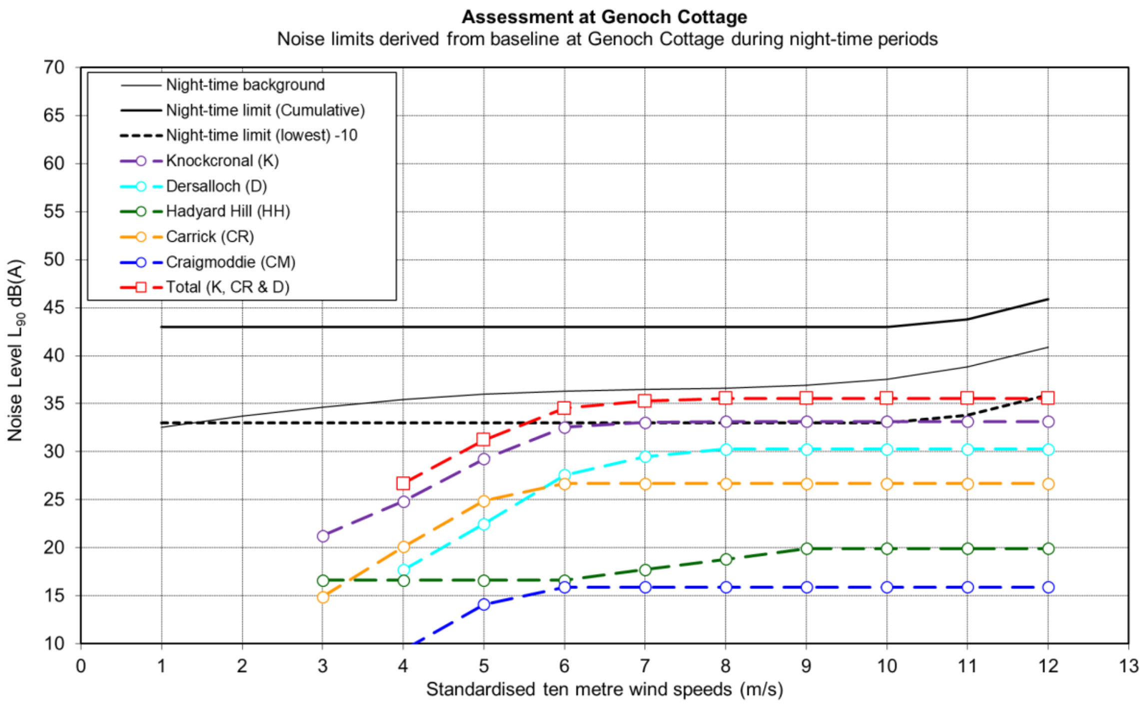


Figure D3 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Knockskae as well as background noise levels, during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

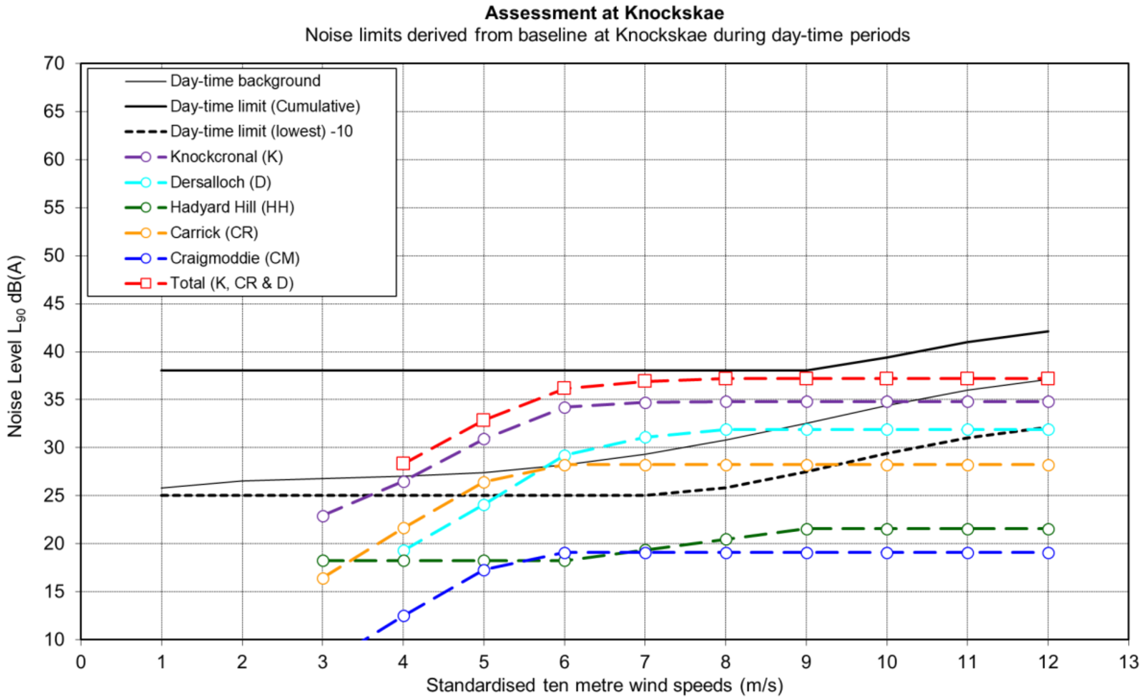


Figure D4 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Knockskae as well as background noise levels, during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

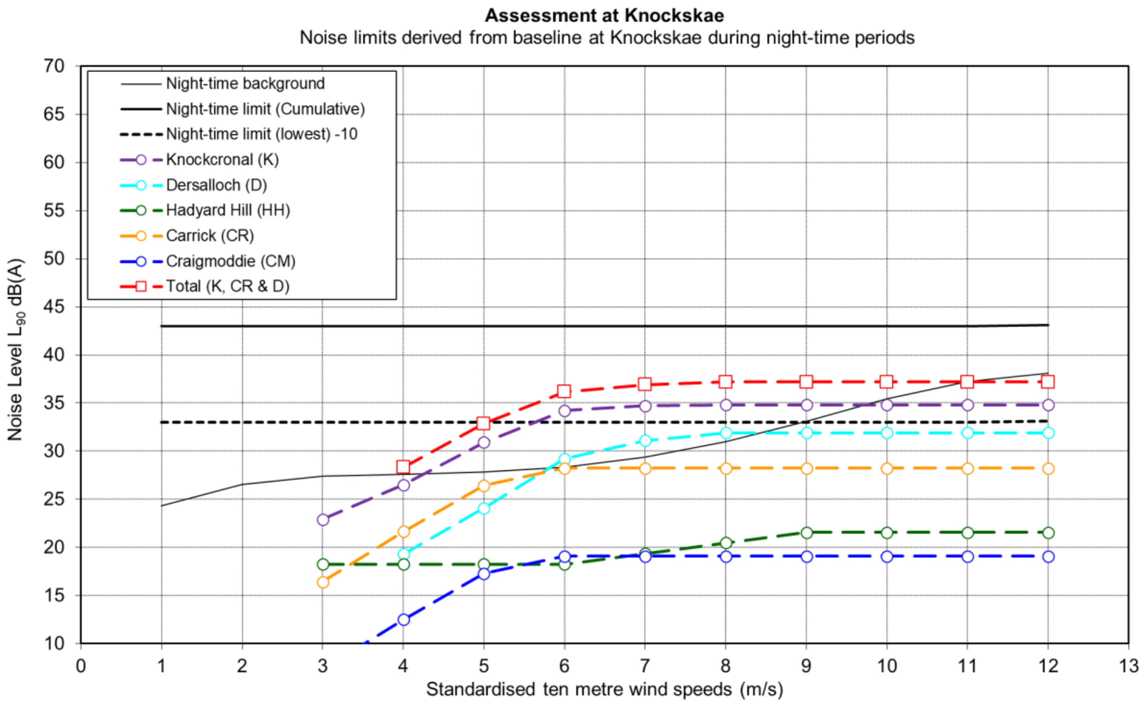


Figure D5 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Linfairn farm (not financially involved) as well as background noise levels, during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

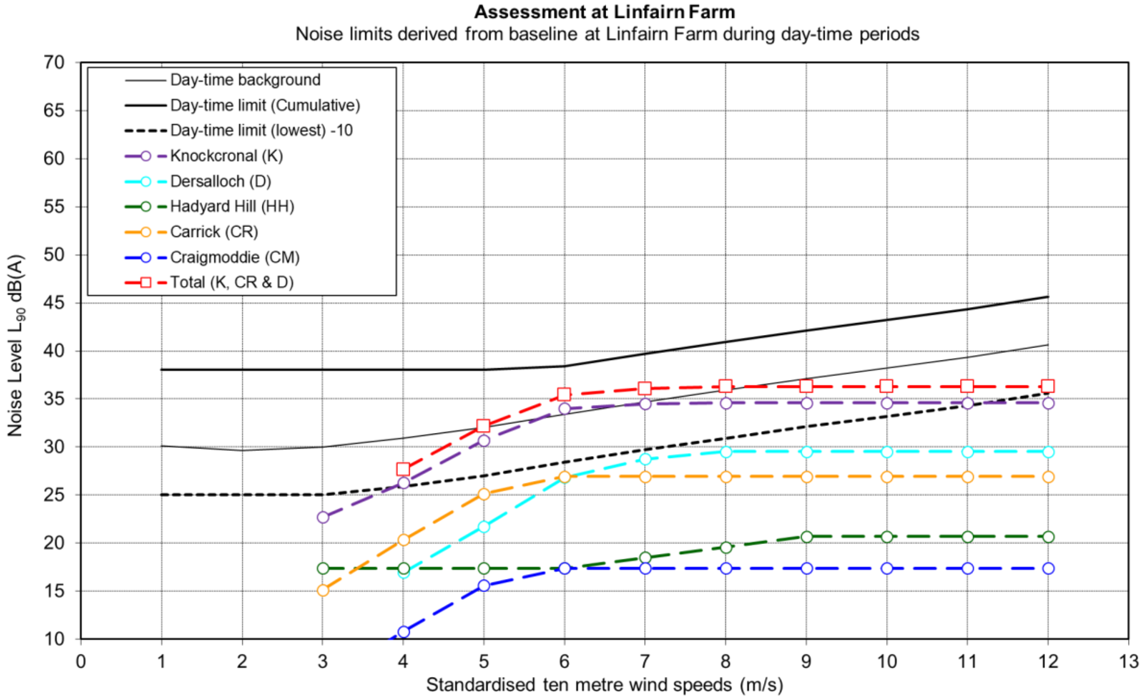


Figure D6 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Linfairn Farm (not financially involved) as well as background noise levels, during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

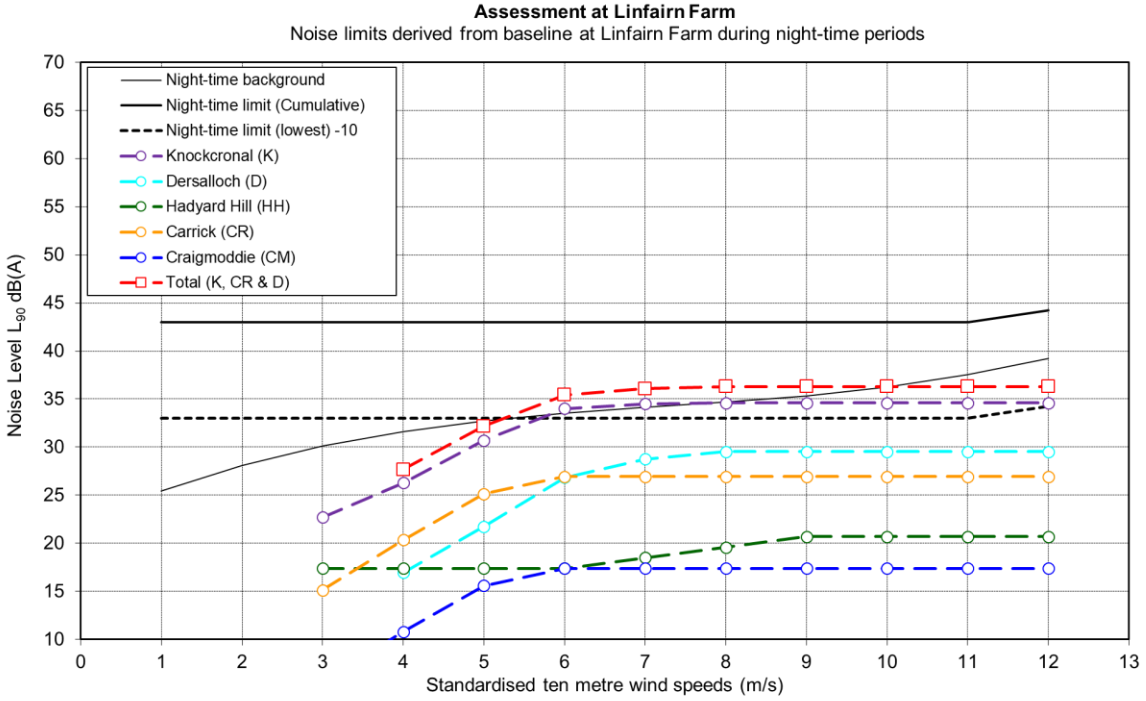


Figure D7 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Linfairn farm (FI) as well as background noise levels, during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

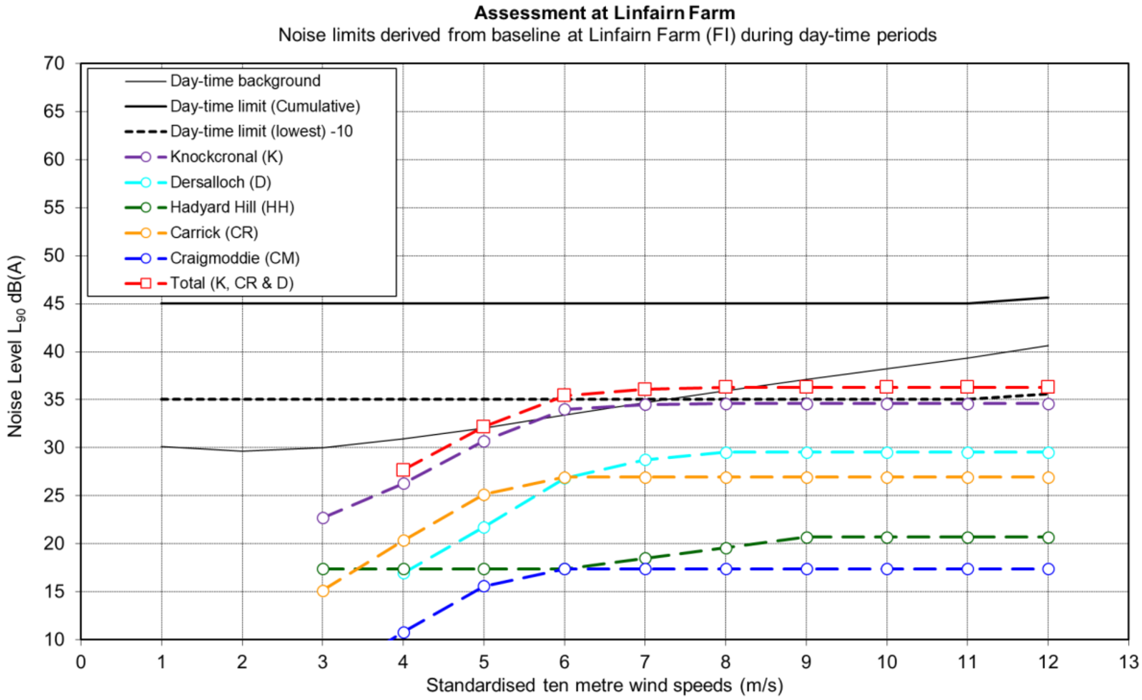


Figure D8 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Linfairn Farm (FI) as well as background noise levels, during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

