12 NOISE

12.1 INTRODUCTION

1. This chapter of the Environmental Statement (ES) evaluates the effects of the proposed Freasdail Wind Farm (hereafter referred to as "the Development") on the Noise resource.

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

3. Additionally, RES has been project co-ordinators for several Joule[1] projects, leading European research into wind turbine noise, and was involved in producing the guideline 'The Assessment and Rating of Noise from Wind Farms'[2] for the DTI in 1996. For example, such papers include:

- An Investigation of Blade Swish from Wind Turbines, by Dr P Dunbabin, RES, proceedings of Internoise 1996 & International Congress on Noise Control Engineering;
- An Automated System for Wind Turbine Tonal Assessment, Ms R Ruffle, RES, proceedings of Internoise 1996 & International Congress on Noise Control Engineering;
- Wind Turbine Measurements for Noise Source Identification, ETSU W/13/003914/00.REP, 1999, Dr P Dunbabin, RES *et al*;
- A Critical Appraisal of Wind Farm Noise Propagation, ETSU W/13/00385/REP, 2000 Dr J Bass, RES;
- Aerodynamic Noise Reduction for Variable Speed Turbines, ETSU/W/45/00504/REP, 2000, Dr P Dunbabin, RES; and
- Fundamental research in amplitude modulation - a project by RenewableUK, Wind Turbine Noise 2011, Dr J Bass (steering group member).

4. Additional information, including survey photos, instrumentation details, charts, and suggested planning conditions are provided in the following Technical Appendices in Volume III of this ES:

- Technical Appendix A12.1 Background Noise Survey Photos and Locations;
- Technical Appendix A12.2 Noise Instrumentation Records; and
- Technical Appendix A12.3 Suggested Planning Conditions.

12.1.1 Wind Turbine Noise

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

6. Table 12.1 indicates the noise generated by wind turbines compared with other everyday activities[3].

Table 12.1: Noise generated by wind turbines compared with other everyday activities

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

13. As described by the Scottish Government in Onshore Wind Turbines Renewable Advice[4], most recently updated in May 2012:

> *"Technically, there are two quite distinct types of noise sources within a wind turbine - the mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise produced by the passage of the blades through the air. There has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design."*[4]

12.1.2 Construction Noise

14. The sources of construction noise, which are temporary, will vary both in location and their duration as the different elements of the Development are constructed and will arise primarily through the operation of large items of plant. Noise will also arise due to the temporary increase in construction traffic near the site; this level also depends on which element of the Development is being constructed at the time.

12.1.3 Operational Noise

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

12.1.3.1 Low Frequency Noise

16. The frequency range of 'audible noise' is generally taken to be 20 Hz to 20,000 Hz, with the greatest sensitivity to sound typically in the central 500 Hz to 4,000 Hz region. The range from 10 Hz to 200 Hz is generally used to describe 'low frequency noise', and noise with frequencies below 20 Hz used to describe 'infrasound'[5], although there is sometimes a lack of consistency regarding the definition of these terms in both common usage and the literature.

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

[2] ETSU, 1996. "The Assessment and Rating of Noise from Wind Farms", The Working Group on Noise from Wind Turbines, ETSU Report for the DTI, ETSU-R-97

[3] PPS22 ("Planning for Renewable Energy – A Companion Guide to PPS22", Office of the Deputy Prime Minister, August 2004)

[4] Scottish Government, 2011a. Web based renewables advice for Onshore wind turbines, www.scotland.gov.uk/Topics/Built-Environment/planning/National-Planning-Policy/themes/renewables/Onshore

[5] Leventhall, 2003. "A Review of Published Research on Low Frequency Noise and Its Effects", Report for DEFRA

17. Low frequency noise is always present, even in an ambient 'quiet' background[5]. It is generated by natural sources, including the sea, earthquakes, the rumble of thunder and wind. It is additionally an emission from many artificial sources found in modern life, such as household appliances (e.g. washing machines, dishwashers) and all forms of transport.

18. Noise emitted from wind turbines covers a broad spectrum from low to high frequencies. In relation to human perception of the broadband noise produced by wind turbines, the dominant frequency range is not the low frequency or infrasonic ranges[6]. The reason for this is that the perception threshold for hearing in these ranges is much higher than for speech frequencies of between 250 Hz and 4000 Hz. As a result of this decreased sensitivity, wind turbine noise at the lowest frequencies of the range described as 'low frequency noise' would be below the average hearing threshold.

19. A comprehensive literature review of 'Low Frequency Noise and Infrasound Associated with Wind Turbine Generator Systems', undertaken for the Ontario Ministry for the Environment in 2010, indicates that low frequency noise from wind turbines crosses the threshold boundary, and thus would be considered to become audible, above frequencies of around 40-50 Hz[6]. The degree of audibility depends upon the wind conditions, the degree of masking from background noise sources and the distance from the wind turbines[6].

20. Although audible under some conditions, a paper; 'Infrasound and low frequency noise from wind turbines: exposure and health effects'[7], published by the authors of a literature review on the subject prepared for the Swedish Environmental Protection Agency in 2011[8], concludes that the level of low frequency noise produced by wind turbines does not exceed levels from other common sources, such as road traffic noise[7].

21. In response to an article published in the national press in 2004, alleging that low frequency noise from wind turbines may give rise to adverse health effects, the Department of Trade and Industry (DTI) commissioned the Hayes McKenzie Partnership to perform an independent study to investigate these claims[9]. The Government released the following advice based on the report's findings:

> *"The report concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines."*[10]

22. This is re-iterated in the review undertaken for the Ontario Ministry for the Environment[5], which concludes that publications by medical professionals indicate that; at typical setback distances, the noise levels produced by wind turbines, including noise at low and infrasound frequencies, do not represent a direct health risk[6].

23. Whilst low frequency content of the noise from wind farms shall be considered through the use of octave band specific noise emission and propagation modelling within the assessment presented here, it is considered that specific and targeted assessment on low frequency content of noise emissions from the Development is unjustified.

[6] Ontario Ministry of the Environment, 2010. "Low Frequency Noise and Infrasound Associates with Wind Turbine Generator Systems, a Literature Review", OSS078696, December 2010
[7] Bolin *et al*, 2011. "Infrasound and low frequency noise from wind turbine: exposure and health effects", Environmental Research Letters 6, September 2011.
[8] SEPA, 2011, "A literature review of infra and low frequency noise from wind turbines: exposure and health effects", prepared for Swedish Environmental Protection Agency, November 2011
[9] Hayes, 2006. "The Measurement of Low Frequency Noise at Three UK Wind Farms", Contract Number W/45/00656/00/00, URN 06/1412, www.berr.gov.uk/files/file31270.pdf
[10] DTI, 2006. "Advice on findings of the Hayes McKenzie report on noise arising from Wind Farms", URN 06/2162, dated November 2006, www.berr.gov.uk/files/file35592.pdf

12.1.3.2 Infrasound

24. In relation to infrasound in general; frequencies below 20 Hz may be audible, although tonality is lost below 16 - 18 Hz, thus losing a key element of perception[5]. In relation to modern, upwind turbines; there is strong evidence that the levels of infrasound produced will be well below the average threshold of human hearing[6]. The aforementioned DTI report[9] extended this conclusion to more sensitive members of the population:

> *"Even assuming 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*[9]*.*

25. As such:

> *"infrasound from wind turbines is not audible at close range and even less so at distances where residents are living"*[5].

26. In February 2005, the BWEA[11] published background information on low frequency noise from wind farms[12]. The conclusion states that:

> *"It has been repeatedly shown, by measurements of wind turbine noise undertaken in the UK, Denmark, Germany and the USA over the past decade, and accepted by experienced noise professionals, that the levels of infrasonic noise and vibration radiated from modern upwind configuration wind turbines are at a very low level; so low that they lie below the threshold of perception, even for those people who are particularly sensitive to such noise, and even on an actual wind turbine site"*[11]

27. The BWEA report goes on to quote Dr Geoff Leventhall, author of the DEFRA report on "Low Frequency Noise and its Effects"[11], as saying:

> *"I can state, quite categorically, that there is no significant infrasound from current designs of wind turbines"*[11]

28. With regard to health effects, the DTI report quotes the document 'Community Noise', prepared for the World Health Organisation (WHO), which states that:

> *"there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects"*[9]

29. The DTI report goes on to conclude 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"*[9]

30. Furthermore, researchers at Keele University explain that:

> *"The infrasound generated by wind turbines can only be detected by the most sensitive equipment, and again this is at levels far below that at which humans will detect the low frequency sound. There is no scientific evidence to suggest that infrasound has an impact on human health."*[13]

[11] BWEA is now known as RenewableUK, a group representing the concerns of companies in the Renewable Energy Industry
[12] BWEA, 2005. "Low Frequency Noise and Wind Turbines", The British Wind Energy Association, www.bwea.com/ref/lowfrequencynoise.html & Technical Annex www.bwea.com/pdf/lfn-annex.pdf
[13] Styles, & Toon, 2005. "Wind farm noise", printed in the Scotsman newspaper as a rebuttal of claims made by the Renewable Energy Foundation, August 2005

31. Therefore, in accordance with literature, it is not considered appropriate or relevant to undertake specific assessment in relation to infrasound for the Development.

12.1.3.3 Sleep Disturbance

32. The Department of Trade and Industry's 'The Assessment and Rating of Noise from Wind Farms, hereafter referred to as 'ETSU-R-97', states that different limits should be applied during quiet waking and night-time hours. The quiet waking hour's limits are intended to preserve outdoor amenity, while the night-time limits are intended to prevent sleep disturbance. The night-time criterion is derived from the 35 dB(A) sleep disturbance criterion referred to in ETSU-R-97, with an allowance of 10 dB(A) for attenuation through an open window (which is conservative) and a correction of 2 dB(A) to allow for the use of L_{A90}, rather than L_{Aeq}.

33. A report entitled "Sleep Disturbance and Wind Turbine Noise" by Dr Christopher Hanning reviewed the potential consequences of wind turbine noise and its effect on sleep and health, and made recommendations on setback distances[14]. The report was created on behalf of Stop Swinford Wind Farm Action Group (SSWFAG). Dr Hanning states that:

> *"There can be no doubt, that groups of industrial wind turbines ("wind farms") generate sufficient noise to disturb the sleep and impair the health of those living nearby"*

34. Dr Hanning's paper fails to acknowledge the link between noise level and sleep disturbance. This link is acknowledged in the most recent advice published by the World Health Organisation Night Noise Guidelines for Europe[15]. This report recommends acceptable levels of night time noise below which no appreciable adverse effects on sleep can reasonably be identified and levels above which sleep effects may be expected.

35. The levels identified in these guidelines indicate an outdoor annualised free field noise level of 40 dB(A). Such averaging would allow short term levels in excess of this. In comparison to the likely noise limits to be imposed upon the wind farm, based upon ETSU-R-97 recommendations, this 40 dB(A) annualised limit is much more lenient. There will be significant portions of time that the noise levels shown in this report, due to wind direction, wind speed or conservatism in modelling, are not realised.

36. In another article published by Dr Hanning and Professor Alun Evans, in the British Medical Journal [14] it states:

> *"A large body of evidence now exists to suggest that wind turbines disturb sleep and impair health at distances and external noise levels that are permitted in most jurisdictions, including the United Kingdom."*

37. Therefore, research evidence supports the conclusion that noise from any source will result in measurable effects on sleep when it reaches a certain level. Such effects may comprise changes in sleep state without those exposed actually awakening, or they may comprise complete awakenings. Either of these responses may or may not have a consequential long term effect on wellbeing depending on the subjects concerned and the extent of the effects being considered.

38. There is no reason why wind turbine noise should be any different to other forms of noise, in that there will be a certain level at which wind turbine noise would affect the sleep of those exposed to it. As with other forms of noise, some variability in response across the exposed population would be expected, with some people being more noise sensitive and others more noise tolerant.

39. In a report by the Chief Medical Officer of Health of Ontario[6], in response to public health concerns about wind turbine noise, the review concluded that:

> *"...while some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects. The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct health effects..."*

40. Since ETSU-R-97 accounts for sleep disturbance when setting night time noise limits, it is therefore concluded that protection from sleep disturbance is adequately considered within this assessment.