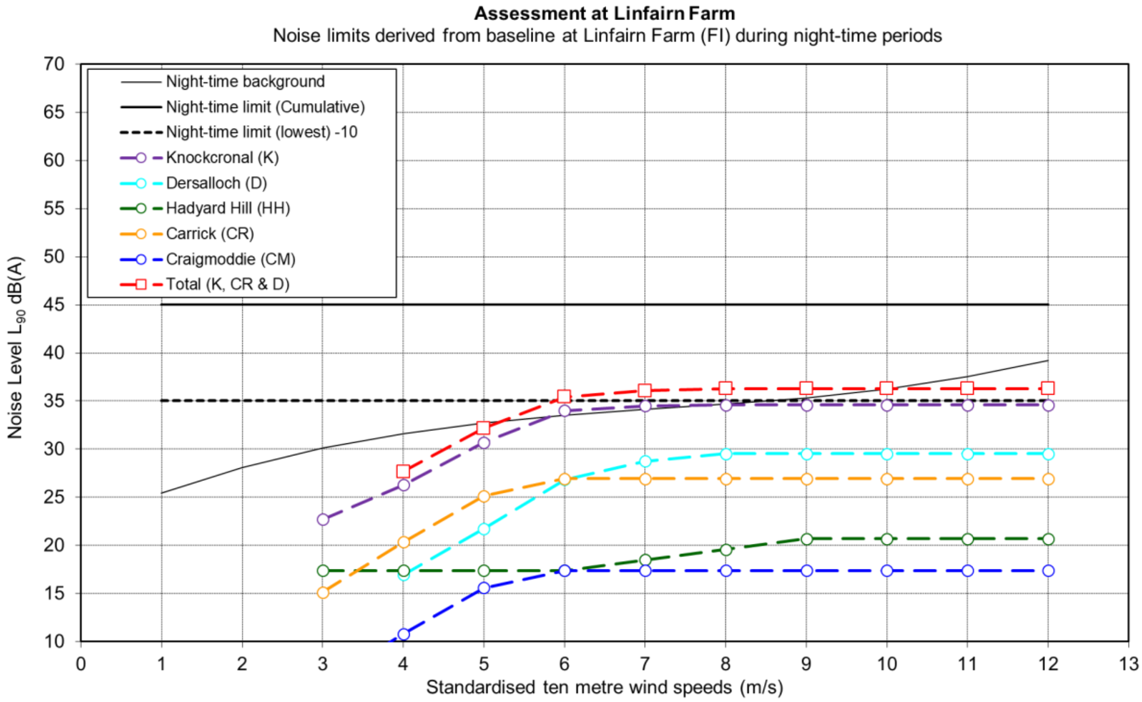


Figure D9 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tairlaw Toll Cottage as well as background noise levels, during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

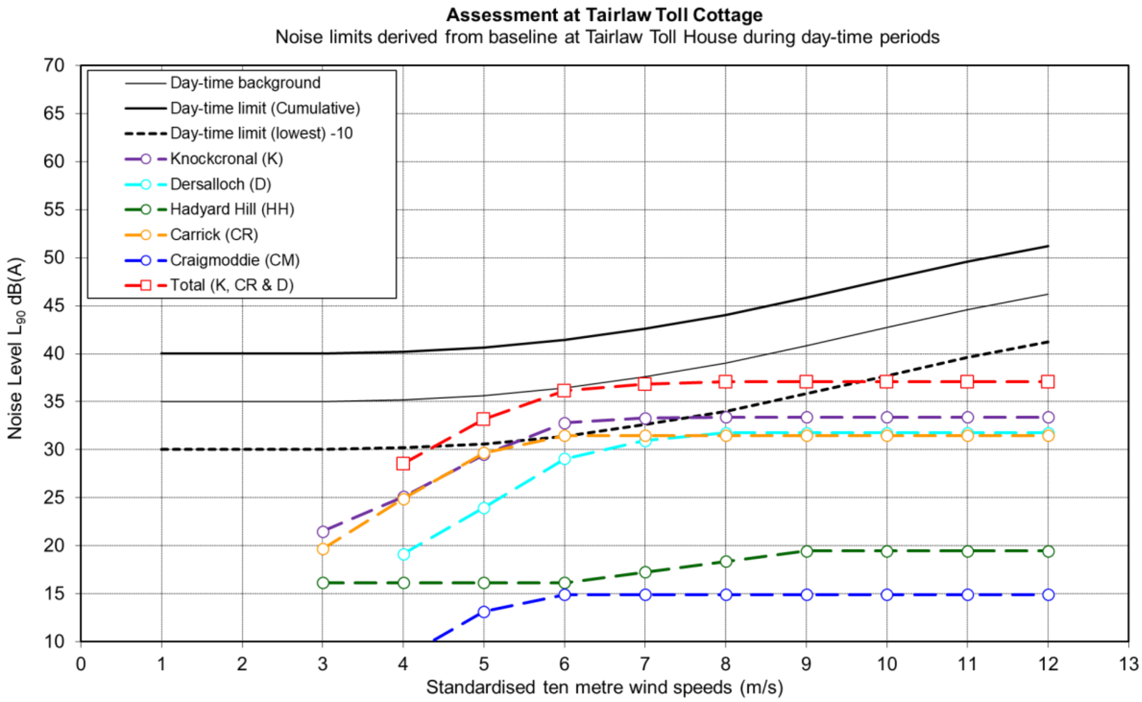


Figure D10 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tairlaw Toll Cottage as well as background noise levels, during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

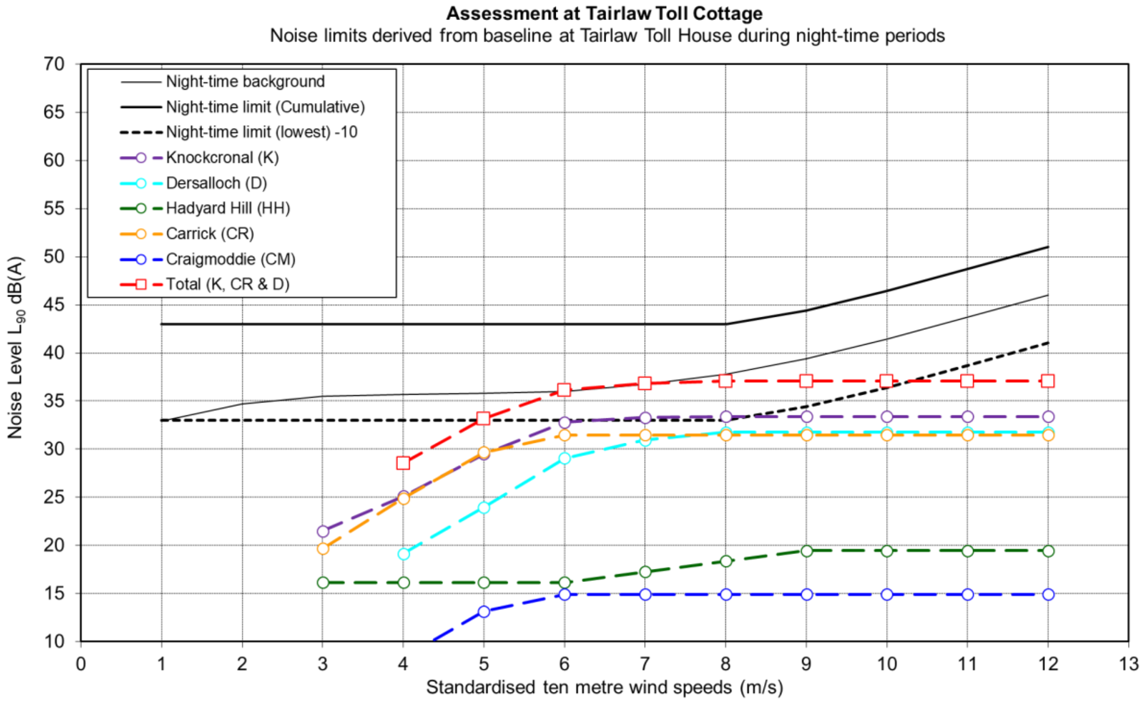


Figure D11 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tallaminnoch as well as background noise levels, during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

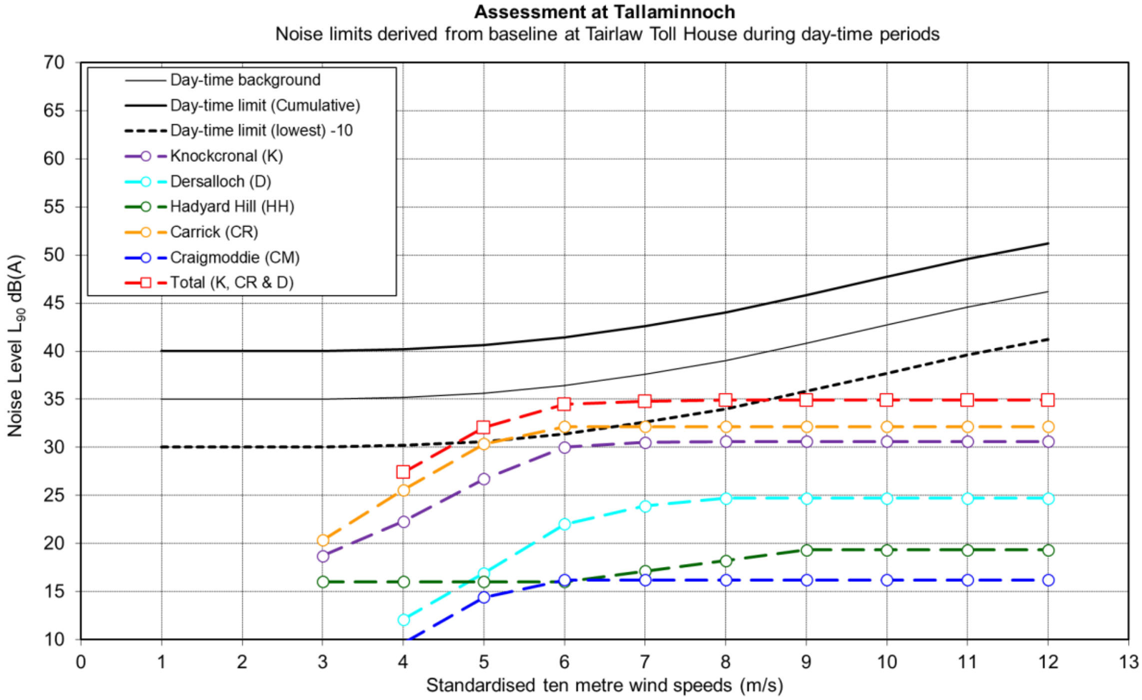


Figure D12 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tallaminnoch as well as background noise levels, during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

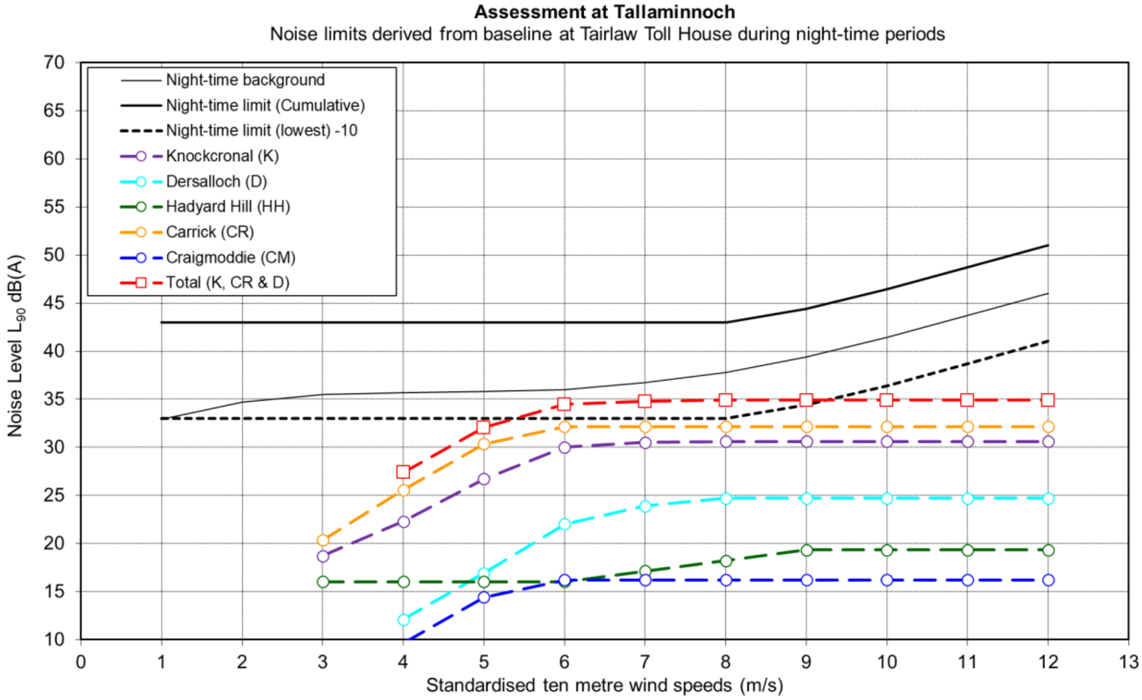


Figure D13 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Glenalla Farm as well as background noise levels, during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

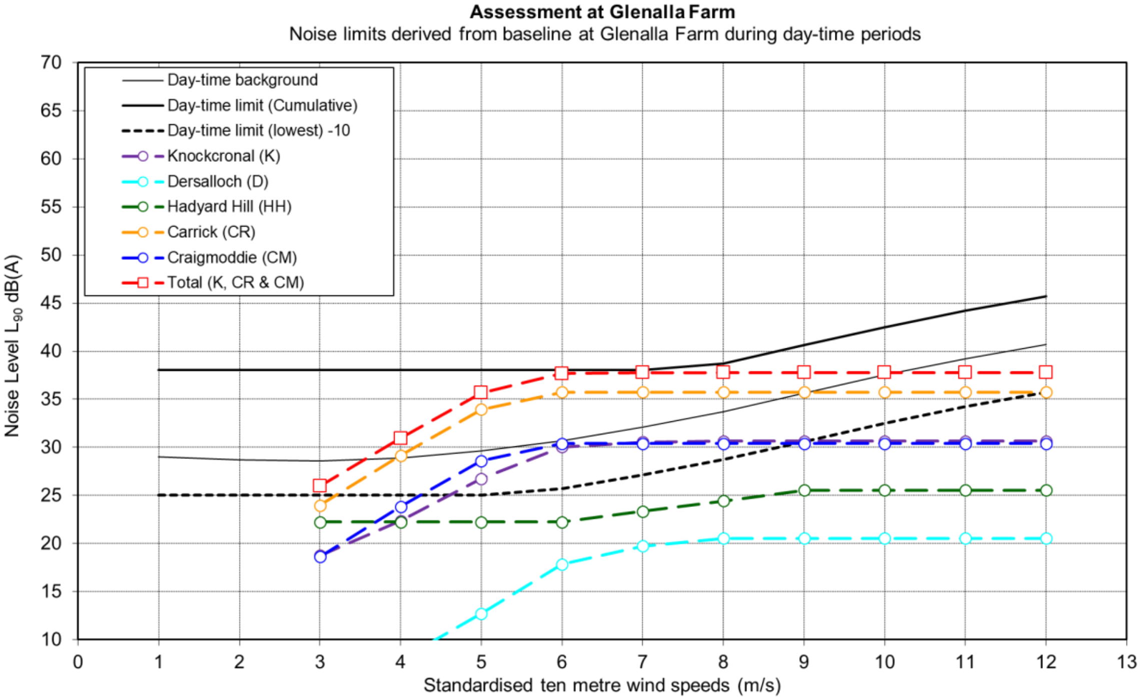


Figure D14 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Glenalla Farm as well as background noise levels, during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

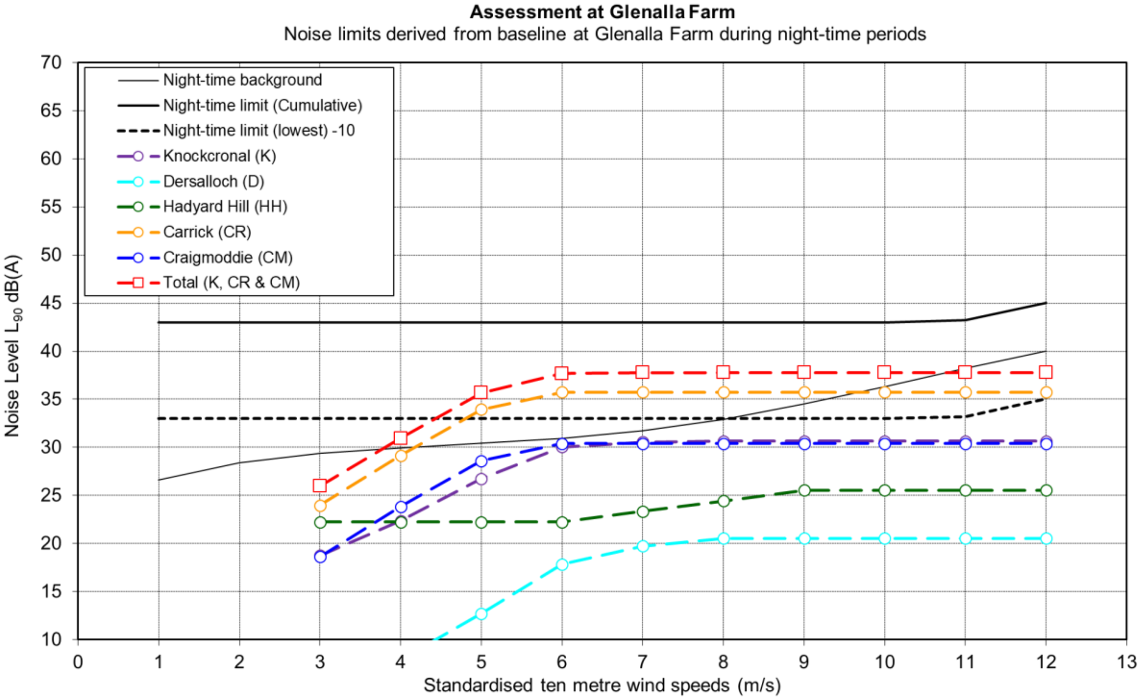


Figure D15 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Genoch Cottage as well as background noise levels (from Carrick survey), during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential day-time noise limit (based on 35 dB(A)). Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

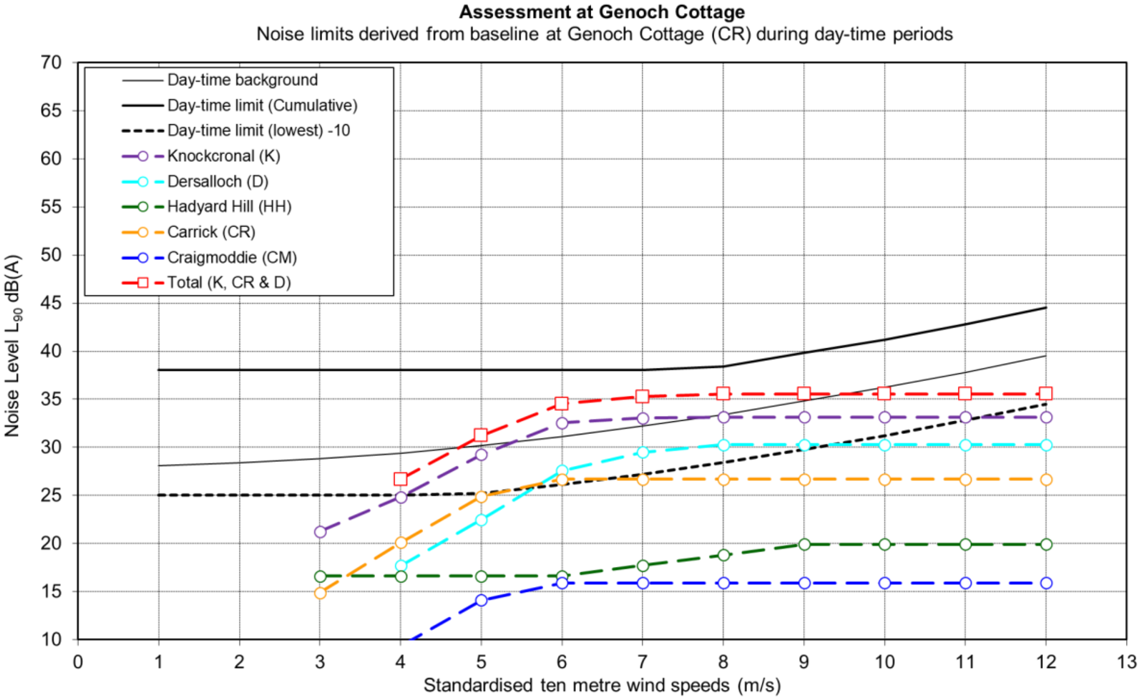


Figure D16 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Genoch Cottage as well as background noise levels (from Carrick survey), during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

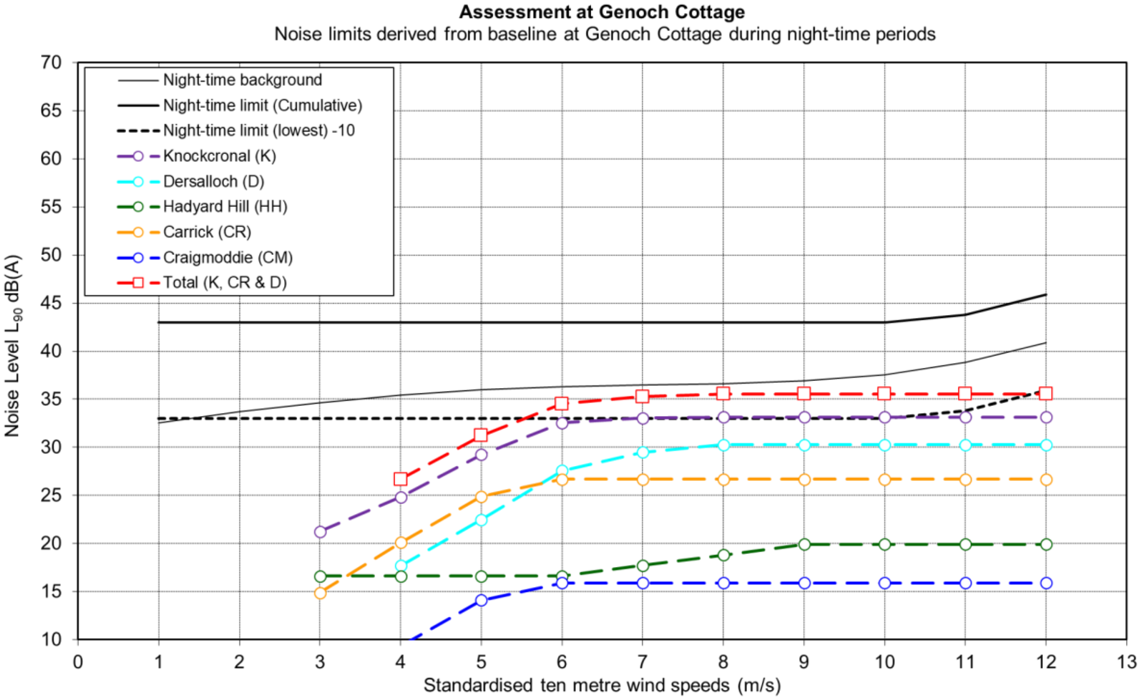


Figure D17 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tairlaw Toll Cottage as well as background noise levels (from Carrick survey), during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

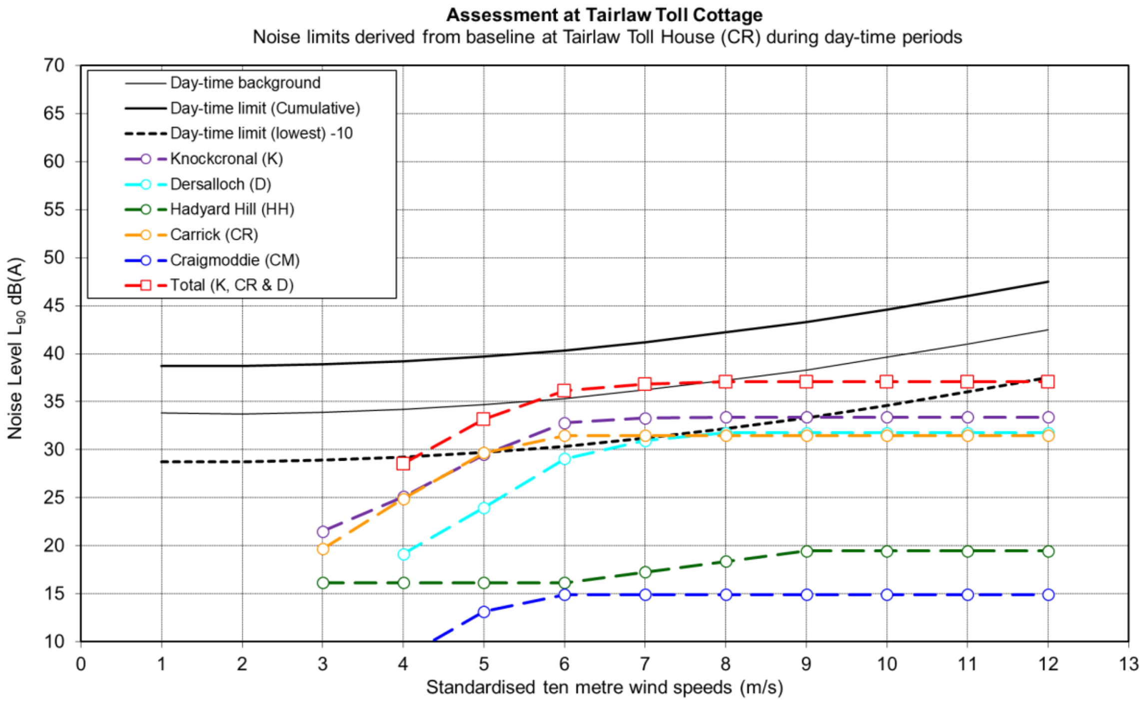


Figure D18 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tairlaw Toll Cottage as well as background noise levels (from Carrick survey), during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

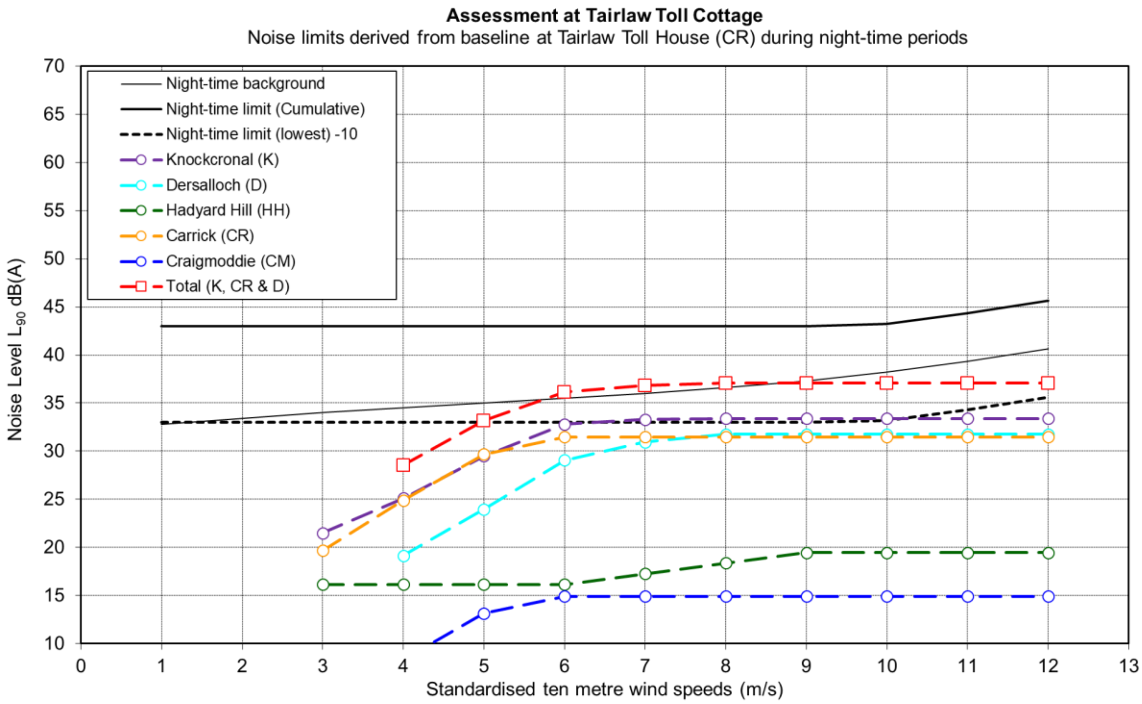


Figure D19 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tallaminnoch as well as background noise levels (from Carrick survey), during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