12.1.3.4 Vibration

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

42. A report by Snow gives details of low frequency noise and vibration measurements made at a wind farm[16]. Measurements were made both on the wind farm site, and at distances of up to 1 km. It was found that the vibration levels at 100 m from the nearest turbine itself were a factor of 10 lower than those recommended for human exposure in the most critical buildings (i.e. laboratories for precision measurements), and lower again than the limits specified for residential premises[17]. Noise and vibration levels were found to comply with recommended residential criteria, even on the wind turbine site itself, and the acoustic signal was below the generally assumed frequency range of audible noise i.e. below 20 Hz. In addition, it was found that there was no clear relationship between vibration levels and wind speed, and that some vibrations appeared to come from other sources, as they were found even when the turbines were switched off.

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

> *"The levels of vibration from wind turbines are so small that only the most sophisticated instrumentation and data processing can reveal their presence, and they are almost impossible to detect"*[13].

44. They go on to say:

> *"Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise - they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health"*[13]

45. Therefore, in accordance with literature, it is not considered appropriate or relevant to undertake specific assessment in relation to vibration caused by the operation of the Development.

[14] Hanning, 2009, "Sleep Disturbance and Wind Turbine Noise", 2009
[15] WHO, 2009. "Night Noise Guidelines for Europe", World Health Organisation, 2009
[16] Snow, 1997. "Low Frequency Noise & Vibration Measurements at a Modern Wind farm", ETSU W/13/00392/REP=
[17] BSI, 1992. "Guide to Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)", British Standards Institution, BS 6472

12.1.3.5 Aerodynamic Modulation

46. The noise normally associated with wind turbines and commonly referred to as "Swish" is the modulation of aerodynamic noise produced at blade passing frequency (the frequency at which a blade passes a fixed point). This noise character is acknowledged by, and accounted for, in the recommendations of ETSU-R-97[2]. However the aforementioned DTI report[9] researching low frequency noise and/or infrasound emitted by wind turbines noted that a related phenomenon known as 'Aerodynamic Modulation' (AM) - alternatively referred to as 'Amplitude Modulation', was, in some isolated circumstances, occurring in ways not anticipated by ETSU-R-97. Such AM above and beyond that considered by ETSU-R-97 is often referred to as Excess, or Other, AM.

47. To investigate whether or not Other AM was an issue which might require attention in the context of the rating advice in ETSU-R-97, the Government subsequently commissioned the University of Salford to undertake further research in the area[9].

48. On 1 August 2007, the Government issued a statement[18] regarding the findings of the University of Salford report into (Other) AM of wind turbine noise[19] published earlier in 2007 which found that, of 133 operational wind farms in the UK at the time of the report, there were only 4 cases where AM may have been a factor. It is known that complaints have now subsided for 3 of these cases (one due to introduced mitigation by a wind farm control system) and in the remaining case a settlement has been reached. The statement says that:

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

49. In consequence the statement[19] makes it clear that the approach contained in the ETSU-R-97 report, to assess and rate noise from wind energy developments, is still recommended.

50. Several potential causes for these occurrences of this Other AM have been suggested including: high wind shear; stall; yaw error; blade-tower interaction; inflow turbulence; & wake interference between closely located turbines. There is, however, currently no clear evidence to support any of the proposed causative mechanisms of Other AM. This is partly due to the difficulty in obtaining sufficiently detailed measurements of Other AM and the conditions under which it occurs, this being as a direct consequence of the infrequency of occurrence and the small number of sites at which high levels of Other AM have been reported. Consequently, the cause of Other AM is still a subject of ongoing research.

51. There is no evidence to suggest that the Development is likely to result in AM greater than that accounted for in ETSU-R-97.

52. As the occurrence of "Other AM" at any given site and the frequency of the occurrence at sites where it is acknowledged to exist is low, it is RES's opinion that a specific noise condition relating to Other AM is not required on the planning basis of necessity. Should the unlikely event occur that Other AM manifests at the Development and gives rise to complaint it should be noted that action could still be taken against the operator via statutory nuisance legislation.

53. Therefore, in accordance with literature and advice, it is not considered appropriate or relevant to undertake specific assessment in relation to AM above and beyond that considered by ETSU-R-97 that may be potentially produced by the operation of the Development.

12.1.3.6 Wind Turbine Syndrome

54. The condition proposed by paediatrician Dr Nina Pierpont in her report 'Wind Turbine Syndrome: A Report on a Natural Experiment'[20] cites a range of physical sensations and effects as being caused by living near a wind farm. This study is based on a series of interviews comprising a study group of 10 families. It is a self-published report with none of the research being published in any peer reviewed medical journal.

55. In a NHS response to the Pierpont report, a report titled 'Are wind farms a health risk?'[21] states that there is no conclusive evidence that wind turbines have an effect on health or are causing the set of symptoms described as 'wind turbine syndrome'. It was noted that the group study by Pierpont was not sufficient to grant the claims stated.

56. A scientific advisory panel conducted a review of current literature available on the issue of perceived health effects of wind turbines 'Wind Turbine Sound and Health Effects - An Expert Panel Review'[22]. This was carried out by the American and Canadian Wind Energy Associations and the conclusion on Wind Turbine Syndrome was that it is:

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

57. The goes on to say:

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

58. A further independent review of the state of knowledge about the alleged health condition was carried out[23]. This report includes three expert opinions provided by: Richard J.Q. McNally - Reader in Epidemiology at the Institute of Health and Society Newcastle University; Geoff Leventhall - an independent consultant specialising in low frequency noise, infrasound and vibration; and Mark E. Lutman - Professor of Audiology at the University of Southampton. Their critique of Pierpont's study concludes that the reported symptoms are the effects mediated by stress and anxiety when exposed to an adverse element in their environment. There is no evidence that they are patho-physiological effects of wind turbine noise.

59. A paper by Pedersen explores data from three cross-sectional studies comprising A-weighted sound pressure levels of wind turbine noise, and subjectively measured responses from 1,755 people, to find the relationships between sound levels and aspects of health and well-being. It was concluded that there is no consistent association between wind turbine noise exposure and the symptoms associated with Wind Turbine Syndrome[24].

[18] BERR, 2007. "Government statement regarding the findings of the Salford University report into Amplitude Modulation of Wind Turbine Noise", URN 07/1276, dated July 2007, www.berr.gov.uk/files/file40571.pdf
[19] University of Salford, 2007. "Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report", URN 07/1235, dated July 2007, www.berr.gov.uk/files/file40570.pdf
[20] Pierpont, 2009. "Wind Turbine Syndrome - A Report on a Natural Experiment", K-Selected Books.
[21] NHS, 2009. "Are wind farms a health risk?", www.nhs.uk/news/2009/08August/Pages/Arewindfarmsahealthrisk.aspx
[22] Colby *et al.*, 2009. "Wind Turbine Sound and Health Effects - An Expert Panel Review 2009", prepared for American Wind Energy Association and Canadian Wind Energy Association.
[23] RenewableUK, 2010. "Wind Turbine Syndrome (WTS) - An independent review of the state of knowledge about the alleged health condition", www.bwea.com/pdf/publications/HS_WTS_review.pdf
[24] Pedersen, 2011. "health aspects associated with wind turbine noise-results from three field studies" Noise Control Engineering Journal, Volume 59, Issue 1

60. Therefore, in accordance with literature, it is not considered appropriate or relevant to undertake specific assessment in relation to Wind Turbine Syndrome potentially caused by the operation of the Development.

12.1.3.7 Construction Noise

61. The assessment of the effects of construction noise from the Development presented here is based on the applicant's s experience of constructing wind farms and calculated for the operation of the primary large items of construction equipment. Additionally, consideration is given to the increased noise levels due to increased traffic flows during the construction phase to and from the site.

62. Whilst noise will also arise during decommissioning of the Development, this is not discussed separately as noise levels resulting from it would be lower than those from the construction activity since this would likely only involve removing turbines and applying topsoil covering to concrete bases.

12.1.4 Legislative Framework and Guidance

12.1.4.1 Operational Noise

63. Within Scotland, noise is defined within the planning context by 'Planning Advice Note 1/2011: Planning and Noise'[25]. This Planning Advice Note provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. It supersedes Circular 10/1999 Planning and Noise and PAN 56 Planning and Noise. The Planning Advice Note 1/2011 states that:

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

64. Planning Advice Note 1/2011 refers to the use of 'ETSU-R-97', in the web based planning advice on renewable technologies for Onshore wind turbines[4]. In relation to noise from wind farms the web-based renewables advice states:

65. ETSU-R-97, describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available.

66. It is therefore considered that the use of ETSU-R-97, as criteria for assessment of wind farm noise, fulfils the requirements of Planning Advice Note 1/2011[25].

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

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

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

> *"Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities."*[2]

70. ETSU-R-97 provides a robust basis for assessing the noise effects of a wind farm and has been applied at the vast majority of wind farms currently operating in the UK and is proposed as adequate for use in this assessment. Based on the advice of planning policy as outlined above, a wind farm which can operate within the noise limits which have been derived according to ETSU-R-97 is considered to be acceptable. This approach is consistent with relevant planning policy and has been agreed with the Council Environmental Health Officer, as appropriate - refer to section 12.2.1.

71. An article published in the Institute of Acoustics Bulletin Vol. 34 No. 2, March/April 2009[26], recommends a methodology for addressing issues not made explicit by, or outside the scope of, ETSU-R-97 - such as in relation to wind shear or noise propagation modelling. Whilst this article does not represent formal legislation or guidance it was authored by a group of independent acousticians experienced in wind farm noise issues working for both wind farm developers, local planning authorities and third parties and as such is a good indicator of best practice techniques. The assessment presented herein adopts the recommendations made within this article.

12.1.4.2 Construction Noise

72. In the web based Scottish Government technical advice on construction noise assessment in 'Appendix 1: Legislative Background, Technical Standards and Codes of Practice'[27] it is stated that:

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

73. This refers to BS 5228-1:2009 'Noise control on construction and open sites' Part 1 - Noise[28] and is identified as being suitable for the purpose of giving guidance on appropriate methods for minimising noise from construction activities, and is adopted herein.

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

12.2 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

12.2.1 Consultation

75. Consultation has been undertaken to inform the scope and methods used in the assessment, and to reach agreement on these with Argyll and Bute Council. Consultation undertaken is outlined in Table 12.2.

[25] PAN 1, 2011. "Planning Advice Note 1/2011: Planning and Noise", Scottish Government policy, March 2011

[26] Institute of Acoustics, 2009. "Prediction and Assessment of Wind Turbine Noise", Dr A Bullmore and M Jiggins (Hoare Lea Acoustics), Dr A McKenzie and M Hayes (Hayes McKenzie Partnership), D Bowdler (New Acoustics), R Davis (RD Associates) & Dr G Leventhall, Acoustics Bulletin Vol 34 No 2 March/April 2009

[27] Scottish Government, 2011b. Web based Technical Advice Note: Assessment of Noise, www.scotland.gov.uk/Publications/2011/03/02104659/8

[28] BSI, 2009. "Noise and vibration control on construction and open sites - Part 1: Noise", British Standards Institution, BS 5228-1:2009

Table 12.2: Acoustic Assessment Consultation

Consultees	Date of Consultation	Nature and Purpose of Consultation
Argyll and Bute Council	8th Nov 2011	A scoping opinion request for the Development was sent to Argyll and Bute Council
Argyll and Bute Council	20th Jan 2012	Response to the scoping opinion request was received from Andrew Hill, Environmental Health Officer (EHO) Argyll and Bute
Argyll and Bute Council	23rd Jan 2012	Email response from Andrew Hill reviewing the proposed acoustic assessment for Freasdail Wind Farm and agreement of background noise survey locations, (**RES, 2011a**).
Argyll and Bute Council	20th Feb 2012	EHO agreed to attend site setup and attended on 23rd Feb 2012.
Argyll and Bute Council	23rd May 2012	RES sent updated report "Noise Survey locations for the Acoustic Assessment at the Proposed Freasdail Wind Farm" (ref. 02564-000637) to the EHO. This report provided details of actual survey locations after setting up the background noise survey.
Argyll and Bute Council	30th May 2012	Email response from the EHO confirming acceptance of the noise monitoring locations.
Public	23rd Aug 2012 – 25th Aug 2012	Public exhibitions held at Glenbarr, Whitehouse and Campbeltown.