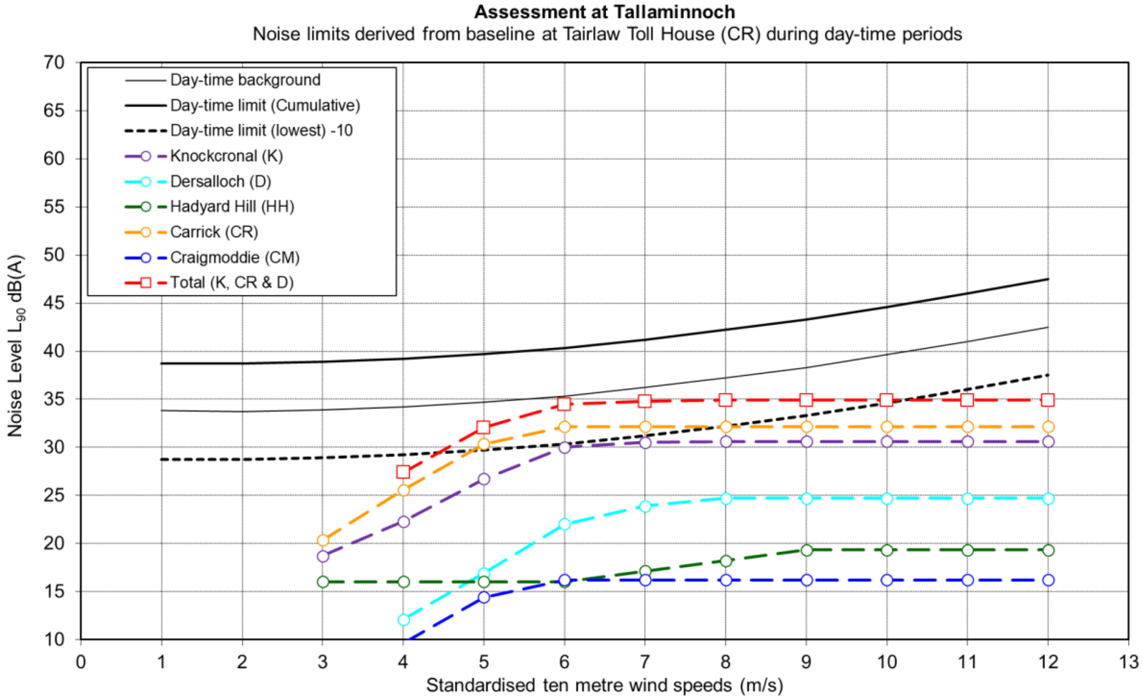


Figure D20 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Tallaminnoch as well as background noise levels (from Carrick survey), during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

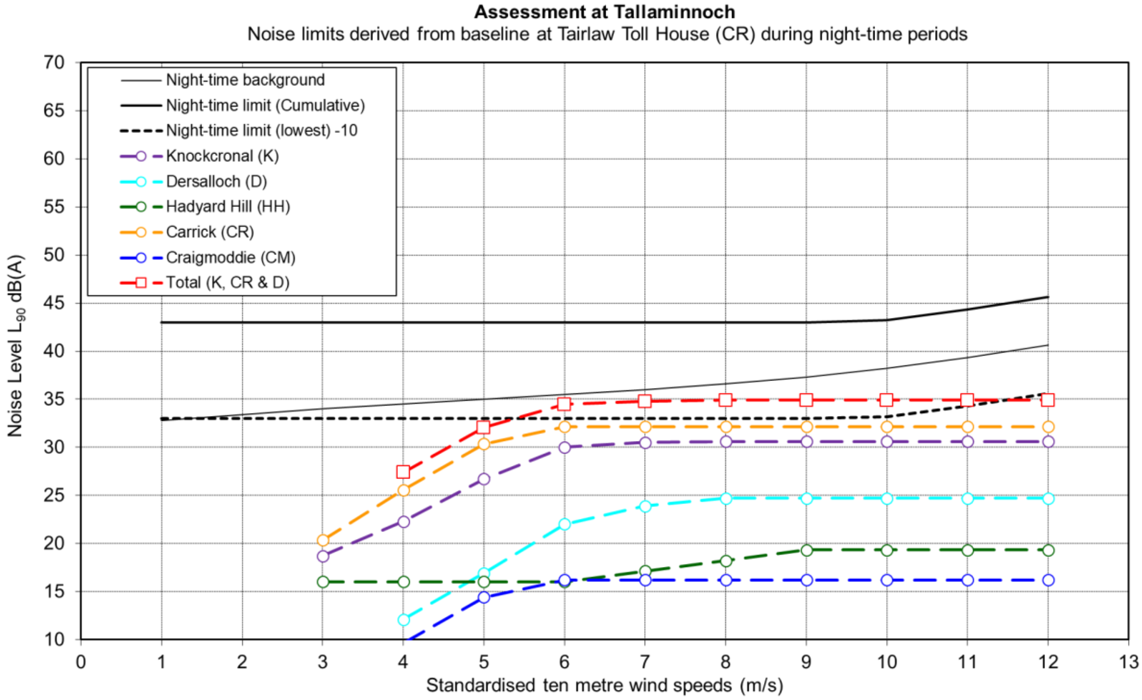


Figure D21 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Glenalla Farm as well as background noise levels (from Carrick survey), during day-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.

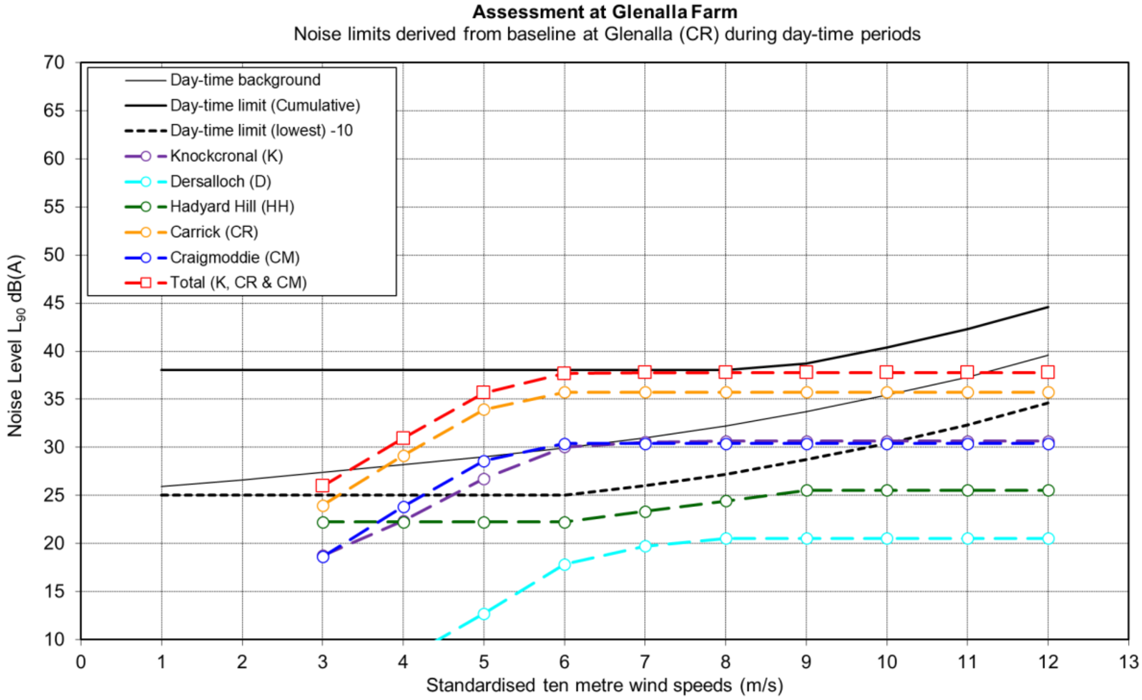
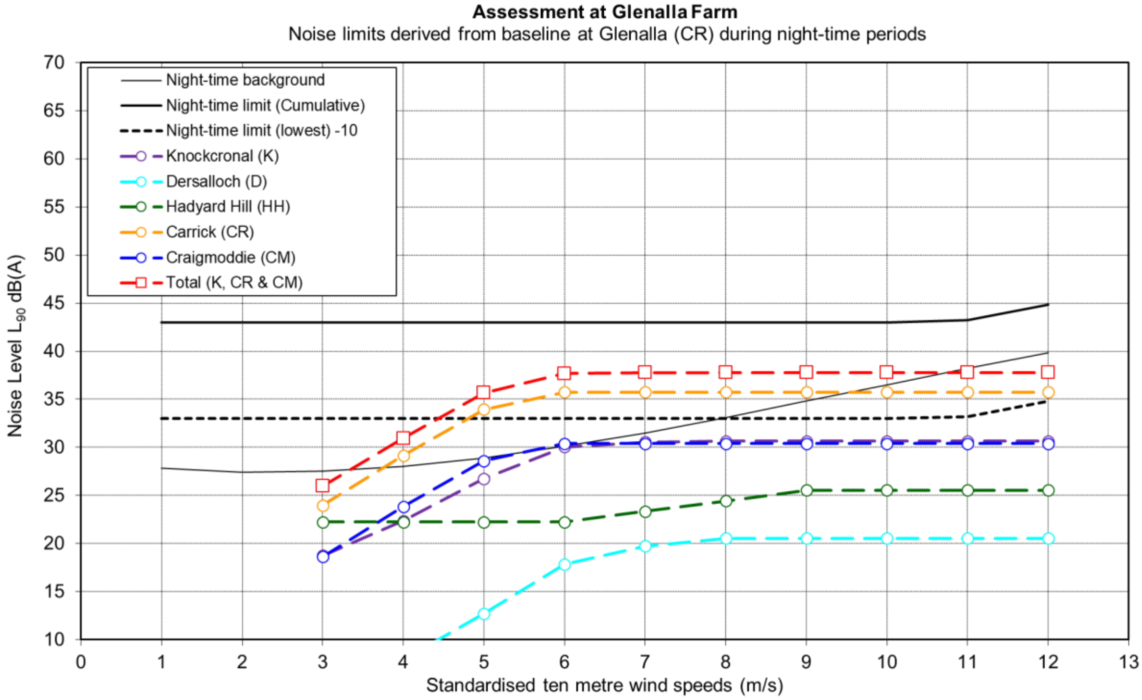


Figure D22 - Chart of the ETSU-R-97 based noise criteria / limit curves appropriate for the assessment location of Glenalla Farm as well as background noise levels (from Carrick survey), during night-time periods. Also shown is the criterion 10 dB(A) below the lowest potential noise limit / criteria. Predicted noise immission levels are shown for the Proposed Development and other wind farms considered, as well as the cumulative total.



Annex E – Apportioned Noise Limits

Figure E1 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time for Genoch Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

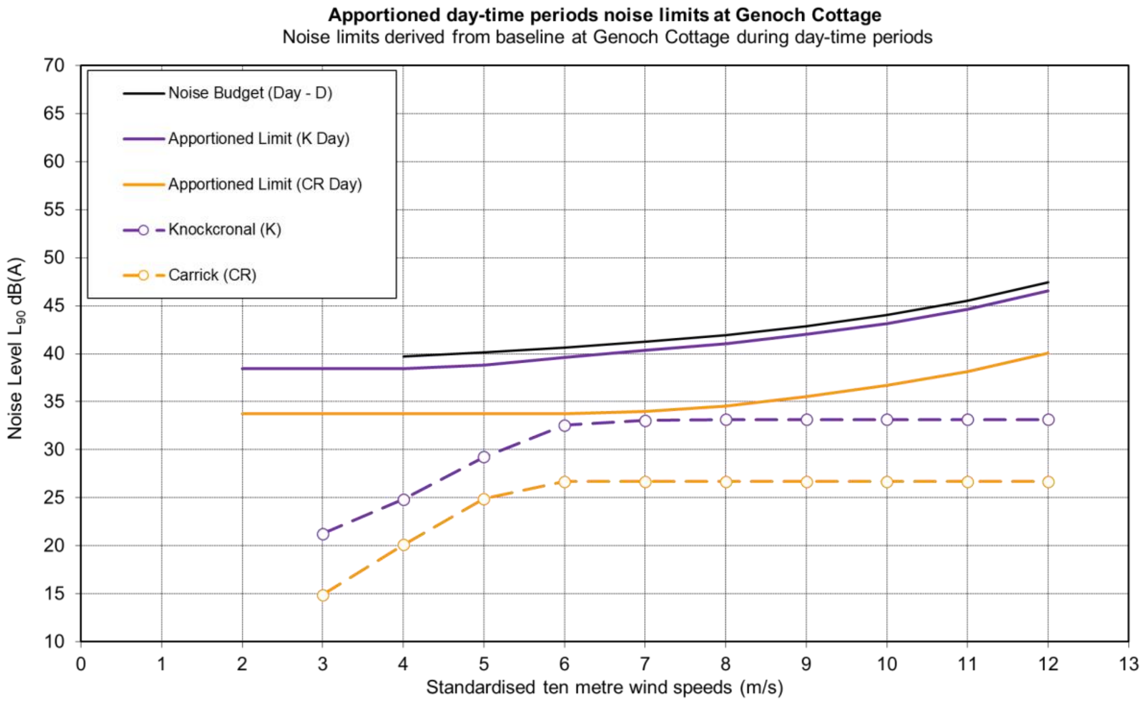


Figure E2 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time for Genoch Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

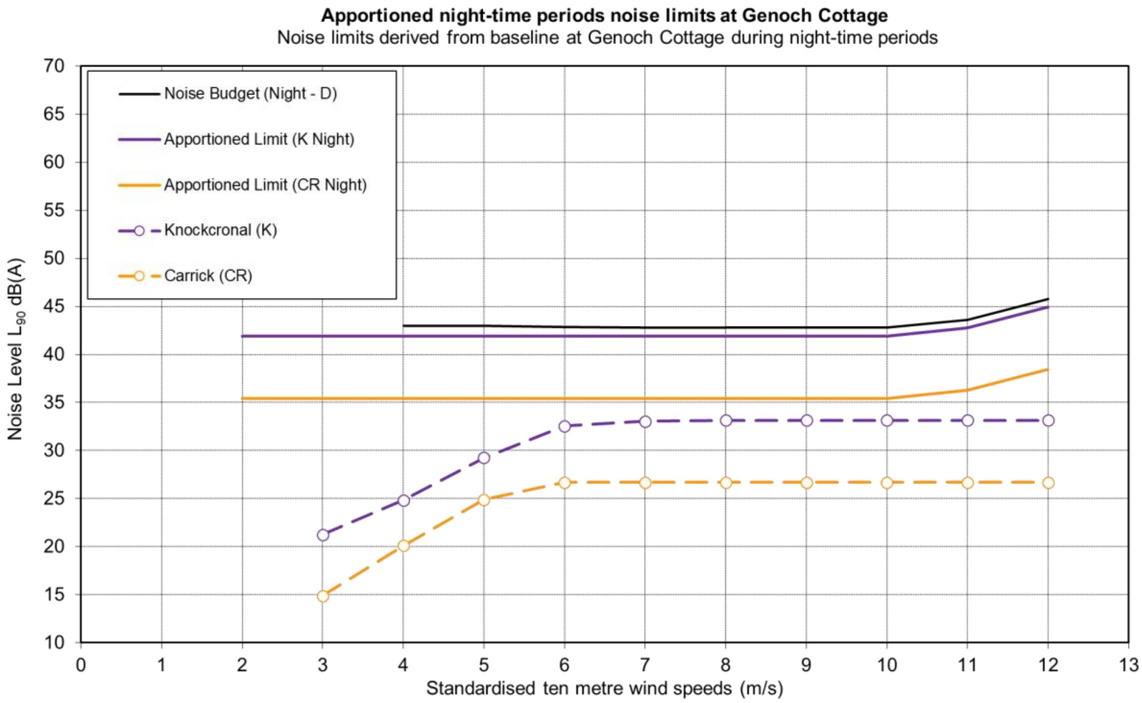


Figure E3 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time for Knockskae, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