12.2.2 Scope of Assessment

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

77. The timescales for decommissioning result in a lack of certainty over the specific activities and machinery likely to be involved. However, it is anticipated that sources of noise during decommissioning are likely to be limited to removal of turbines and on-site buildings, and movement of topsoil during restoration. The emissions associated with these activities are likely to be substantially lower than those associated with the construction of the Development, and will be subject to appropriate control restrictions at the time. The effects of decommissioning are therefore not discussed separately in this assessment.

12.2.3 Operational Noise

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

- The baseline noise conditions at each of the nearest neighbours to the Development were established by way of representative background noise surveys - refer to Section 12.3.2 in this chapter;
- The noise levels incident at the nearest neighbours due to the combined operation of all the wind turbines for the Development using a sound propagation model were estimated giving due regard to the locations of the wind turbines, the locations of the nearest, or most noise sensitive neighbours, the intervening terrain, and the likely noise emission characteristics of the wind turbines - refer to section 12.3.1 in this chapter;
- With due regard to relevant guidance or regulations the acoustic assessment criteria were derived - refer to section 12.5.1.2; and
- The assessment of acceptability was undertaken by comparing the estimated noise levels with the assessment criteria - refer to section 12.5.1.2.

12.2.3.1 Method for Establishing Baseline Conditions

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

80. Since background noise levels depend upon wind speed, as indeed do wind turbine noise emissions, it is important when making reference measurements that they are set in the context of the wind speed. Thus, the assessment of background noise levels at potentially sensitive neighbouring locations requires the measurement of not only noise levels, but concurrent wind conditions, covering a representative range of wind speeds. These wind measurements are made at the wind turbine site rather than at the properties, since it is this wind speed that will subsequently govern the wind farm's noise generation. Often the neighbouring properties themselves will be sheltered from the wind and will consequently have relatively low background noise.

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

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

83. The adoption of this wind speed was presented as appropriate within the article published in the Institute of Acoustics Bulletin[26]. Box 12.1 provides details of the wind speed used for correlation.

Box 12.1: Calculating Standardised Wind Speed

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

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

Two options are available in order to reconcile potential anomalies:

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

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

(1) **"Standardised" 10m Wind Speeds are Calculated**

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

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

(2) **Correlation of "Standardised" 10m Wind Speeds with Background Noise Data**

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

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

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

85. For each background noise measurement location, the measured noise data have been divided into two sets, as specified by ETSU-R-97 and shown in Table 12.3:

Table 12.3: Definition of Time of Day Periods

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

12.2.3.2 Method for Modelling Noise Propagation

86. Whilst there are several sound propagation models available the ISO 9613 Part 2 model has been used[29] , this being identified as most appropriate for use in such rural sites[30]. The specific interpretation of the ISO 9613 Part 2 propagation methodology has been employed as in the aforementioned Institute of Acoustics bulletin article[26] – refer to paragraph 89.

87. To make noise predictions it is assumed that:

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

88. The model takes account of:

- Attenuation due to geometric spreading;
- Atmospheric absorption;
- Ground effects; and
- Barrier effects.

89. The barrier attenuations predicted by ISO 9613 Part 2 have been shown to be significantly greater than those measured in practice under downwind conditions[30]. Therefore, barrier attenuation

[29] ISO, 1996. "Acoustics - Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation", International Organisation for Standardisation, ISO 9613-2:1996
[30] ETSU, 2000. "A Critical Appraisal of Wind Farm Noise Propagation", ETSU Report W/13/00385/REP

according to the ISO 9613 Part 2 method has been discounted. In lieu of this, where there is no direct line of sight between the property in question and any part of the wind turbine, 2 dB attenuation has been assumed as recommended in the aforementioned Institute of Acoustics bulletin article[26].

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

91. The predicted noise levels are changed from the LAeq to the LA90 descriptor (to allow comparisons to be made) by the use of an adjustment factor of 2 dB, as specified by ETSU R 97.

92. It has been shown by measurement based verification studies that the ISO 9613 Part 2 model tends to slightly over-estimate noise levels at nearby dwellings[30]. Examples of additional conservatism modelled are:

- Downwind propagation is modelled in all directions. In reality, noise propagation biases towards downwind locations, therefore predicted values are overestimated for upwind and crosswind of the proposed wind turbines;
- Although, in reality, the ground is predominantly porous (acoustically absorptive) it has been modelled as 'mixed', i.e. a combination of hard and porous, corresponding to a ground absorption coefficient of 0.5 as recommended by the Institute of Acoustics bulletin article[26];
- Receiver heights are modelled at 4.0 m above local ground level, which equates roughly to first floor window level. This results in a predicted noise level anything up to 2 dB(A) higher than at the 'standard' assessment height of 1.2-1.8 m;
- Trees and other non-terrain shielding effects have not been considered; and
- Warranted sound power levels of the presented turbine have had 1 dB added to allow for measurement uncertainty should the turbine emission levels be specifically tested.

12.2.3.3 Method for Deriving the Assessment Criteria

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

94. Planning Policy Guidance Note PPG 24: Planning and Noise[31] states:

> *"A change of 3 dB(A) is the minimum perceptible under normal conditions, 5dB is a clearly perceptible change and a change of 10 dB(A) corresponds roughly to a halving or doubling the loudness of a sound"*

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

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

> *"if the noise is limited to an $L_{A90,10min}$ of 35dB(A) up to wind speeds of 10 m/s at 10 m height, then these conditions alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary"*[2].

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

Table 12.4 Permissible Noise Level Criteria

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

98. It should be noted that a higher noise level is permissible during night-time hours than during quiet waking hours, as it is assumed that residents would be indoors. The night-time criterion is derived from sleep disturbance criterion referred to in ETSU-R-97, with an allowance of 10 dB for attenuation through an open window.

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

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

12.2.3.4 Method for Construction Noise Assessment

101. To ensure adequate assessment of the potential effects of the construction noise from the Development the following steps have been taken:

- Baseline noise criteria is established from the appropriate guidance BS 5228-1:2009 'Noise control on construction and open sites'[28] - refer to section 12.3;
- Noise predictions are made at the most critically sensitive properties due to on-site construction activities. These are calculated using the BS 5228-1:2009 standard - refer to section 12.5.2.1;
- Predictions are made at the same properties due to construction traffic and are calculated using the BS 5228-1:2009 standard - refer to section 12.5.2.2; and

[31] PPG 24, 1994. "Planning Policy Guidance 24: Planning and Noise", Office of the Deputy Prime Minister, September 1994.

- The combined effect of on-site construction activities with construction traffic is compared with the target level specified by BS 5228-1:2009 - refer to section 12.5.2.4.

12.3 BASELINE CONDITIONS

12.3.1 Operational Noise

102. The approximate centre point of the Development is located approximately 2.5 km south of Whitehouse. The surrounding area is predominantly rural in nature, large areas of commercial forestry and used for grazing sheep and cattle with an A-class road running to the North of the site. The general noise character is typical of a rural environment with noise from farm machinery, sheep, cattle and birds.

103. Background noise measurements were undertaken by RES in accordance with ETSU-R-97 as detailed in Table 12.5. The equipment was housed in weather-proof enclosures, and powered by lead-acid batteries. The microphones were placed at a height of approximately 1.2 m - 1.5 m above ground, and equipped with all-weather wind shields to provide an element of water resistance.

104. Noise levels were monitored continuously, and summary statistics stored every 10 minutes in the internal memory of each meter. The relevant statistic measured is the LA90, 10min (The A-weighted sound pressure level exceeded for 90 % of the 10 minute interval).

105. Measurements were made at these locations as they are the most noise sensitive dwellings geographically spread around the proposed site and are more likely to be representative of other houses in the locale. The background noise measurements were agreed in consultation with Argyll and Bute Council[32].

Table 12.5: Background Noise Survey Details

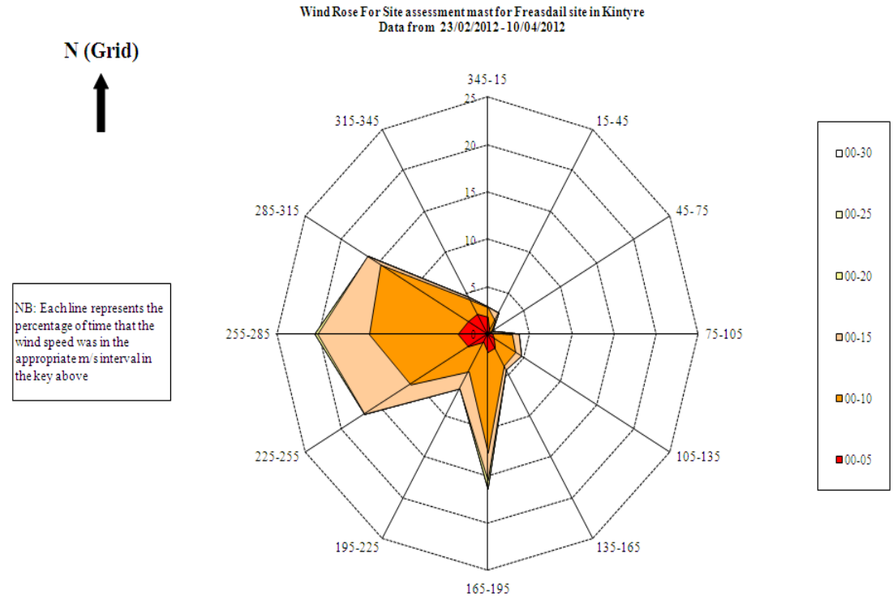
House Name	Measurement Period			Instrument Type
	Start	End	Duration (days)	
Grassfield Farm	23/02/2012	10/04/2012	37[33]	Rion NL31
Housing Plots	23/02/2012	10/04/2012	46[34]	Rion NL31
Lochview	23/02/2012	10/04/2012	36[35]	Rion NL31
Redesdale House	06/03/2012	10/04/2012	36	Rion NL31

106. The meters were placed in moderately exposed positions, away from reflecting walls and vegetation. Photos of the equipment, *in situ*, may be seen in Technical Appendix 12.1. The apparatus were calibrated before and after the survey period and no significant drift was detected. All instrumentation has been subject to laboratory calibration traceable to national standards within the last 24 months, details are provided in Technical Appendix 12.2.

107. The raw noise data and concurrent wind measurements are available upon request for the purposes of further assessment of the Development.

108. Chart12.1 shows the measured wind rose at Freasdail over the background noise survey period, as measured by the meteorological mast located on-site.

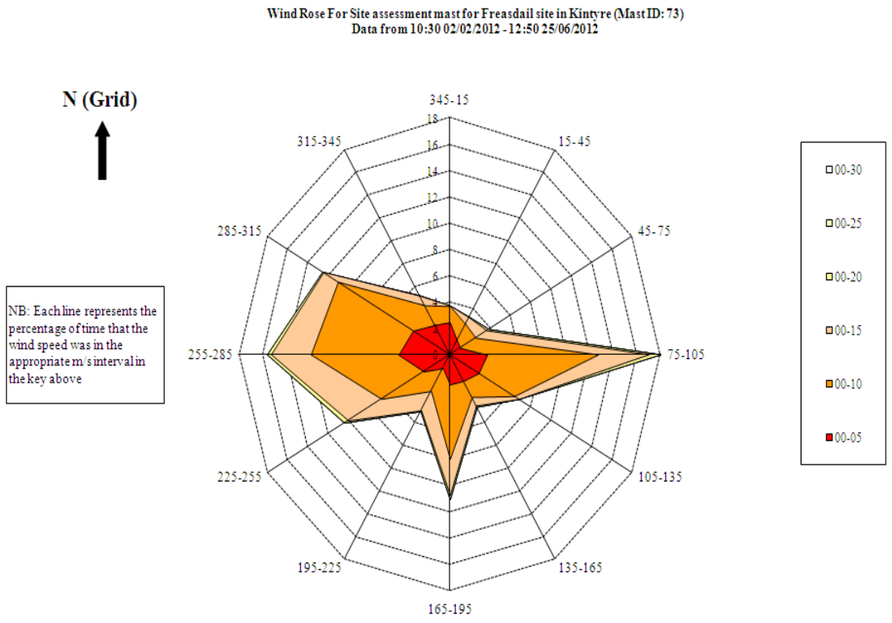
Chart 12.1 Wind Speed and Direction during the Background Noise Survey



109. For illustrative purposes, Chart 12.2**Error! Reference source not found.** shows the measured wind rose over an extended period (02/02/2012 – 08/05/2012) from the 80m high meteorological mast located at the Development site. As discussed before, the noise prediction model employed is likely to overestimate the real noise immission levels for locations not downwind of the turbines. Chart 12.2 therefore may aid the reader as to the likelihood of over-estimation due to this factor.