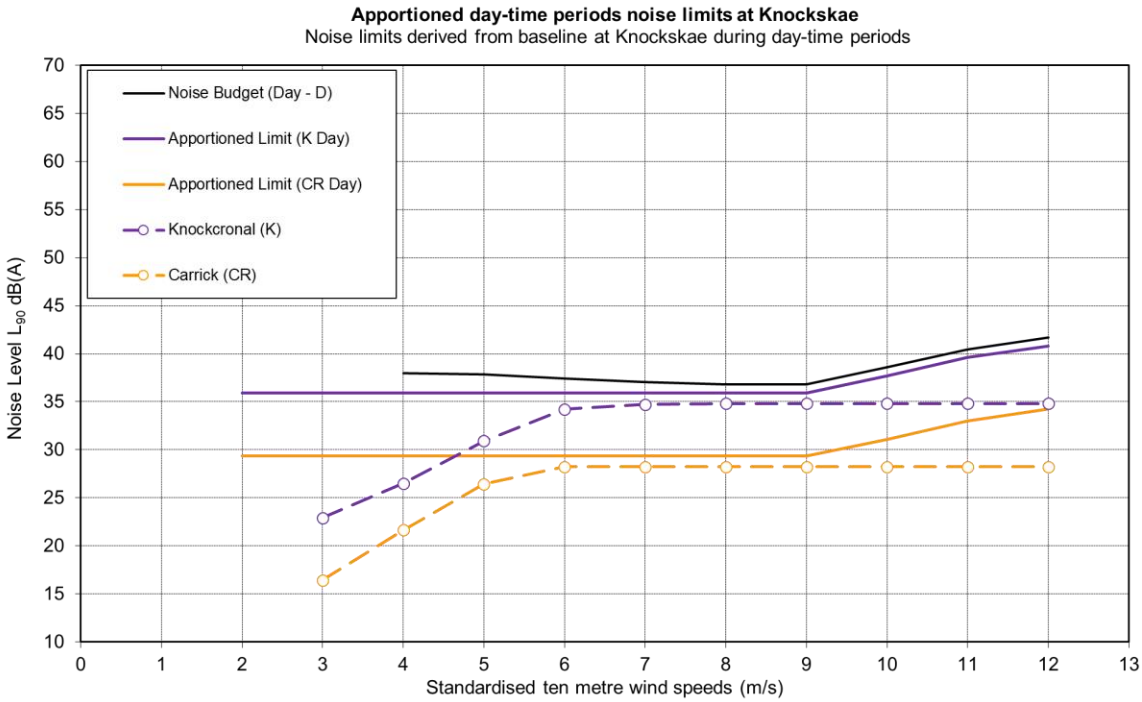


Figure E4 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time for Knockskae, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

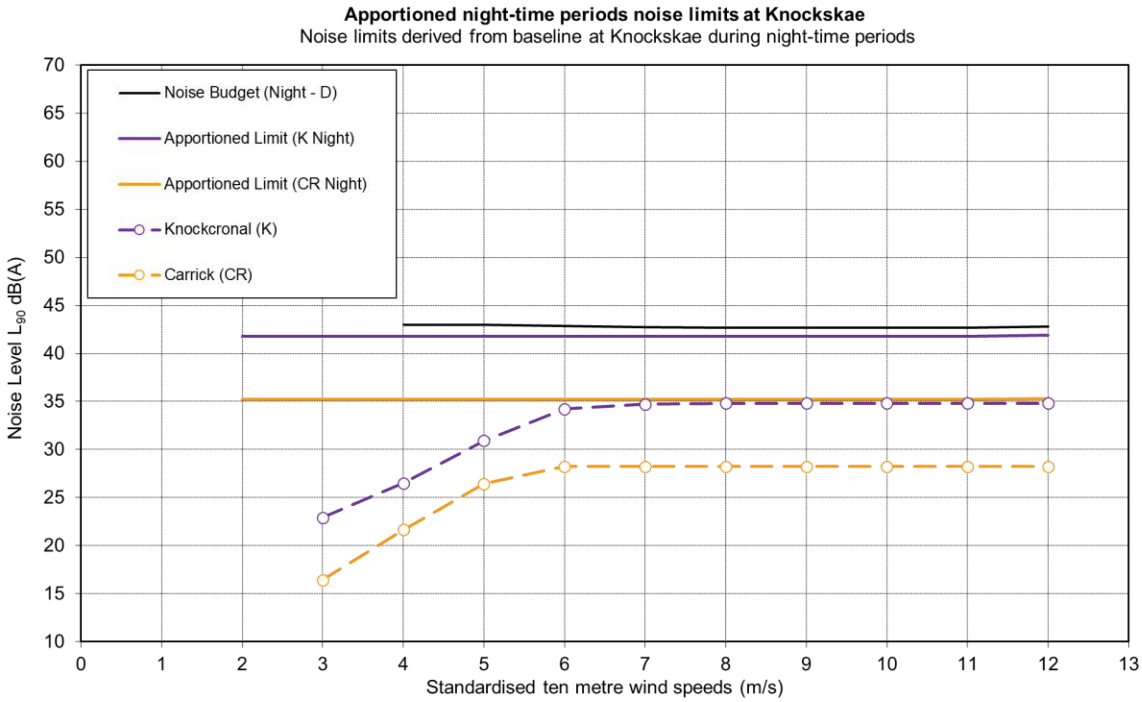


Figure E5 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time for Linfairn Farm (not financially involved), as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

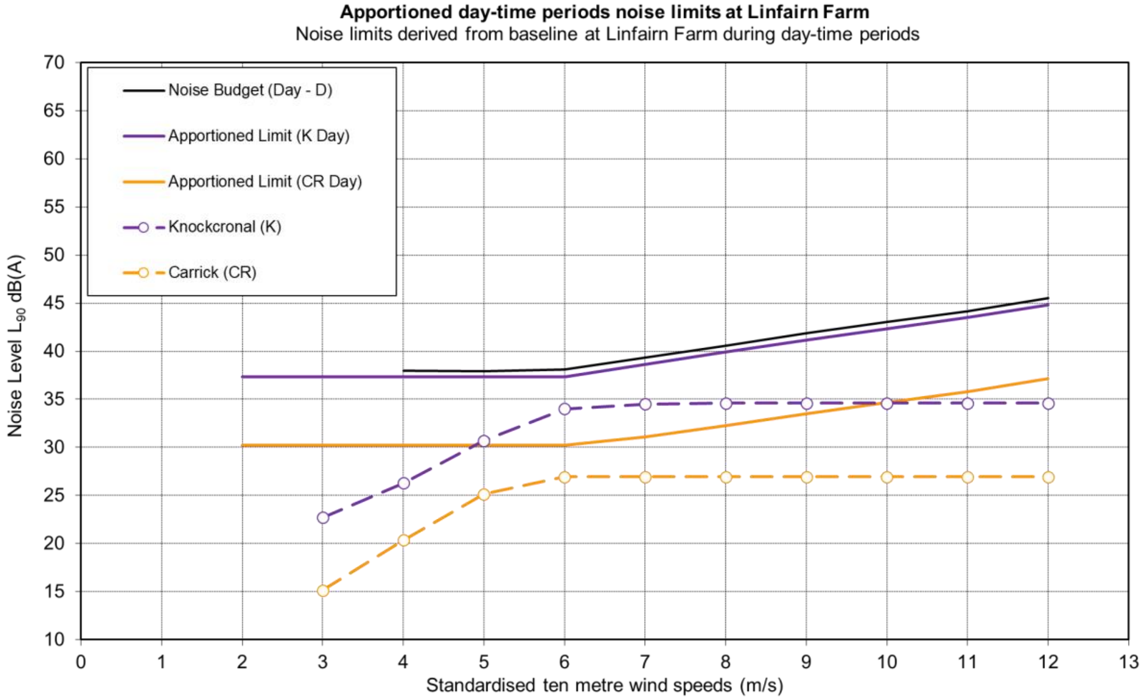


Figure E6 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time for Linfairn Farm (not financially involved), as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

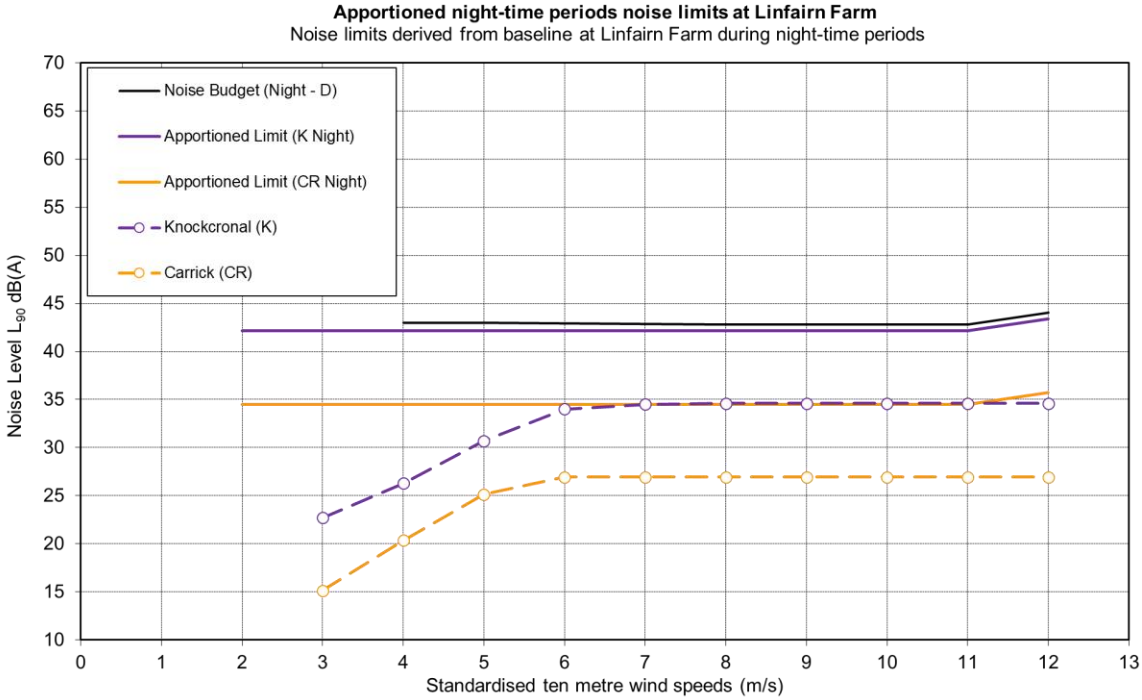


Figure E7 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time for Linfairn Farm (Fl), as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

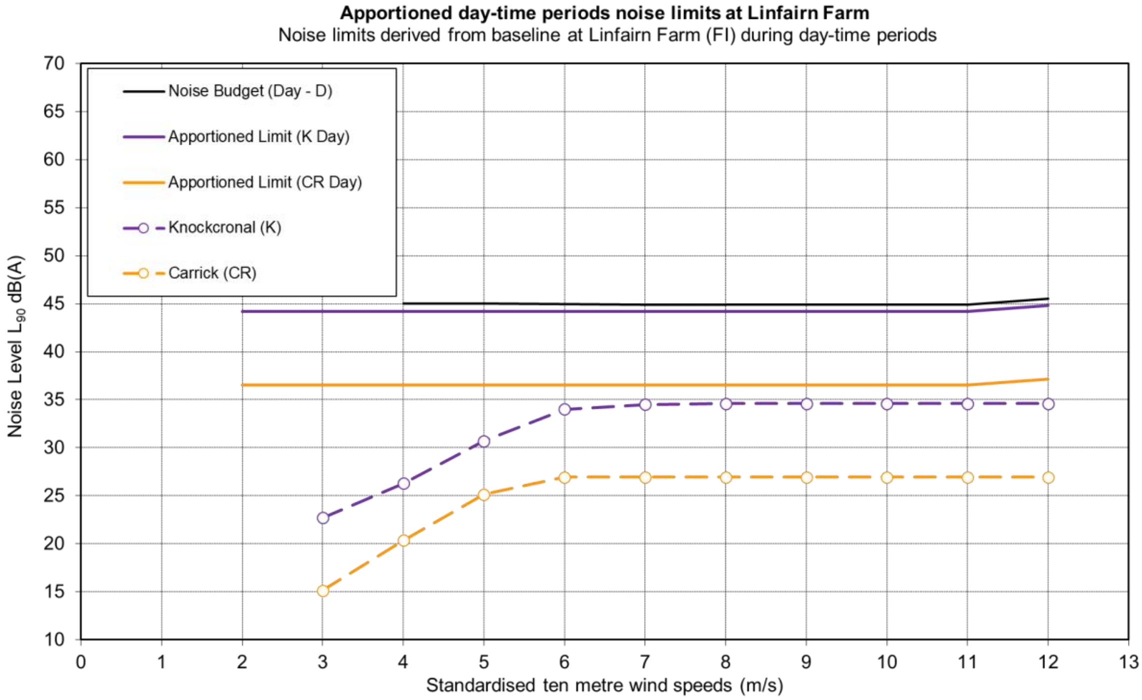


Figure E8 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time for Linfairn Farm (Fl), as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

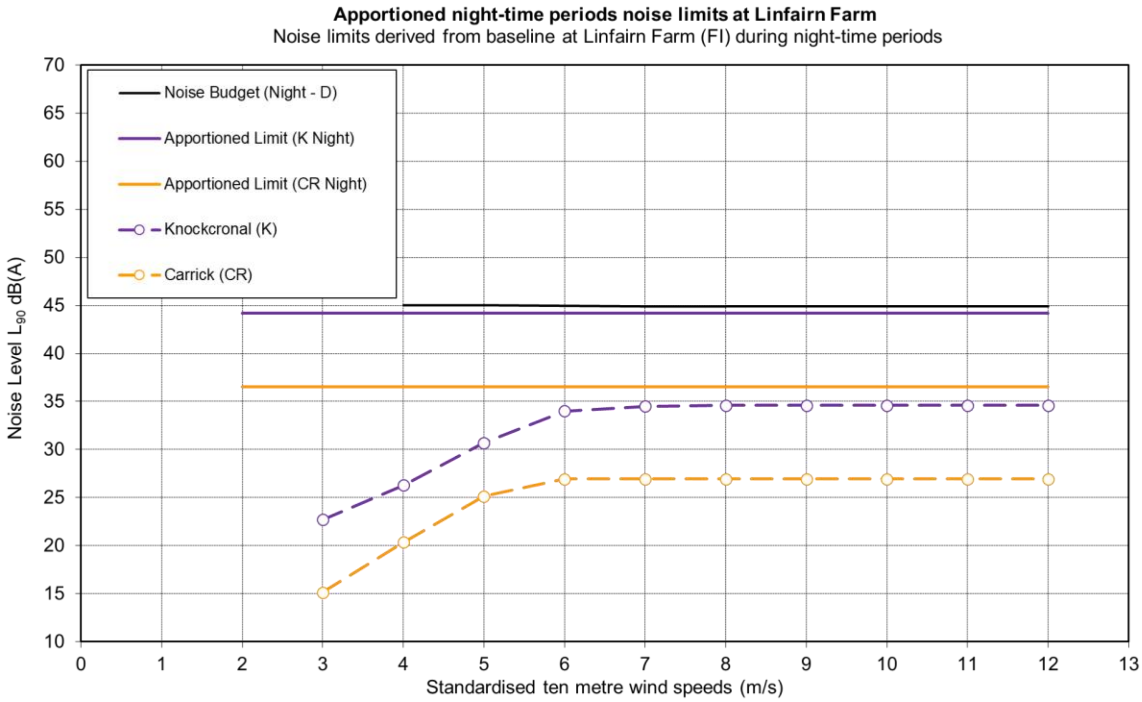


Figure E9 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time for Tairlaw Toll Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

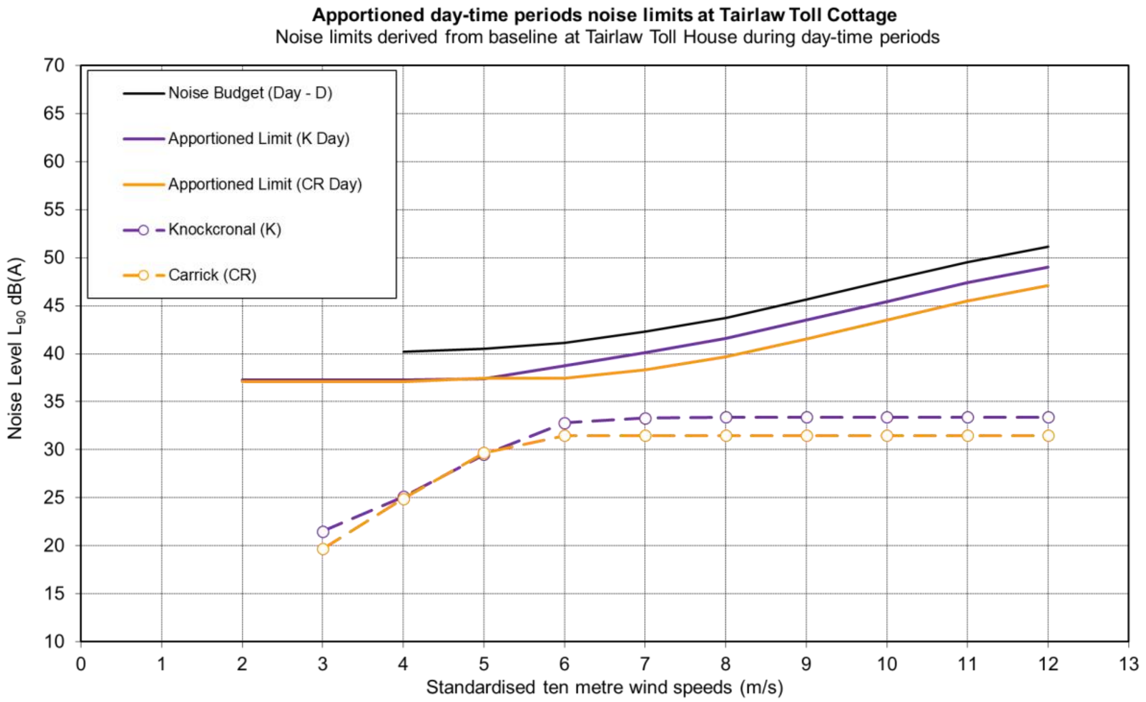


Figure E10 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time for Tairlaw Toll Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

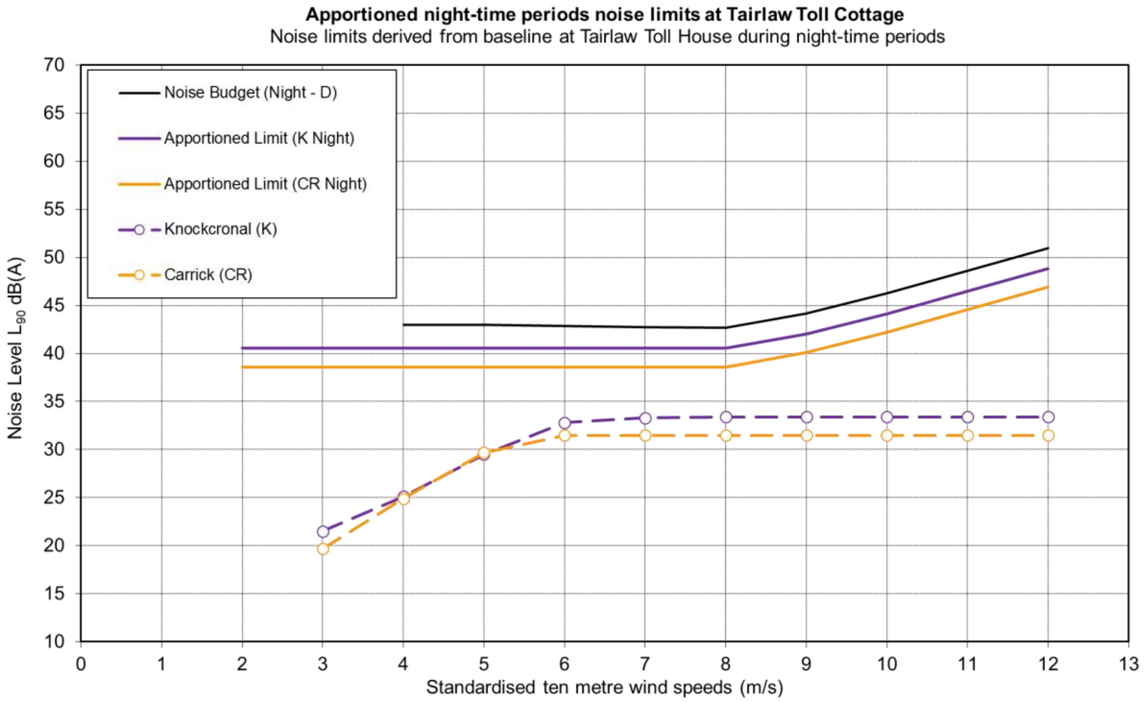


Figure E11 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time for Tallaminnoch, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

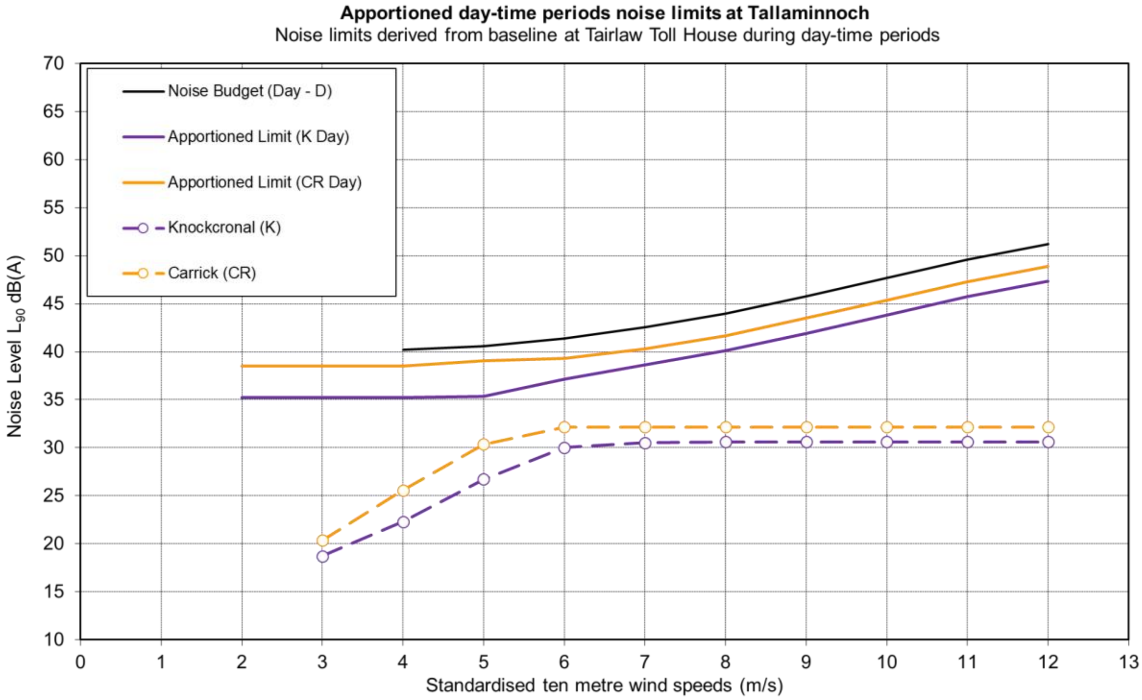


Figure E12 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time for Tallaminnoch, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

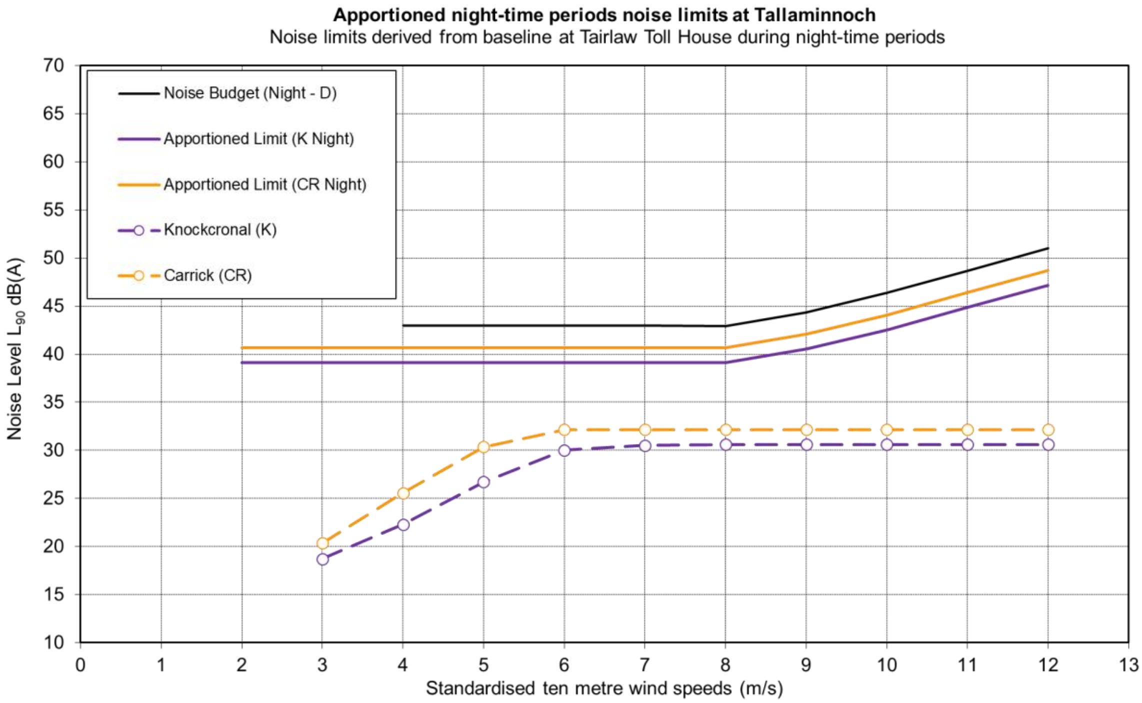


Figure E13 - Chart of the ETSU-R-97 based noise criteria / limit curve during the day-time for Glenalla Farm, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K), Carrick Windfarm (CR) and Craiginmoddie Wind Farm (CM). Predicted noise immission levels also shown for the Proposed Development, Carrick Windfarm and Craiginmoddie Wind Farm.

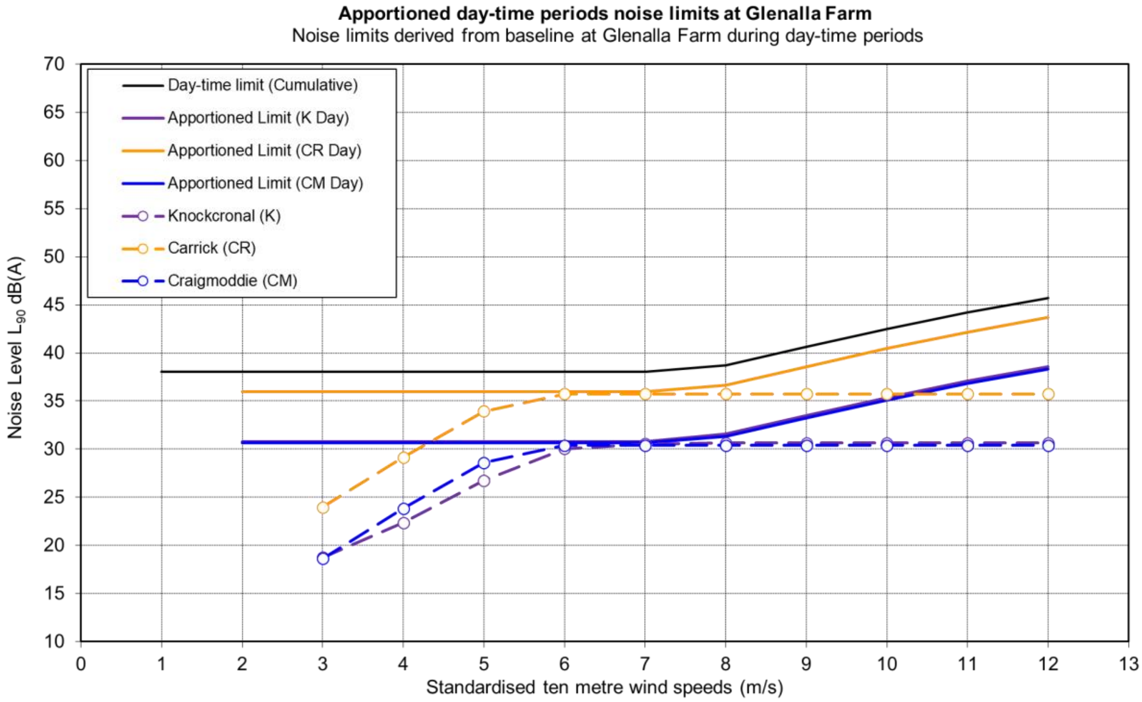


Figure E14 - Chart of the ETSU-R-97 based noise criteria / limit curve during the night-time for Glenalla Farm, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K), Carrick Windfarm (CR) and Craiginmoddie Wind Farm (CM). Predicted noise immission levels also shown for the Proposed Development, Carrick Windfarm and Craiginmoddie Wind Farm.