[32] RES, 2011a. Emails from Andrew Hill, Environmental Health Officer, Argyll and Bute Council, with Colin Bothwell, RES references 02564-000802
[33] Approximately 11 days of data were lost due to battery failure.
[34] Approximately 2 days of data were lost to battery failure.
[35] Approximately 12 days of data were lost due to battery failure.

Chart 12.2: Measured Wind Rose over longer period of 5 months



110. The noise data have been cross-referenced with rainfall data measured at an onsite met mast, and the noise data during periods of rainfall have been removed from the analysis as shown in Chart 12.3 to Chart 12.10.

Chart 12.3: Noise Limits and Background Noise Levels during Quiet Waking Hours at Redesdale House

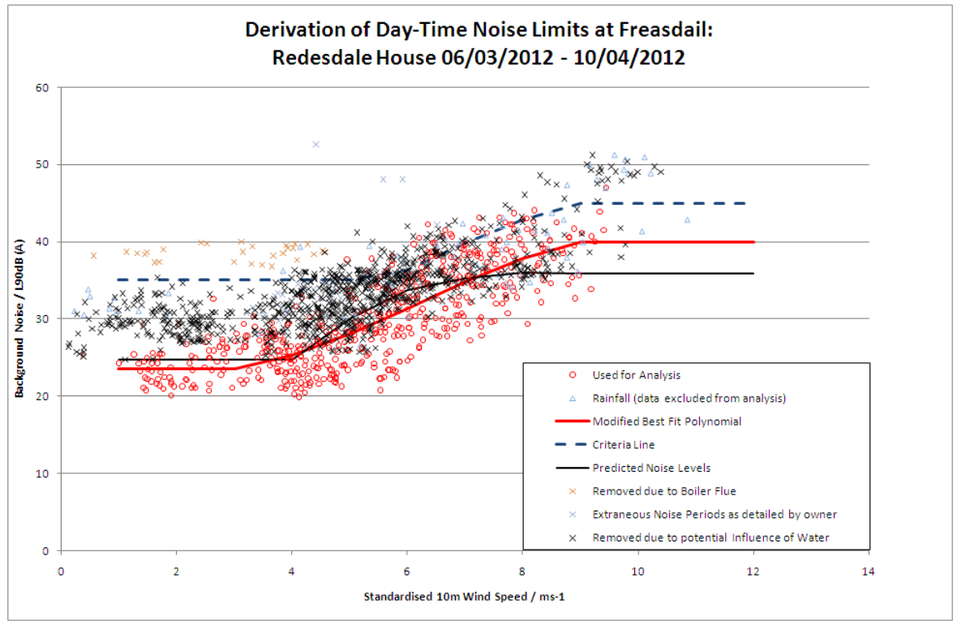


Chart 12.4: Noise Limits and Background Noise Levels during Quiet Waking Hours at Lochview

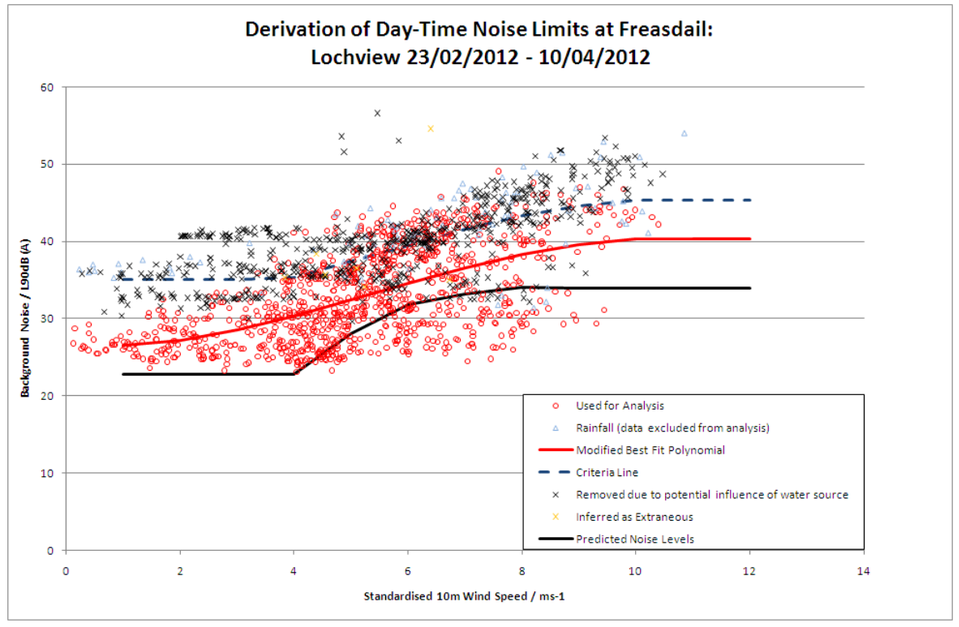


Chart 12.5: Noise Limits and Background Noise Levels during Quiet Waking Hours at Housing Plots

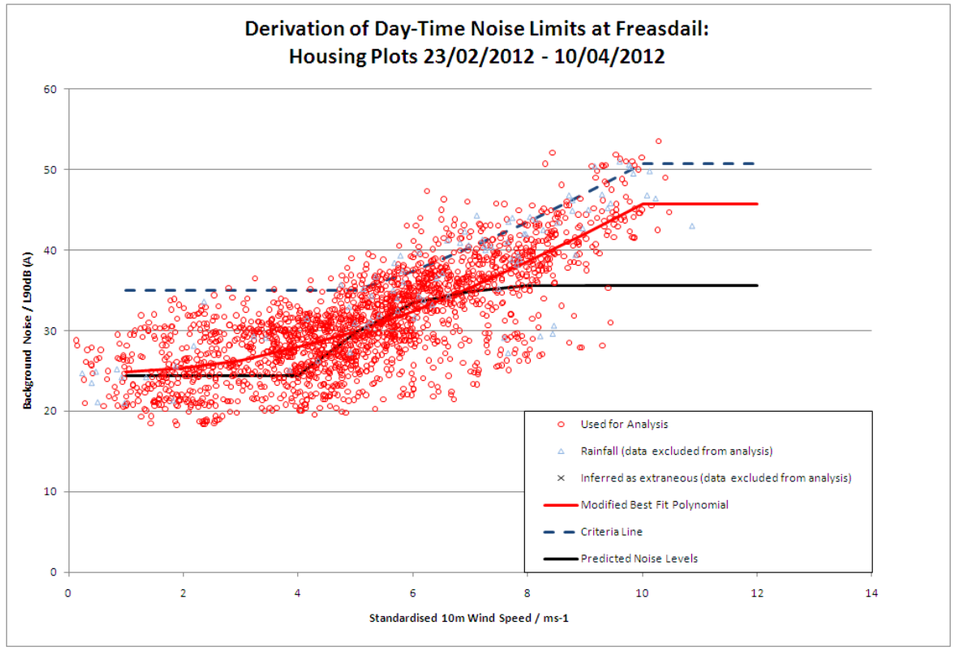


Chart 12.6: Noise Limits and Background Noise Levels during Quiet Waking Hours at Grassfield Farm

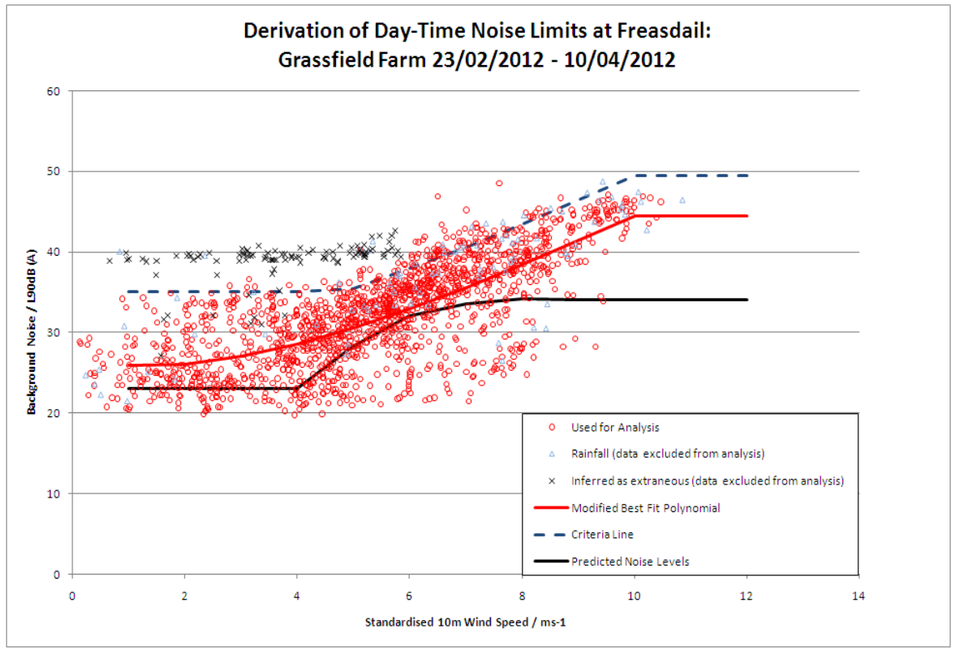


Chart 12.7: Noise Limits and Background Noise Levels Limits during Night-Time Periods at Redesdale House

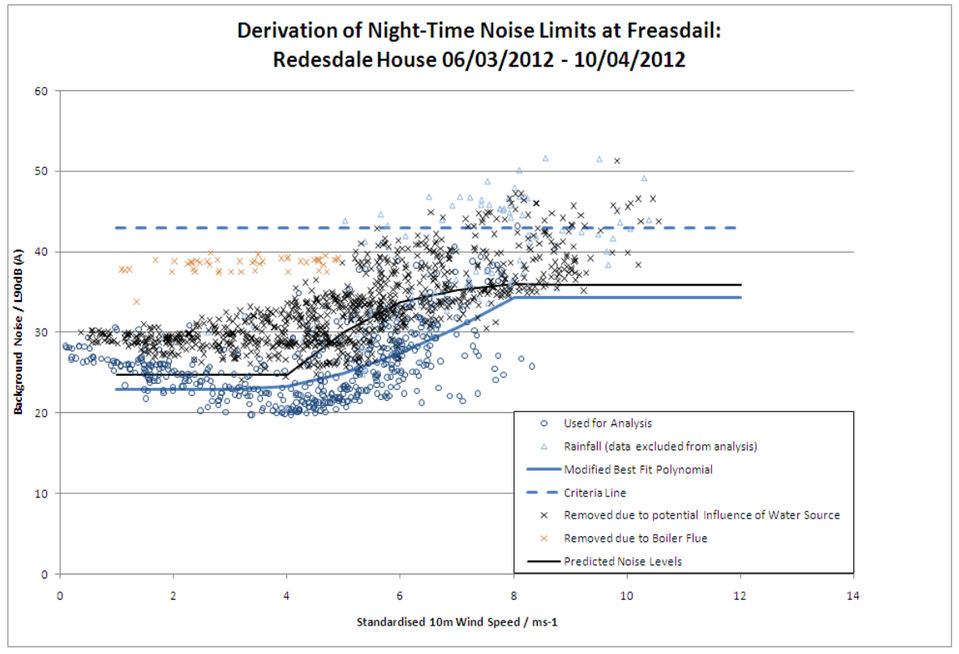


Chart 12.8: Noise Limits and Background Noise Levels Limits during Night-Time Periods at Lochview