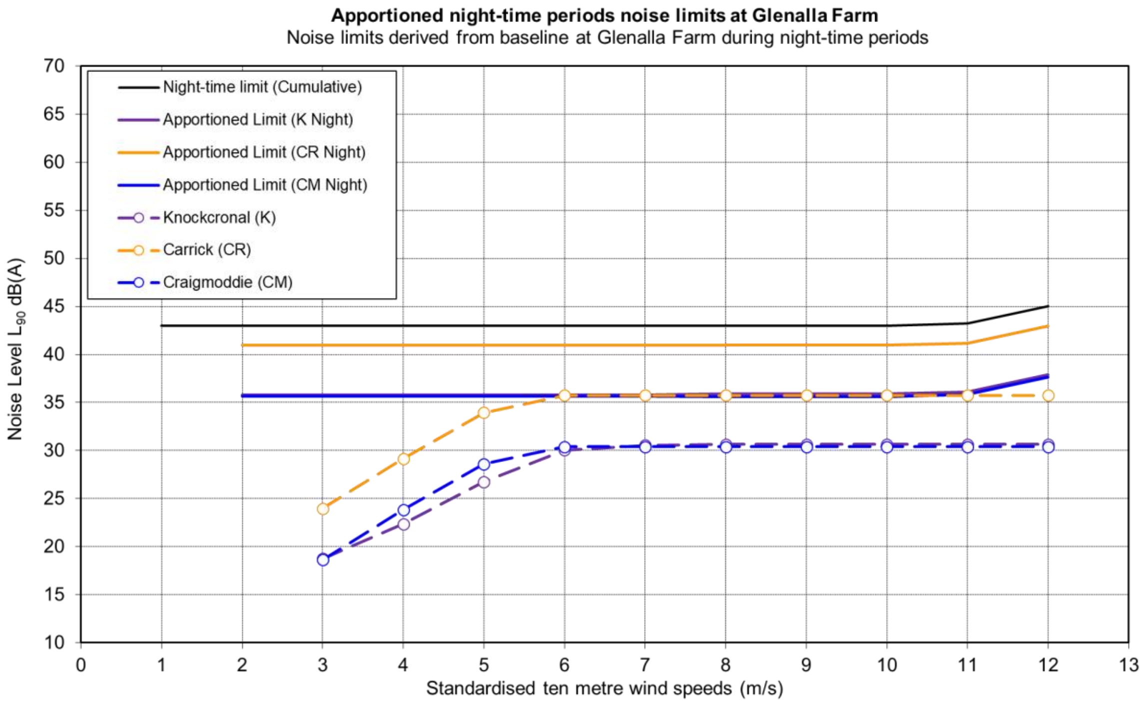


Figure E15 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time (from Carrick survey) for Genoch Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

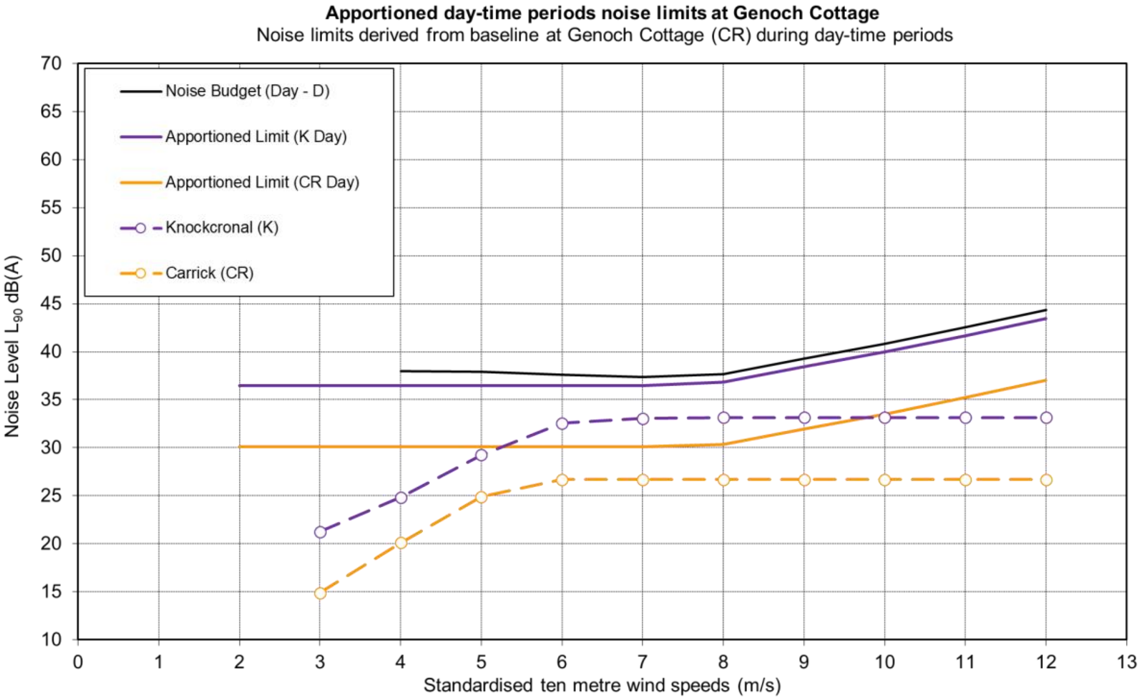


Figure E16 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time (from Carrick survey) for Genoch Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

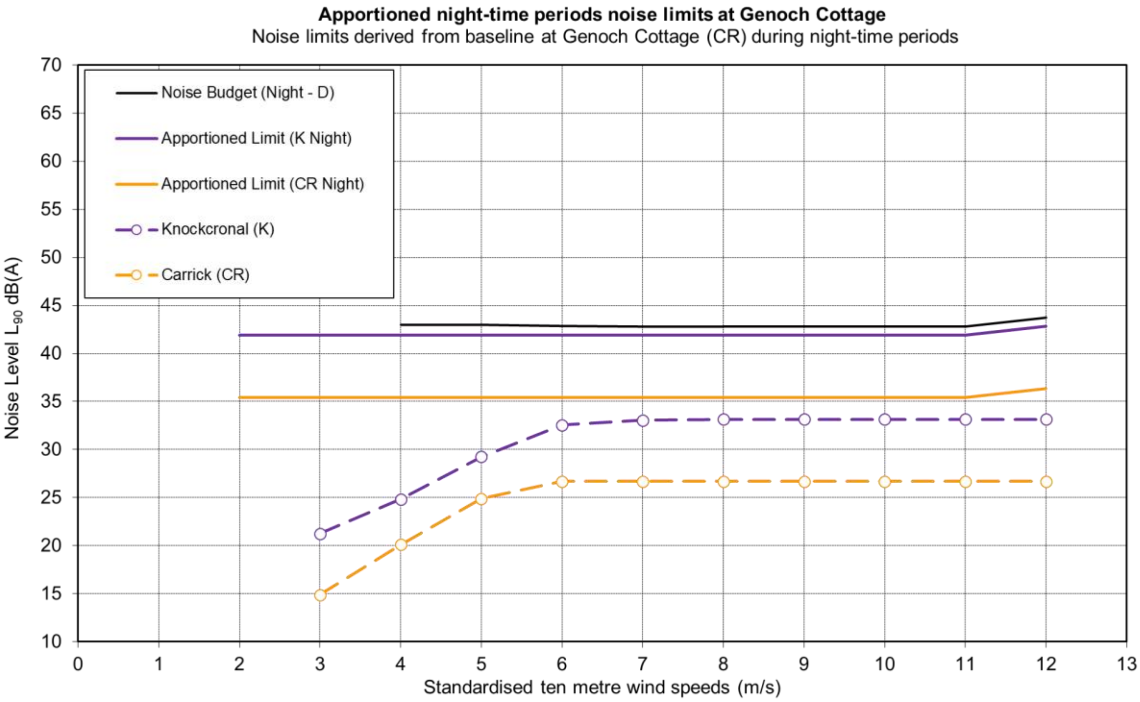


Figure E17 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time (from Carrick survey) for Tairlaw Toll Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

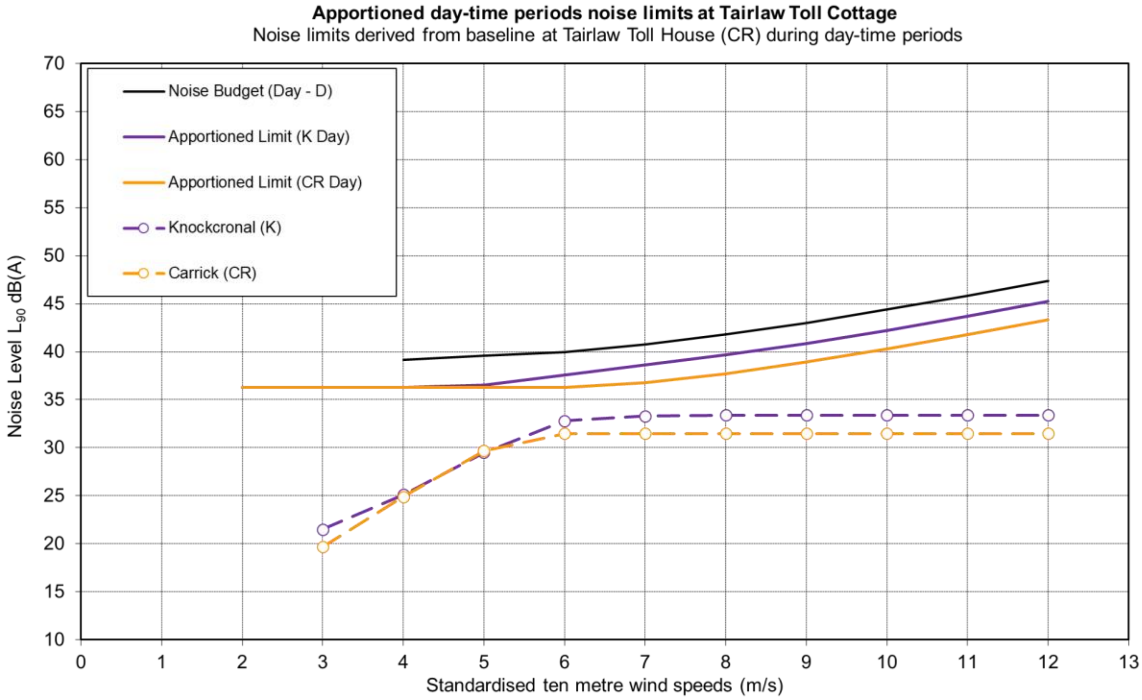


Figure E18 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time (from Carrick survey) for Tairlaw Toll Cottage, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

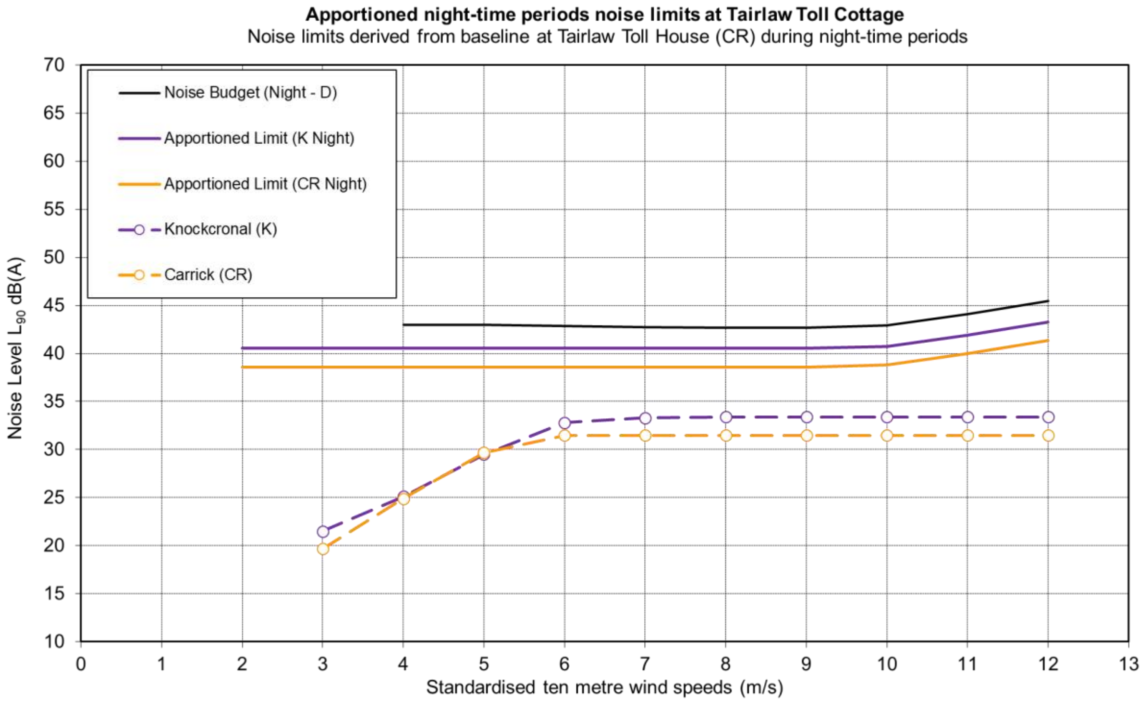


Figure E19 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the day-time (from Carrick survey) for Tallaminnoch, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

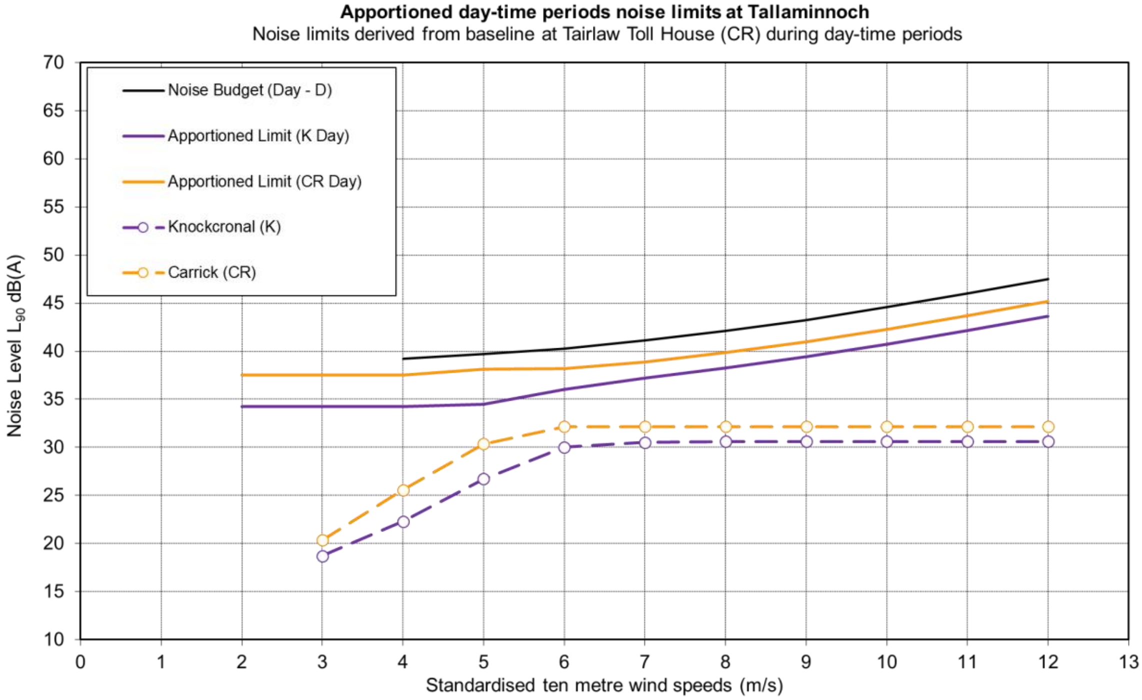


Figure E20 - Chart of remaining noise 'budget' after deducting the contribution from Dersalloch Windfarm (D) from the ETSU-R-97 based noise criteria / limit curve during the night-time (from Carrick survey) for Tallaminnoch, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K) and Carrick Windfarm (CR). Predicted noise immission levels also shown for the Proposed Development and Carrick Windfarm.