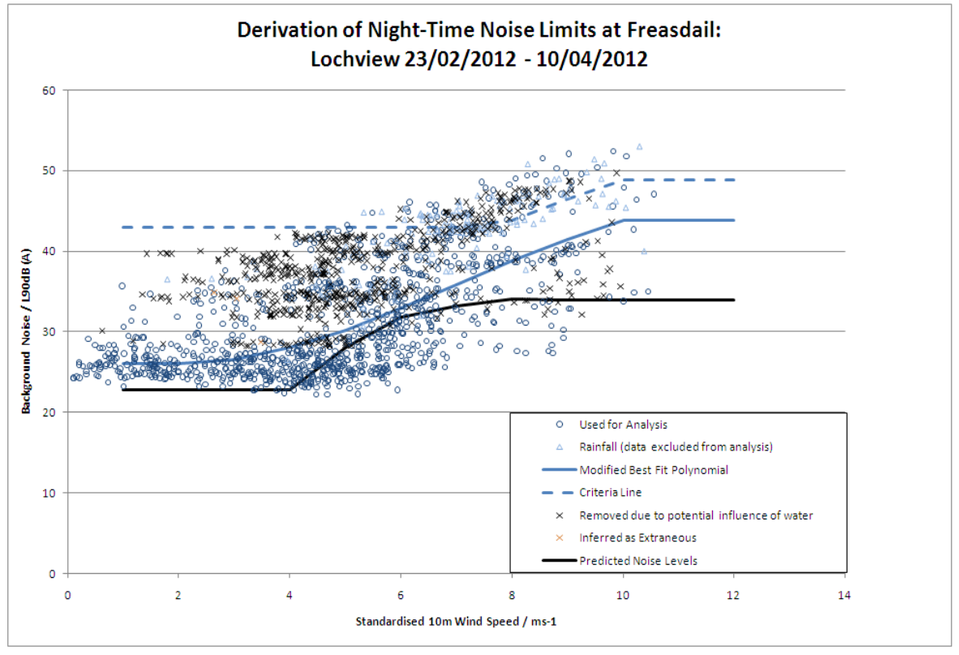


Chart 12.9: Noise Limits and Background Noise Levels Limits during Night-Time Periods at Housing Plots

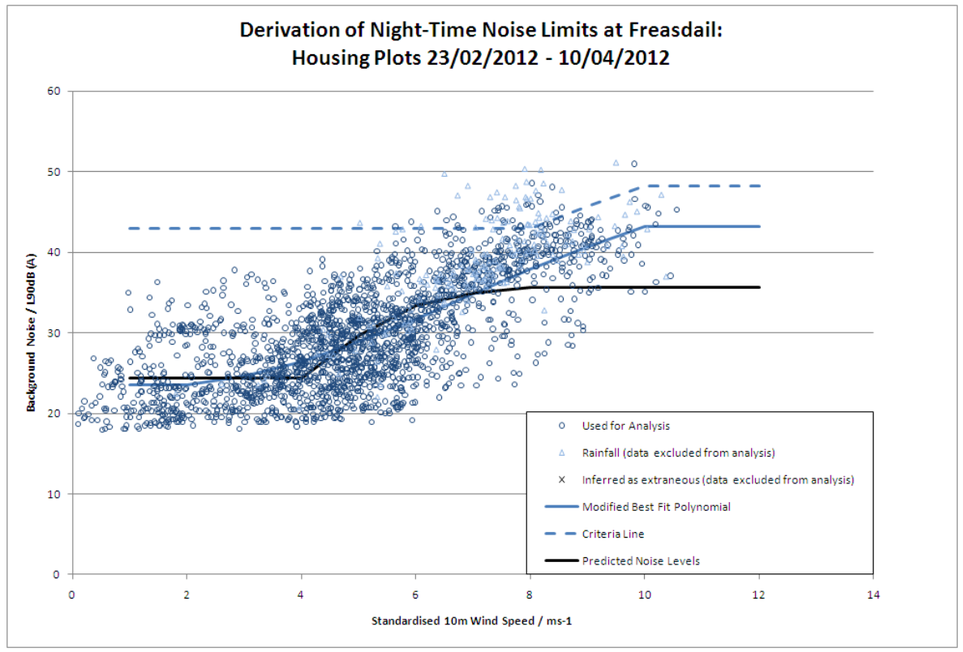
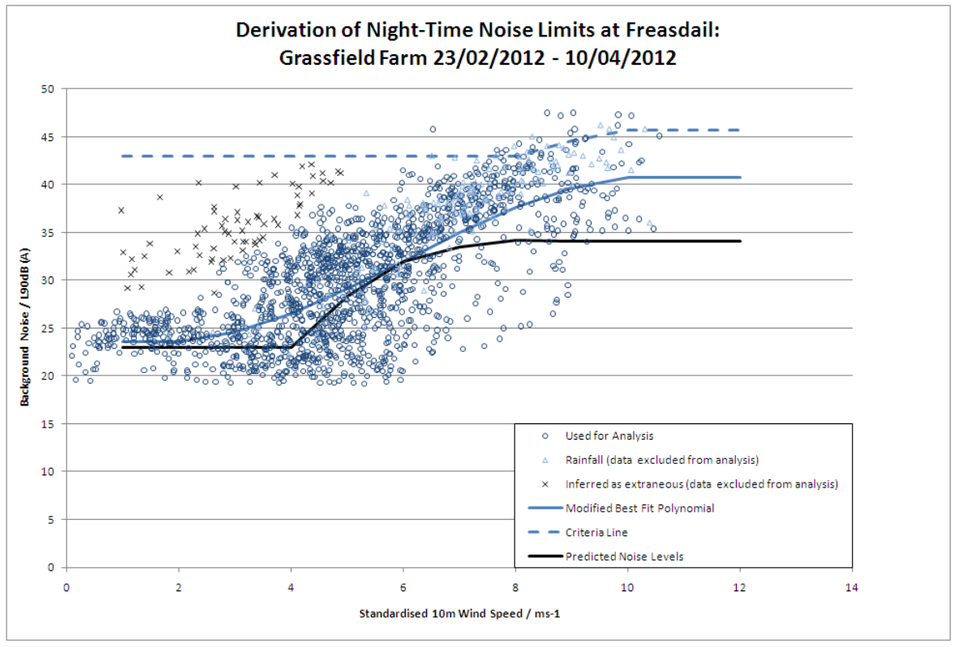


Chart 12.10: Noise Limits and Background Noise Levels Limits during Night-Time Periods at Housing Plots



111. At Redesdale House, influence on background noise from a distant stream was removed as this was visible in the data plots in Chart 12.3 & Chart 12.7.

112. At Lochview, influence on background noise from a distant stream was removed as this was visible in the data plots in Chart 12.4 and Chart 12.8.

113. Chart 12.3, Chart 12.4, Chart 12.5 and Chart 12.6 show $L_{A90,\ 10min}$ correlated against wind speed for quiet waking hour periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the suggested noise limits added (see section 12.5.1.3).

114. Chart 12.7, Chart 12.8, Chart 12.9 and Chart 12.10 show $L_{A90,\ 10min}$ correlated against the wind speed for night-time periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the suggested noise limits added (see section 12.5.1.3). Table 12.6 and Table 12.7 detail the $L_{A90,10min}$ background noise levels calculated from the derived 'best fit' lines, as described above.

Table 12.6: Quiet Waking Hours Noise Levels (dB(A) re 20 μPa)

House Name	Quiet Waking Hours Noise Levels at Indicated Locations Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Redesdale House	23.5	23.5	23.6	25.3	28.0	31.3	34.8	37.8	40.0	40.0	40.0	40.0
Lochview	26.5	27.2	28.6	30.3	32.4	34.5	36.6	38.3	39.6	40.3	40.3	40.3
Housing Plots	24.9	25.3	26.3	27.9	29.9	32.4	35.3	38.5	42.0	45.7	45.7	45.7
Grassfield Farm	25.9	26.1	27.0	28.5	30.5	32.9	35.6	38.5	41.5	44.5	44.5	44.5

Table 12.7: Night-time Noise Levels (dB(A) re 20 μPa)

House Name	Night Time Noise Levels at Indicated Locations Standardised 10 m Wind Speed (ms-1)											
	1	2	3	4	5	6	7	8	9	10	11	12
Redesdale House	22.9	22.9	22.9	23.3	24.9	27.4	30.6	34.3	34.3	34.3	34.3	34.3
Lochview	26.0	26.0	26.6	28.1	30.2	32.9	35.8	38.8	41.5	43.8	43.8	43.8
Housing Plots	23.5	23.6	24.6	26.4	28.9	31.7	34.8	37.9	40.7	43.2	43.2	43.2
Grassfield Farm	23.6	23.6	24.6	26.5	29.1	32.0	35.0	37.6	39.6	40.7	40.7	40.7

12.3.2 Construction Noise

115. One of the factors affecting the acceptability of noise arising from construction sites is the existing background noise levels. The likelihood of complaint increases as the difference between the construction noise level and the existing background noise level increases.

116. A method to determine the significance of construction noise levels is to consider the change in the ambient noise level during the construction noise.

117. Annex E of BS 5228-1:2009 “Code of practice for noise and vibration control on construction and open sites” Part 1 – Noise[28] provides guidance on setting environmental noise targets based upon noise change. The ABC method has been selected to assess the construction noise of the Development.

118. The ABC method sets threshold noise levels for specific periods based on the ambient noise levels. Due to the levels of background noise expected as being less than 65 dB(A) the classification is Category A according to BS 5228-1:2009. Details can be found in section 12.5.2.3.

12.4 DEVELOPMENT DESIGN MITIGATION

119. One of the key turbine layout design constraint considerations was the minimisation of potential noise effects at the nearest residential receptors. As such the turbine layout was initially designed to ensure that there is a separation distance of at least ten rotor diameters between any of the proposed turbines and the nearest neighbour. Initial consideration of potential noise effects indicated that this distance was sufficient to achieve compliance with ETSU-R-97 operational noise requirements for a development of this scale. As such, this separation distance was maintained throughout the design process.

12.5 ASSESSMENT OF EFFECTS

12.5.1 Operational Noise Assessment

12.5.1.1 Noise Propagation Modelling

120. The locations of the Development turbines are provided in Table 12.8 and all considered turbines are shown in Figure 12.1.

Table 12.8: Location of Proposed Turbines

Turbine	OSGB Co-ordinates		Elevation (m)
	X (m)	Y (m)	
T1	183808	658288	138
T2	183367	658156	156
T3	182915	658090	166
T4	182531	657993	164
T5	182189	658225	172
T6	182654	658377	160
T7	183063	658460	179
T8	183473	658507	158
T9	183140	658800	137
T10	182674	658731	160
T11	182288	658621	170

121. The locations of the nearest neighbours to the turbines have been determined by inspection of relevant maps and through site visits. More properties may have been identified but have not been considered critical to this acoustic assessment or may be adequately represented by another property. The locations considered are listed in Table 12.9 and also shown in Figure 12.1. Elevations, given in metres above Ordnance Datum (AOD), have been determined from digital terrain data.

122. Housing Plots 1 -3 do not currently have planning permission. However, they have been included in the operational assessment should they be consented in the future.

123. The distances from each house to the nearest turbine are given in Table 12.9. It can be seen that the minimum house-to-turbine separation to a Freasdail turbine is 1303 m for Housing Plot 1. For the nearest existing neighbour, the minimum house-to-turbine separation is 1541 m from Grassfield Farm.

Table 12.9: Location of Nearby Neighbours & Distances to Nearest Proposed Turbine

House Name	OSGB Co-ordinates		Elevation (m)	Distance (m)	Nearest Turbine
	X (m)	Y (m)			
Gartavaich	185877	658890	81.7	2155	T1
Ardrowan	179969	659544	57.8	2496	T11
Meadowview	180066	659563	57.0	2413	T11
Gartnagrenach Lodge	180053	659618	52.3	2447	T11
Gartnagrenach Cottage	180002	659796	33.4	2570	T11
Gartnagrenach Farm	180019	659851	30.7	2581	T11
Grassfield Farm	181964	660128	69.6	1541	T11
Lochview	182356	660335	77.6	1635	T10
Lonlia	183841	660487	107.4	1827	T9
Redesdale House	183888	660523	111.7	1878	T9
Arivore Farm	182446	660654	72.8	1936	T10
Arivore Cottage	182494	660689	73.8	1966	T10
Birchfield	181166	660702	52.9	2364	T11
Glenreasdale House	182274	660717	62.3	2026	T10
Kilchamaig Gate	181115	660724	53.6	2408	T11
Tigh-Na-Cnoc	182595	660736	77.1	2007	T10
Kilchamaig Cottage	180720	660753	44.5	2647	T11
Ashnacloed Cottage	180699	660772	41.8	2674	T11
Spion Kop	183802	660802	123.1	2109	T9
Arovore Lodge	182344	660849	59.7	2144	T10
The Manse	181294	660924	42.5	2508	T11
Pinmore Cottage	181357	660995	41.2	2550	T11
Pinwherrie Cottage	181385	661029	40.9	2572	T11
Kilchamaig Farm	180269	661045	12.6	3155	T11
South Lodge	182003	661047	36.1	2411	T10
Home Farm	182028	661100	36.1	2455	T10

House Name	OSGB Co-ordinates		Elevation (m)	Distance (m)	Nearest Turbine
	X (m)	Y (m)			
Glenreasdell Farm	182028	661100	36.1	2455	T10
The Schoolhouse	181801	661171	24.4	2591	T10
The Old School	181796	661174	23.7	2596	T10
Laphroaig	181643	661216	17.7	2674	T11
Lagavullin House	181627	661254	16.3	2715	T11
1 Lagavullin	181623	661258	16.1	2720	T11
Rose Cottage	181623	661258	16.1	2720	T11
2 Lagavullin	181614	661265	15.5	2729	T11
Millwood Croft	181588	661300	12.5	2769	T11
Smithy House	181609	661325	15.0	2788	T11
Ghrianaig	181615	661333	15.8	2794	T11
Eden House	181623	661341	16.8	2800	T11
Craigard	181631	661351	17.9	2808	T11
The Weaver	181641	661361	18.7	2815	T11
Braeside	181660	661378	20.0	2828	T11
Cnoc Don	181678	661394	21.4	2839	T11
Tigh Na Croit	181695	661413	23.7	2854	T11
Dougies Croft	181819	661417	28.3	2819	T10
Craig View	183078	661425	56.5	2626	T9
Whitehouse	182698	661614	29.9	2849	T9
Anconeas	182482	661683	17.2	2957	T9
Bluebell Cottage	182441	661754	11.4	3032	T10
The Rhinns	182304	661790	12.1	3081	T10
Housing Plot 1	181474	659638	87.4	1303	T11
Housing Plot 2	181751	659903	74.7	1390	T11
Housing Plot 3	181711	659972	65.3	1469	T11
Glenreasdell Mains	186349	658388	46.3	2543	T1
East Of Aviore Farm	182807	660690	90.5	1919	T9

124. Although not finalised, the turbine type for the Development is likely to be acoustically similar to the Vestas V80 2 MW machine. This report uses the acoustic data from the manufacturer's general specification from this machine for all analysis[36]. The manufacturer has identified these values as warranted. However, should the levels be tested, it may be that a level of uncertainty in the test measurement would need to be accounted for. Accordingly, as a conservative measure, an additional 1dB has been added to the warranted turbine noise levels to allow for this measurement uncertainty. Details assumed in this analysis are as follows:

- A hub height of 60 m;
- A rotor diameter of 80 m;
- Sound power levels, LWA, for standardised 10 m height wind speeds (v10) as shown in Table 12.10;
- 1/1 octave band spectra, standardised 10 m height wind speeds (v10), as shown in Table 12.11; and
- Tonal emission characteristics such that no clearly audible tones are present at any wind speed.

Table 12.10: Sound Power Levels for the Vestas V80 2MW Wind Turbine

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	A-Weighted Sound Power Level (dB(A) re 1 pW)	
	Warranted noise levels	+1 dB uncertainty
4	94.0	95.0
5	99.3	100.3
6	103.0	104.0
7	104.5	105.5
8	105.2	106.2
9	105.2	106.2
10	105.2	106.2
11	105.2	106.2
12	105.2	106.2

Table 12.11: Assumed Octave Band Sound Power Level Spectrum for the Vestas V80 2MW Wind Turbine

Octave Band (Hz)	A-Weighted Sound Power Level at 10m standardised wind speeds/ dB(A) re 1 pW				
	6 ms^{-1}	7 ms^{-1}	8 ms^{-1}	9 ms^{-1}	10 ms^{-1}
63	84.9	86.5	87.8	88.3	89.0
125	91.2	93.1	94.2	94.3	94.3
250	96.4	98.0	98.7	98.4	97.7
500	98.5	99.9	100.5	100.4	100.3
1000	96.2	97.1	97.8	98.0	98.5
2000	93.7	95.4	96.0	96.2	96.6
4000	87.5	89.5	90.3	90.1	89.8
8000	68.5	70.5	71.2	71.0	70.5
OVERALL	103.0	104.5	105.2	105.2	105.2

[36] Vestas, 2012. "Preliminary General Specification V80 - 2.0 MW GridStreamer", Document ID: 0006-7054 V18, Jan 2012

125. Table 12.12 shows the predicted noise immission levels at the nearest neighbours at each wind speed considered, calculated from the operation of the Development. The property with the highest predicted noise immission level is Lonlia at 36.2 dB(A) and is highlighted in bold.

126. Figure 12.1 shows an isobel (i.e. noise contour) plot for the site at a 10 m height wind speed of 8 ms^{-1}. Such plots are useful for evaluating the noise 'footprint' of a given development and for identifying the most sensitive receptors to noise immissions.

Table 12.12: Predicted Noise Levels At Nearby Dwellings (dB(A) re 20 μPa)

House Name	Reference Wind Speed, Standardised v10 (ms-1)								
	4	5	6	7	8	9	10	11	12
GARTAVAICH	21.6	26.9	30.6	32.1	32.9	32.8	32.7	32.7	32.7
ARDROWAN	16.4	21.7	25.4	26.9	27.6	27.6	27.5	27.5	27.5
MEADOWVIEW	16.7	22.0	25.7	27.2	28.0	27.9	27.8	27.8	27.8
GARTNAGRENACH LODGE	16.5	21.8	25.5	27.1	27.8	27.8	27.7	27.7	27.7
GARTNAGRENACH COTTAGE	16.0	21.3	25.0	26.6	27.3	27.3	27.2	27.2	27.2
GARTNAGRENACH FARM	16.0	21.3	25.0	26.5	27.3	27.2	27.2	27.2	27.2
GRASSFIELD FARM	23.0	28.3	32.0	33.5	34.2	34.1	34.1	34.1	34.1
LOCHVIEW	22.8	28.1	31.8	33.2	34.0	33.9	33.9	33.9	33.9
LONLIA	**25.0**	**30.3**	**34.0**	**35.5**	**36.2**	**36.2**	**36.1**	**36.1**	**36.1**
REDESDALE HOUSE	24.7	30.0	33.7	35.2	36.0	35.9	35.9	35.9	35.9
ARIVORE FARM	21.5	26.8	30.5	32.0	32.7	32.7	32.6	32.6	32.6
ARIVORE COTTAGE	21.4	26.7	30.4	31.9	32.6	32.5	32.5	32.5	32.5
BIRCHFIELD	19.5	24.8	28.5	30.0	30.7	30.7	30.6	30.6	30.6
GLENREASDALE HOUSE	21.2	26.5	30.2	31.7	32.4	32.4	32.3	32.3	32.3
KILCHAMAIG GATE	19.2	24.5	28.2	29.8	30.5	30.4	30.4	30.4	30.4
TIGH-NA-CNOC	21.2	26.5	30.2	31.7	32.5	32.4	32.4	32.4	32.4
KILCHAMAIG COTTAGE	17.0	22.3	26.0	27.5	28.3	28.2	28.1	28.1	28.1
ASHNACLOED COTTAGE	16.9	22.2	25.9	27.4	28.1	28.1	28.0	28.0	28.0
SPION KOP	23.7	29.0	32.7	34.2	35.0	34.9	34.9	34.9	34.9
ARIVORE LODGE	20.5	25.8	29.5	31.0	31.7	31.7	31.6	31.6	31.6
THE MANSE	18.9	24.2	27.9	29.4	30.2	30.2	30.1	30.1	30.1
PINMORE COTTAGE	18.8	24.1	27.8	29.3	30.1	30.0	30.0	30.0	30.0
PINWHERRIE COTTAGE	19.3	24.6	28.3	29.8	30.6	30.5	30.5	30.5	30.5
KILCHAMAIG FARM	14.8	20.1	23.8	25.4	26.2	26.1	26.1	26.1	26.1
SOUTH LODGE	19.5	24.8	28.5	30.0	30.7	30.7	30.6	30.6	30.6
HOME FARM	19.3	24.6	28.3	29.8	30.6	30.5	30.5	30.5	30.5
GLENREASDELL FARM	19.3	24.6	28.3	29.8	30.6	30.5	30.5	30.5	30.5
THE SCHOOLHOUSE	18.7	24.0	27.7	29.2	29.9	29.9	29.8	29.8	29.8
THE OLD SCHOOL	18.6	23.9	27.6	29.2	29.9	29.8	29.8	29.8	29.8
LAPHROAIG	18.2	23.5	27.2	28.8	29.5	29.5	29.4	29.4	29.4
LAGAVULLIN HOUSE	18.1	23.4	27.1	28.6	29.4	29.3	29.3	29.3	29.3
1 LAGAVULLIN	18.1	23.4	27.1	28.6	29.4	29.3	29.3	29.3	29.3
ROSE COTTAGE	18.1	23.4	27.1	28.6	29.4	29.3	29.3	29.3	29.3
2 LAGAVULLIN	18.0	23.3	27.0	28.5	29.3	29.2	29.2	29.2	29.2
MILLWOOD CROFT	17.9	23.2	26.9	28.5	29.2	29.2	29.2	29.2	29.2
SMITHY HOUSE	17.9	23.2	26.9	28.4	29.2	29.1	29.1	29.1	29.1
GHRIANAIG	17.9	23.2	26.9	28.4	29.2	29.1	29.1	29.1	29.1
EDEN HOUSE	17.9	23.2	26.9	28.4	29.2	29.1	29.1	29.1	29.1
CRAIGARD	17.9	23.2	26.9	28.4	29.2	29.1	29.1	29.1	29.1
THE WEAVER	17.8	23.1	26.8	28.4	29.1	29.1	29.1	29.1	29.1
BRAESIDE	17.8	23.1	26.8	28.3	29.1	29.1	29.0	29.0	29.0
CNOC DON	17.8	23.1	26.8	28.3	29.1	29.0	29.0	29.0	29.0
TIGH NA CROIT	17.8	23.1	26.8	28.3	29.1	29.0	29.0	29.0	29.0
DOUGIES CROFT	17.9	23.2	26.9	28.4	29.2	29.1	29.1	29.1	29.1
CRAIG VIEW	17.2	22.5	26.2	27.7	28.5	28.4	28.4	28.4	28.4
WHITEHOUSE	16.7	22.0	25.7	27.2	28.0	27.9	27.9	27.9	27.9
ANCONEAS	17.0	22.3	26.0	27.5	28.3	28.2	28.2	28.2	28.2
BLUEBELL COTTAGE	16.1	21.4	25.1	26.7	27.5	27.4	27.3	27.3	27.3
THE RHINNS	15.9	21.2	24.9	26.4	27.2	27.1	27.1	27.1	27.1
HOUSING PLOT 1	24.4	29.7	33.4	34.9	35.6	35.6	35.6	35.6	35.6
HOUSING PLOT 2	23.9	29.2	32.9	34.4	35.1	35.1	35.0	35.0	35.0
HOUSING PLOT 3	23.0	28.3	32.0	33.5	34.2	34.1	34.1	34.1	34.1
GLENREASDELL MAINS	19.5	24.8	28.5	30.0	30.8	30.8	30.8	30.8	30.8
EAST OF AVIORE FARM	22.5	27.8	31.5	33.0	33.7	33.7	33.6	33.6	33.6

Values in bold indicate the maximum predicted noise levelShading indicates properties with predicted noise levels greater that 35 dB(A), refer to paragraph 127

127. Noise levels at 50 of the 54 nearest neighbours are below 35 dB(A) level, indicating that the noise immission levels would be regarded as acceptable and the householders' amenities as receiving 'sufficient protection' without further assessment requiring to be undertaken (refer to section 12.2.3.3).

128. There are four properties that have predicted noise levels greater than this simplified noise criteria as indicated in Table 12.12. Therefore the 'full' acoustic assessment is only required at these. However, as background noise surveys were carried out at Grassfield Farm and Lochview, as agreed

with the local authority[31], despite receiving a predicted noise level of less than 35 dB(A), these properties have also been considered in the full acoustic assessment so as to provide a more comprehensive description of the acoustic effects of the Development.