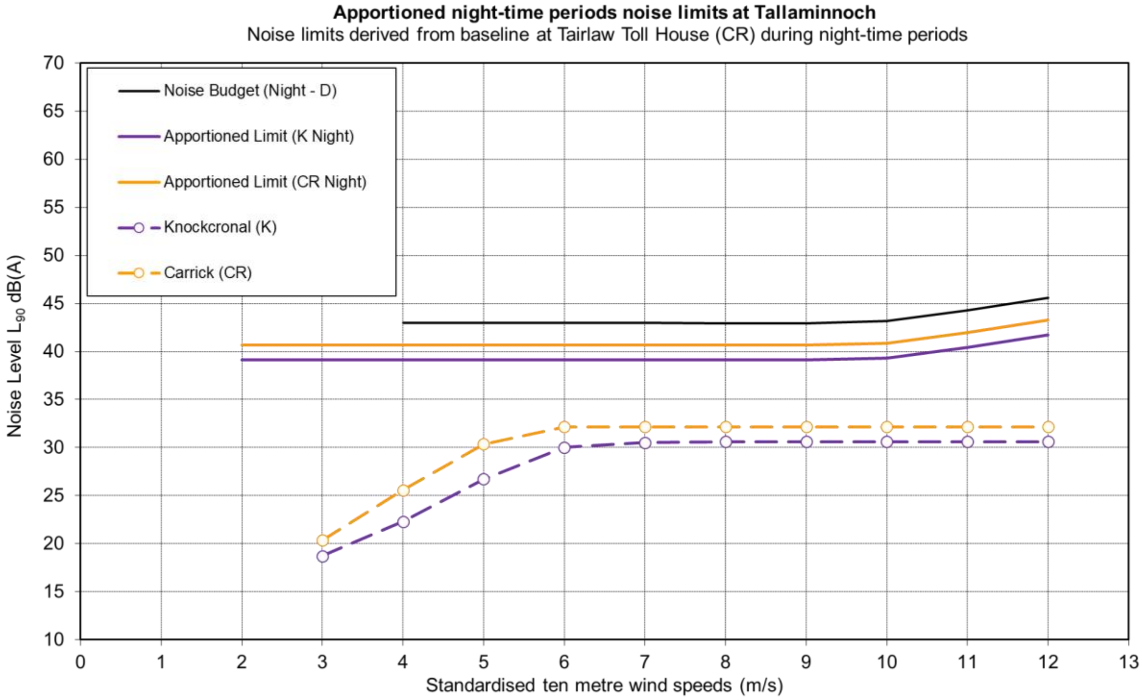


Figure E21 - Chart of the ETSU-R-97 based noise criteria / limit curve during the day-time (from Carrick survey) for Glenalla Farm, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K), Carrick Windfarm (CR) and Craiginmoddie Wind Farm (CM). Predicted noise immission levels also shown for the Proposed Development, Carrick Windfarm and Craiginmoddie Wind Farm.

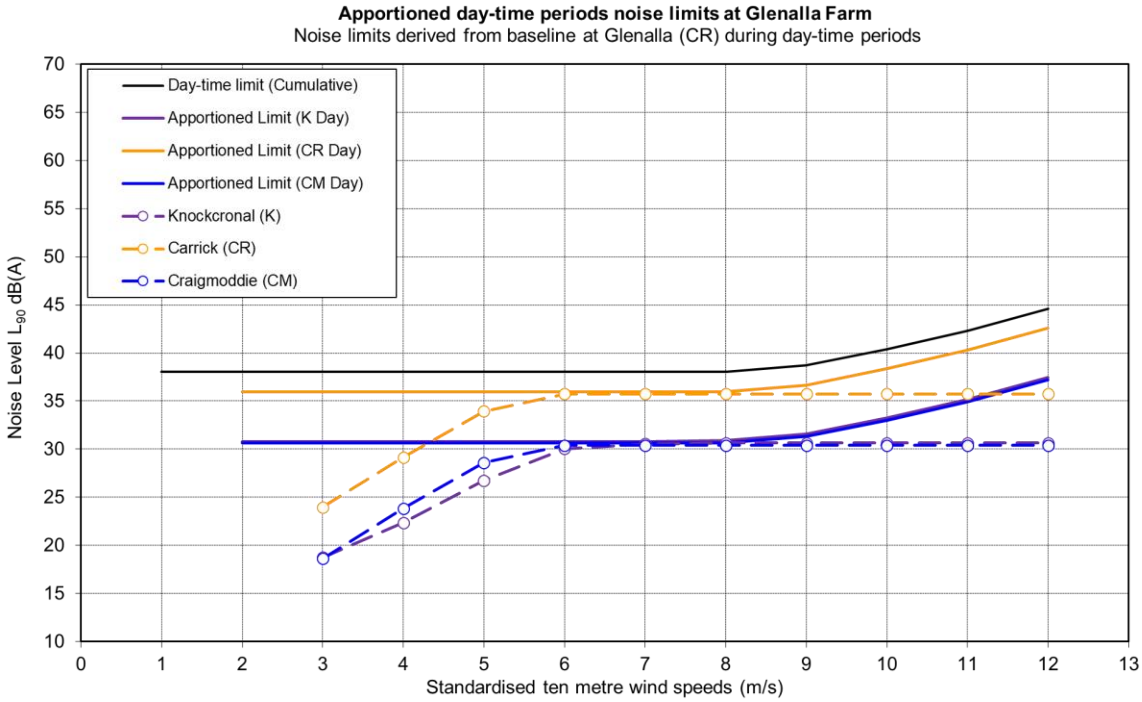


Figure E22 - Chart of the ETSU-R-97 based noise criteria / limit curve during the night-time (from Carrick survey) for Glenalla Farm, as well as the apportioned site-specific noise limits applicable to the Proposed Development (K), Carrick Windfarm (CR) and Craiginmoddie Wind Farm (CM). Predicted noise immission levels also shown for the Proposed Development, Carrick Windfarm and Craiginmoddie Wind Farm.

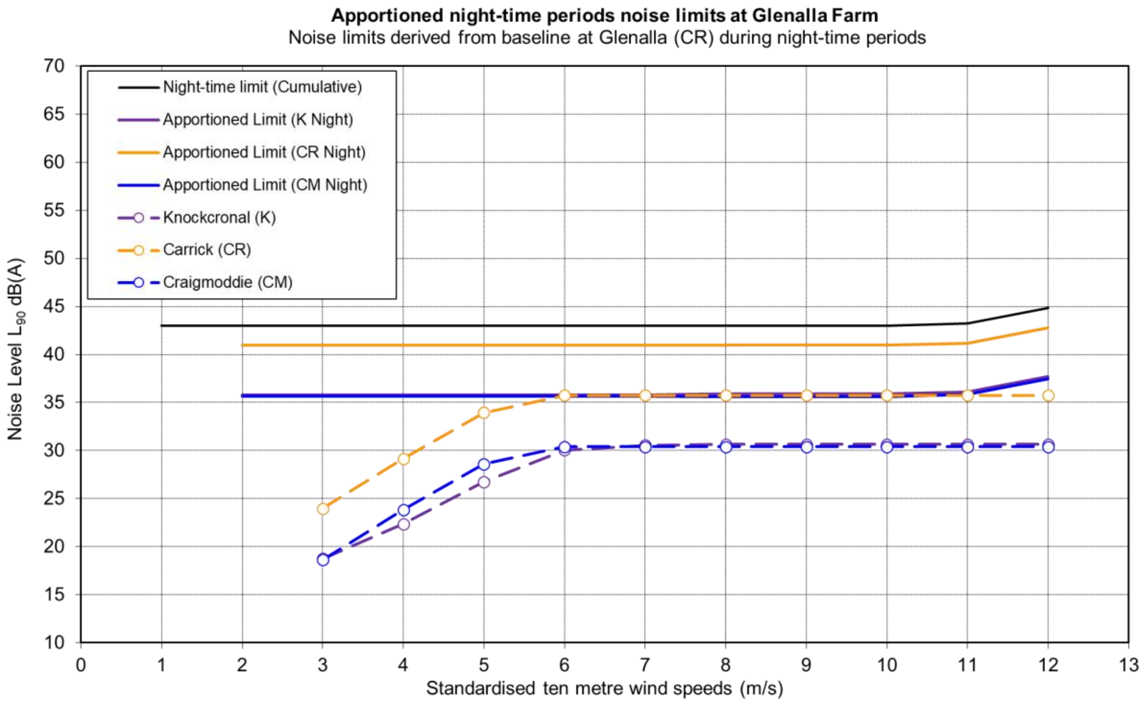


Table E1 – Site-specific partial noise limits ($L_{A90,T}$ dB) which could be applied to the Proposed Development at each of the noise assessment locations as a function of standardised wind speed for day-time periods.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	38.4	38.4	38.4	38.8	39.6	40.3	41.0	42.0	43.1	44.6	46.5
Knockskae	-	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	37.7	39.6	40.8
Linfairn Farm	-	37.3	37.3	37.3	37.3	37.3	38.6	39.9	41.2	42.3	43.5	44.8
Linfairn Farm (FI)	-	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.8
Tairlaw Toll Cot.	-	37.3	37.3	37.3	37.4	38.7	40.1	41.6	43.5	45.4	47.4	49.0
Tallaminnoch	-	35.2	35.2	35.2	35.4	37.1	38.6	40.1	41.9	43.8	45.7	47.3
Glenalla Farm	-	30.8	30.8	30.8	30.8	30.8	30.8	31.6	33.5	35.4	37.1	38.6
Genoch Cot. (CR)	-	36.4	36.4	36.4	36.4	36.4	36.4	36.8	38.4	40.0	41.7	43.4
Tairlaw Toll Cot. (CR)	-	36.2	36.2	36.2	36.5	37.6	38.6	39.6	40.8	42.2	43.7	45.2
Tallaminnoch (CR)	-	34.2	34.2	34.2	34.5	36.0	37.2	38.3	39.4	40.7	42.1	43.6
Glenalla Farm (CR)	-	30.8	30.8	30.8	30.8	30.8	30.8	30.9	31.6	33.3	35.2	37.5
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

Table E2 – Site-specific partial noise limits ($L_{A90,T}$ dB) which could be applied to the Proposed Development at each of the noise assessment locations as a function of standardised wind speed for night-time periods.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	42.7	44.9
Knockskae	-	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.9
Linfairn Farm	-	42.1	42.1	42.1	42.1	42.1	42.1	42.1	42.1	42.1	42.1	43.4
Linfairn Farm (FI)	-	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2
Tairlaw Toll Cot.	-	40.5	40.5	40.5	40.5	40.5	40.5	40.5	42.0	44.1	46.5	48.8
Tallaminnoch	-	39.1	39.1	39.1	39.1	39.1	39.1	39.1	40.5	42.5	44.8	47.1
Glenalla Farm	-	35.8	35.8	35.8	35.8	35.8	35.8	35.9	35.9	35.9	36.1	37.9
Genoch Cot. (CR)	-	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	42.8
Tairlaw Toll Cot. (CR)	-	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.7	41.9	43.3
Tallaminnoch (CR)	-	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.3	40.4	41.7
Glenalla Farm (CR)	-	35.8	35.8	35.8	35.8	35.8	35.8	35.9	35.9	35.9	36.1	37.7
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

Table E3 – Site-specific partial noise limits ($L_{A90,T}$ dB) which could be applied to the Carrick Windfarm at each of the noise assessment locations as a function of standardised wind speed for day-time periods.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	33.7	33.7	33.7	33.7	33.7	33.9	34.6	35.5	36.7	38.1	40.1
Knockskae	-	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	31.1	33.0	34.2
Linfairn Farm	-	30.2	30.2	30.2	30.2	30.2	31.1	32.2	33.5	34.7	35.8	37.1
Linfairn Farm (FI)	-	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	37.1
Tairlaw Toll Cot.	-	37.1	37.1	37.1	37.4	37.4	38.3	39.7	41.5	43.5	45.4	47.1
Tallaminnoch	-	38.5	38.5	38.5	39.0	39.3	40.3	41.6	43.5	45.4	47.3	48.9
Glenalla Farm	-	36.0	36.0	36.0	36.0	36.0	36.0	36.7	38.6	40.5	42.2	43.7
Genoch Cot. (CR)	-	30.1	30.1	30.1	30.1	30.1	30.1	30.3	31.9	33.5	35.2	37.0
Tairlaw Toll Cot. (CR)	-	36.2	36.2	36.2	36.2	36.2	36.7	37.7	38.9	40.3	41.8	43.3
Tallaminnoch (CR)	-	37.5	37.5	37.5	38.1	38.2	38.9	39.8	40.9	42.3	43.7	45.2
Glenalla Farm (CR)	-	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.7	38.4	40.3	42.6
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

Table E4 – Site-specific partial noise limits ($L_{A90,T}$ dB) which could be applied to the Carrick Windfarm at each of the noise assessment locations as a function of standardised wind speed for night-time periods.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Genoch Cot.	-	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	36.3	38.4
Knockskae	-	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.3
Linfairn Farm	-	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	35.7
Linfairn Farm (FI)	-	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5
Tairlaw Toll Cot.	-	38.6	38.6	38.6	38.6	38.6	38.6	38.6	40.1	42.2	44.5	46.9
Tallaminnoch	-	40.6	40.6	40.6	40.6	40.6	40.6	40.6	42.0	44.1	46.4	48.7
Glenalla Farm	-	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.2	43.0
Genoch Cot. (CR)	-	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	36.4
Tairlaw Toll Cot. (CR)	-	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.8	40.0	41.3
Tallaminnoch (CR)	-	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.8	41.9	43.3
Glenalla Farm (CR)	-	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.2	42.8
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

Table E5 – Site-specific partial noise limits ($L_{A90,T}$ dB) which could be applied to the Craiginmoddie Wind Farm at the Glenalla Farm noise assessment location as a function of standardised wind speed for day-time periods.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla Farm	-	30.6	30.6	30.6	30.6	30.6	30.6	31.3	33.2	35.1	36.8	38.3
Glenalla Farm (CR)	-	30.6	30.6	30.6	30.6	30.6	30.6	30.6	31.3	33.0	34.9	37.2
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

Table E6 – Site-specific partial noise limits ($L_{A90,T}$ dB) which could be applied to the Craiginmoddie Wind Farm at the Glenalla Farm noise assessment location as a function of standardised wind speed for night-time periods.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla Farm	-	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.8	37.6
Glenalla Farm (CR)	-	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.8	37.4
CR Comparison with noise limits derived from Carrick Windfarm noise survey data.												

HOARE LEA

MARK JIGGINS
ASSOCIATE

+44 1556 670052
markjiggins@hoarelea.com

HOARELEA.COM

155 Aztec West
Almondsbury
Bristol
BS32 4UB
England