12.5.1.2 Acoustic Acceptance Criteria

129. As described in section 12.2.3.3, during quiet waking hours and at low background noise levels, a permissible noise level of 35-40 dB(A) should be used. The exact value is dependent upon a number of factors: the number of nearby dwellings, the effect of the noise limits on energy produced and the duration and level of exposure.

130. There are four properties with a predicted noise level greater than 35 dB(A). Given that there are so few houses for the scale and benefit this scheme would bring, this would suggest a limit towards the upper end of the range may be appropriate. However despite a higher level potentially being justifiable, for the purposes of this assessment, RES has provided results in relation to the lowest 35 dB(A) level. The permissible noise level criteria are shown in Table 12.13.

Table 12.13: Permissible Noise Level Criteria in Vicinity of the Development

Time of Day	Permissible Noise Level
Quiet waking hours	35.0 dB(A) for L_B less than [30.0] dB(A) L_B + 5 dB, for L_B greater than [30.0] dB(A)
Night-time hours	43 dB(A) for L_B less than 38 dB(A) L_B + 5 dB, for L_B greater than 38 dB(A)

12.5.1.3 Calculation of Acceptable Noise Limits from Baseline Conditions

131. The 'best-fit' lines of Chart 12.3 – Chart 12.10, have been used to deduce the acceptable noise limits at the background noise measurement locations. Table 12.14 shows the suggested quiet waking hours noise limits and Table 12.15 the suggested night time noise limits.

Table 12.14: Recommended Quiet Waking Hours Noise Limits (dB(A) re 20 μPa)

House Name	Quiet Waking Hours Noise Limits at Indicated Locations Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Redesdale House	35.0	35.0	35.0	35.0	35.0	36.3	39.8	42.8	45.0	45.0	45.0	45.0
Lochview	35.0	35.0	35.0	35.3	37.4	39.5	41.6	43.3	44.6	45.3	45.3	45.3
Housing Plots	35.0	35.0	35.0	35.0	35.0	37.4	40.3	43.5	47.0	50.7	50.7	50.7
Grassfield Farm	35.0	35.0	35.0	35.0	35.5	37.9	40.6	43.5	46.5	49.5	49.5	49.5

Table 12.15: Recommended Night-time Noise Limits (dB(A) re 20 μPa)

House Name	Night Time Noise Limits at Indicated Locations Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Redesdale House	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Lochview	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.5	48.8	48.8	48.8
Housing Plots	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.7	48.2	48.2	48.2
Grassfield Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.6	45.7	45.7	45.7

132. The recommendations of ETSU-R-97 state that where there are groups of properties that are likely to have a similar background noise environment, it is appropriate to use data from one representative location as the basis for assessment at the other properties. The survey results inferred to be representative for each property is shown in Table 12.16. The representative background noise location for each property has been selected based upon the distance to the nearest survey location and the likelihood of experiencing a broadly similar exposure as the survey.

Table 12.16: Assumed Representative Background Noise Survey Locations

House Name	Assumed Representative Background Noise Survey
GARTAVAICH	Redesdale House
ARDROWAN	Grassfield Farm
MEADOWVIEW	Grassfield Farm
GARTNAGRENACH LODGE	Grassfield Farm
GARTNAGRENACH COTTAGE	Grassfield Farm
GARTNAGRENACH FARM	Grassfield Farm
GRASSFIELD FARM	Grassfield Farm
LOCHVIEW	Lochview
LONLIA	Redesdale House
REDESDALE HOUSE	Redesdale House
ARIVORE FARM	Lochview
ARIVORE COTTAGE	Lochview
BIRCHFIELD	Grassfield Farm
GLENREASDALE HOUSE	Lochview
KILCHAMAIG GATE	Grassfield Farm
TIGH-NA-CNOC	Lochview
KILCHAMAIG COTTAGE	Grassfield Farm
ASHNACLOED COTTAGE	Grassfield Farm
SPION KOP	Redesdale House
ARIVORE LODGE	Lochview
THE MANSE	Grassfield Farm
PINMORE COTTAGE	Grassfield Farm

House Name	Assumed Representative Background Noise Survey
PINWHERRIE COTTAGE	Grassfield Farm
KILCHAMAIG FARM	Grassfield Farm
SOUTH LODGE	Lochview
HOME FARM	Lochview
GLENREASDELL FARM	Lochview
THE SCHOOLHOUSE	Lochview
THE OLD SCHOOL	Lochview
LAPHROAIG	Grassfield Farm
LAGAVULLIN HOUSE	Grassfield Farm
1 LAGAVULLIN	Grassfield Farm
ROSE COTTAGE	Grassfield Farm
2 LAGAVULLIN	Grassfield Farm
MILLWOOD CROFT	Grassfield Farm
SMITHY HOUSE	Grassfield Farm
GHRIANAIG	Grassfield Farm
EDEN HOUSE	Grassfield Farm
CRAIGARD	Grassfield Farm
THE WEAVER	Grassfield Farm
BRAESIDE	Grassfield Farm
CNOC DON	Grassfield Farm
TIGH NA CROIT	Grassfield Farm
DOUGIES CROFT	Grassfield Farm
CRAIG VIEW	Redesdale House
WHITEHOUSE	Redesdale House
ANCONEAS	Redesdale House
BLUEBELL COTTAGE	Redesdale House
THE RHINNS	Redesdale House
HOUSING PLOT 1	Housing Plots
HOUSING PLOT 2	Housing Plots
HOUSING PLOT 3	Housing Plots
GLENREASDELL MAINS	Redesdale House
EAST OF AVIORE FARM	Lochview

133. As recommended in ETSU-R-97, the absolute lower noise limits may be increased up to 45 dB(A) if the occupant has a financial involvement in the development. However, these limits have not been adopted in the presented results.

12.5.1.4 Acoustic Assessment

134. Table 12.17 shows a comparison of the predicted noise levels with the recommended quiet waking hours noise limits for each house where the full assessment procedure is being applied. The predicted noise levels at 1 ms^{-1}, 2 ms^{-1} and 3 ms^{-1} have been assumed as equal to 4 ms^{-1}, though this is a conservative measure as noise levels at these wind speeds would typically be less. The term ΔL is used to denote the difference between the predicted noise level as a result of the Development and the recommended limit. A negative value indicates that the predicted noise level is within the limit. Table 12.18 shows a comparison with the recommended night-time noise limits, following the same nomenclature.

135. Noise levels at all locations are within both the quiet waking hours limit and night-time noise limits at all wind speeds considered. The minimum margin of predicted noise levels below derived noise limits, for all wind speeds considered, during quiet waking hours, is -2.3 dB(A). Similarly the minimum margin during night time periods, for all wind speeds considered, is -6.8 dB(A). These are highlighted in Table 12.17a-b and Table 12.18a.b.

Table 12.17a: Comparison of Predicted Noise Levels and Quiet Waking Hours Limits - (dB(A) re 20 μPa) (wind speeds 1ms^{-1}-6 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	1			2			3			4			5			6		
	Lp	Limit	ΔL	Lp	Limit	ΔL	Lp	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	24.7	35.0	-10.3	24.7	35.0	-10.3	24.7	35.0	-10.3	24.7	35.0	-10.3	30.0	35.0	-5.0	33.7	36.3	-2.6
LONLIA	25.0	35.0	-10.0	25.0	35.0	-10.0	25.0	35.0	-10.0	25.0	35.0	-10.0	30.3	35.0	-4.7	34.0	36.3	-2.3
LOCHVIEW	22.8	35.0	-12.2	22.8	35.0	-12.2	22.8	35.0	-12.2	22.8	35.3	-12.5	28.1	37.4	-9.3	31.8	39.5	-7.7
HOUSING PLOT 1	24.4	35.0	-10.6	24.4	35.0	-10.6	24.4	35.0	-10.6	24.4	35.0	-10.6	29.7	35.0	-5.3	33.4	37.4	-4.0
HOUSING PLOT 2	23.9	35.0	-11.1	23.9	35.0	-11.1	23.9	35.0	-11.1	23.9	35.0	-11.1	29.2	35.0	-5.8	32.9	37.4	-4.5
GRASSFIELD FARM	23.0	35.0	-12.0	23.0	35.0	-12.0	23.0	35.0	-12.0	23.0	35.0	-12.0	28.3	35.5	-7.2	32.0	37.9	-5.9

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

Table 12.17b: Comparison of Predicted Noise Levels and Quiet Waking Hours Limits - (dB(A) re 20 μPa) (wind speeds 7ms^{-1}-12 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	35.2	39.8	-4.6	36.0	42.8	-6.8	35.9	45.0	-9.1	35.9	45.0	-9.1	35.9	45.0	-9.1	35.9	45.0	-9.1
LONLIA	35.5	39.8	-4.3	36.2	42.8	-6.6	36.2	45.0	-8.8	36.1	45.0	-8.9	36.1	45.0	-8.9	36.1	45.0	-8.9
LOCHVIEW	33.2	41.6	-8.4	34.0	43.3	-9.3	33.9	44.6	-10.7	33.9	45.3	-11.4	33.9	45.3	-11.4	33.9	45.3	-11.4
HOUSING PLOT 1	34.9	40.3	-5.4	35.6	43.5	-7.9	35.6	47.0	-11.4	35.6	50.7	-15.1	35.6	50.7	-15.1	35.6	50.7	-15.1
HOUSING PLOT 2	34.4	40.3	-5.9	35.1	43.5	-8.4	35.1	47.0	-11.9	35	50.7	-15.7	35	50.7	-15.7	35	50.7	-15.7
GRASSFIELD FARM	33.5	40.6	-7.1	34.2	43.5	-9.3	34.1	46.5	-12.4	34.1	49.5	-15.4	34.1	49.5	-15.4	34.1	49.5	-15.4

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

Table 12.18a: Comparison of Predicted Noise Levels and Night Time Limits - (dB(A) re 20 μPa) (wind speeds 1 ms^{-1}-6 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	1			2			3			4			5			6		
	Lp	Limit	ΔL	Lp	Limit	ΔL	Lp	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	24.7	43.0	-18.3	24.7	43.0	-18.3	24.7	43.0	-18.3	24.7	43.0	-18.3	30.0	43.0	-13.0	33.7	43.0	-9.3
LONLIA	25.0	43.0	-18.0	25.0	43.0	-18.0	25.0	43.0	-18.0	25.0	43.0	-18.0	30.3	43.0	-12.7	34.0	43.0	-9.0
LOCHVIEW	22.8	43.0	-20.2	22.8	43.0	-20.2	22.8	43.0	-20.2	22.8	43.0	-20.2	28.1	43.0	-14.9	31.8	43.0	-11.2
HOUSING PLOT 1	24.4	43.0	-18.6	24.4	43.0	-18.6	24.4	43.0	-18.6	24.4	43.0	-18.6	29.7	43.0	-13.3	33.4	43.0	-9.6
HOUSING PLOT 2	23.9	43.0	-19.1	23.9	43.0	-19.1	23.9	43.0	-19.1	23.9	43.0	-19.1	29.2	43.0	-13.8	32.9	43.0	-10.1
GRASSFIELD FARM	23.0	43.0	-20.0	23.0	43.0	-20.0	23.0	43.0	-20.0	23.0	43.0	-20.0	28.3	43.0	-14.7	32.0	43.0	-11.0

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

Table 12.18b: Comparison of Predicted Noise Levels and Night Time Limits - (dB(A) re 20 μPa) (wind speeds 7 ms^{-1}-12 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	35.2	43.0	-7.8	36.0	43.0	-7.0	35.9	43.0	-7.1	35.9	43.0	-7.1	35.9	43.0	-7.1	35.9	43.0	-7.1
LONLIA	35.5	43.0	-7.5	36.2	43.0	-6.8	36.2	43.0	-6.8	36.1	43.0	-6.9	36.1	43.0	-6.9	36.1	43.0	-6.9
LOCHVIEW	33.2	43.0	-9.8	34.0	43.8	-9.8	33.9	46.5	-12.6	33.9	48.8	-14.9	33.9	48.8	-14.9	33.9	48.8	-14.9
HOUSING PLOT 1	34.9	43.0	-8.1	35.6	43.0	-7.4	35.6	45.7	-10.1	35.6	48.2	-12.6	35.6	48.2	-12.6	35.6	48.2	-12.6
HOUSING PLOT 2	34.4	43.0	-8.6	35.1	43.0	-7.9	35.1	45.7	-10.6	35	48.2	-13.2	35	48.2	-13.2	35	48.2	-13.2
GRASSFIELD FARM	33.5	43.0	-9.5	34.2	43.0	-8.8	34.1	44.6	-10.5	34.1	45.7	-11.6	34.1	45.7	-11.6	34.1	45.7	-11.6

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

12.5.2 Construction Noise Assessment

136. Primary activities for which noise arises during the construction period are from:

- The construction of the turbine bases;
- The erection of the turbines;
- The excavation of trenches for cables;
- The felling of forestry; and
- The construction of associated hard standings, access tracks and construction compound.

137. Noise from vehicles on local roads and access tracks will also arise due to the delivery of turbine components and construction materials, notably aggregates, concrete and steel reinforcement.

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

12.5.2.1 Construction Noise Predictions

139. The plant assumed for each construction activity is shown in Table 12.19. The number of items indicates how many of each plant are required for the specified activity, and the duration of activity is a percentage of a given 12 hour day period needed for that plant to operate. Overall sound power levels are based upon the data in Annex C of BS 5228-1:2009.

Table 12.19: Construction Phases and Sound Power Levels

Activities	Plant	Sound Power (L_{WA})	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA})
Upgrade Access Track	Tracked excavator	113	2	100	120
	Dump truck	113	2	100	
	Tipper lorry	107	4	50	
	Dozer	109	2	75	
	Vibratory roller	102	1	75	
Construct temporary site compounds	Tracked excavator	113	2	100	119
	Dump truck	113	2	100	
	Tipper lorry	107	2	50	
	Vibratory roller	102	1	75	
	Lorry	108	1	75	
Construct/ Excavate site tracks	Tracked excavator	113	3	100	122
	Dump truck	113	2	75	
	Tipper lorry	107	4	50	
	Dozer	109	1	100	
	Vibratory roller	102	1	75	
	Excavated mounted rock breaker[37]	121	1	50	
Construct Sub-Station	Tracked excavator	113	1	100	115
	Concrete mixer truck	108	2	50	
	Lorry	108	1	50	
	Telescopic Handler	99	1	100	
Construct crane hardstandings	Tracked excavator	113	3	100	120
	Dump truck	113	2	100	
	Tipper lorry	107	4	50	
	Vibratory roller	102	1	50	
Construct turbine foundations	Tracked excavator	113	2	75	122
	Dump truck	113	2	75	
	Concrete mixer truck	108	4	50	
	Mobile telescopic crane	110	1	50	
	Concrete pump	106	2	50	
	Water pump	93	1	100	
	Hand-held pneumatic breaker	111	1	75	
	Compressor	103	3	50	
	Poker vibrator	106	3	50	
	Excavated mounted rock breaker[7]	121	1	50	

[37] The excavated mounted rock breaker may not be required but has been included to allow for conservative predictions.

Activities	Plant	Sound Power (L_{WA})	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA})
Excavate and lay site cables	Tracked excavator	113	2	100	122
	Dump truck	113	2	75	
	Tractor with hydraulic winch (towing equipment)	108	1	75	
	Tractor (towing trailer)	107	1	75	
	Vibratory plate	108	1	50	
	Excavated mounted rock breaker[7]	121	1	50	
Reinstate Road Verges	Tracked Excavator	113	1	75	115
Erect turbines	Mobile telescopic crane	110	2	75	119
	Lorry	108	1	75	
	Diesel generator	102	1	100	
	Torque guns	111	4	100	
Lay cable to substations	Wheeled loader	108	1	100	120
	Saws	114	1	50	
	Hydraulic breaker	121	1	50	
	Dump truck	113	1	75	
	Tipper lorry	107	1	50	
	Vibratory plate	108	1	75	
	Tandem roller	102	1	75	
	Tractor & cable drum trailer	108	1	50	
	Lorry	108	1	75	
Forestry Felling	Saws	114	1	100	116
	Harvester	108	2	100	

140. Predictions of noise levels have been carried out using the methods prescribed in Annex F of BS 5228-1:2009 with adoption of the worst case scenario where all major construction activities take place at the nearest possible location to each assessed house. The locations of the construction activities are taken from the infrastructure drawing as shown in Figure 4.1. The results of these predictions, made at five representative properties in close proximity to the Development, are shown in Table 12.20. It should be noted that the Housing Plots 1-3 have not been considered in this analysis as they do not currently have full planning permission. They have been included in the operational noise assessment as there is a greater likelihood of these existing within the operational lifetime of the Development.

141. Noise levels over the vast majority of the construction period are likely to be lower than those presented, as these represent the worst case effects i.e. when the activities are closest to the property.

Table 12.20: Construction Noise Predictions

Activity*	Predicted Sound Pressure Level (dB L_{Aeq})				
	Birchfield	Gartnagrenach Lodge	Grassfield Farm	The Manse	Kilchamaig Cottage
Upgrade Site Track	49.1	45.9	55.5	46.8	46.7
Excavate Site Track	56.5	50.5	56.8	52.5	58.8
Construct temporary site compounds	39.6	38.7	44.4	39.0	38.4
Construct secondary temporary site compounds	53.2	47.4	46.0	49.5	54.5
Construct Sub-Station	34.6	33.8	39.1	34.0	33.4
Construct crane hardstandings	39.9	39.6	44.1	39.3	38.8
Construct turbine foundations	41.6	41.3	45.8	41.1	40.5
Excavate and lay site cables	41.3	40.8	45.8	40.8	40.1
Erect turbines	38.1	37.8	42.3	37.6	37.0
Reinstate road verges	48.8	42.8	50.1	44.8	51.1
Lay cable to substations	40.3	39.7	44.8	39.7	39.0
Forestry Felling	39.1	42.0	44.9	38.1	37.5

Activity*	Predicted Sound Pressure Level (dB L_{Aeq})				
	Birchfield	Gartnagrenach Lodge	Grassfield Farm	The Manse	Kilchamaig Cottage
Total Activity Noise[38]	56.5	50.5	56.8	52.5	58.8

*Note that these activities do not take place simultaneously, see section 12.5.2.2.

12.5.2.2 Construction Traffic

142. Due to the provision of construction material and wind farm components, vehicle movements either into or away from the site shall increase levels of traffic flow on public roads in the area. Traffic regularly accessing the site is shown in Chapter 14: *Access, Traffic and Transport* of this ES and is assumed to be characterised by the sound power levels of Concrete Mixers as a worst case. It is estimated therein that a total of 110 vehicle movements per day would be required during the most intensive period of activity.

143. Construction traffic noise has been quantified at this location using the method described in BS 5228:2009 Part 1. Using the distances from residential properties to the centre of the relevant carriageway where site traffic will be, the noise levels predicted are presented in Table 12.21. According to the assumptions made the maximum sound pressure level due to traffic flows at the most intensive period of activity will be 55.4 dB L_{Aeq}.

Table 12.21: Results of the Traffic Noise Predictions

Activity	Predicted Sound Pressure Level (dB L_{Aeq})				
	BIRCHFIELD	GARTNAGRENACH LODGE	GRASSFIELD FARM	THE MANSE	KILCHAMAIG COTTAGE
Concrete mixer truck	53.0	54.6	38.2	55.4	43.0

144. Worst case construction noise levels may arise when the following simultaneous activities occur:

- Construction of substation;
- Construction of nearest crane hardstandings; and
- Construction of nearest turbine foundations.

145. Therefore, the worst case of either the site track construction or the in combination predictions of these construction activities and the additional noise contribution from construction traffic have been calculated and are shown in

146. Table 12.22.

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

[38] This has been taken to represent the maximum value from the construction of the site tracks or the combined noise levels for construction of the sub-station, hardstandings and foundations.

Table 12.22: Predicted Noise Due to Combined Traffic Noise and Construction Plant Noise

Activity	Predicted Sound Pressure Level (dB L_{Aeq})				
	BIRCHFIELD	GARTNAGRENACH LODGE	GRASSFIELD FARM	THE MANSE	KILCHAMAIG COTTAGE
Construction Plant Noise	56.5	50.5	56.8	52.5	58.8
Traffic Noise	53.0	54.6	38.2	55.4	43.0
Combined Noise	58.1	56.0	56.8	57.2	58.9

12.5.2.3 Acceptable Noise Limits from Baseline Conditions

148. Due to the relatively low levels of ambient noise at the Development site, a Category A assessment of the ABC method in BS 5228-1:2009 is used for thresholds as stated in section 12.3.2. This category sets threshold L_{Aeq} criteria of:

- 65 dB(A) during weekdays (0700-1900) and Saturdays (0700-1300);
- Below 55 dB(A) at evenings and weekends; and
- Below 45 dB(A) for night-time (2300-0700).

12.5.2.4 Assessment of Construction Noise

149. Table 12.22 shows that predicted noise levels from the combined effect of increased traffic flows and activities associated with peak construction of the wind farm are below the 65 dB(A) daytime target level specified by BS 5228-1:2009 at all locations. The predictions made represent the worst case combination of most intensive traffic activity with simultaneous construction activity at the nearest possible location to each noise receptor.

150. The temporary higher levels of construction noise (above the 55 dB(A) threshold at evenings and weekends) for upgrading the access track, and constructing the site access track at the nearest point to Birchfield, Grassfield Farm and Kilmachaig Cottage, will only occur in the limited time period when the activity is at the closest point to the property. Noise levels are predicted to drop below the 55 dB(A) target level when the construction activity is more than 620 m away, and this is likely to only occur for up to 8 days based on typical rates of construction.

151. The increased traffic noise above the 55 dB(A) target levels at evenings[39] for the traffic noise at The Manse will only occur for a limited time period during which concrete deliveries will be taking place. It will require one day of deliveries for each turbine and so this increased level will last for approximately 11 days.

[39] RES would not deliver concrete to site during the weekends.

12.6 MITIGATION MEASURES AND RESIDUAL EFFECTS

12.6.1 Operational Noise

152. No mitigation measures are required for the operation of the proposed turbines as the site complies with noise criteria.

153. Before a turbine type could be employed, the applicant's standard practice would be to seek to obtain a warranty from the manufacturer that the turbines will not incur a tonal penalty of 5dB at the nearest noise sensitive properties, based upon the ETSU-R-97 guideline definition[2].

154. If the Development is successful in its application for planning permission, any resulting decision notice would likely contain noise conditions which would provide a degree of protection to nearby residents in the unlikely event that the wind farm noise would give rise to complaint. Technical Appendix A12.3 contains a set of conditions that RES considers appropriate for this Development. Any final conditions attached to the proposal, if consented, would be according to the discretion of the Local Planning Authority.

12.6.2 Construction Noise

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

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

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

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

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

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

159. There are many strategies to reduce construction noise by the limitation of activities that would result in predicted noise levels being lower than the specified target. Any such measures should be considered adequate and the mitigation adopted should not be limited to the measures proposed.

12.6.3 Residual Effects

12.6.3.1 Operational

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

12.6.3.2 Construction

161. There may be a temporary increase above the 55 dB(A) target level due to upgrading the access track near Birchfield, Grassfield Farm and Kilmachaig Cottage but this is only when this activity is at its closest. At all other times predicted noise from worst case combination of increased traffic and site construction noise will not exceed relevant criteria and therefore no significant effects are expected.

12.7 CUMULATIVE EFFECTS

12.7.1 Cumulative Operational Noise Assessment

162. An assessment of the cumulative acoustic effect of the Development comprising 11 wind turbines in conjunction with the proposed Fraoch-Choile turbine[40] and the proposed Whiteside Burn turbine[41] has been undertaken in accordance with the guidance in ETSU-R-97. This guidance states:

> *"It is clearly unreasonable to suggest that, because a wind farm has been constructed in the vicinity in the past which resulted in increased noise levels at some properties, the residents of those properties are now able to tolerate higher noise levels still. The existing wind farm should not be considered as part of the prevailing background noise."*

163. The locations of the 11 proposed turbines at Freasdail and the 1 proposed turbine at Fraoch-Choile and the 1 proposed turbine at Whiteside Burn are shown in **Error! Reference source not found.**Figure 12.2.

164. The nearest neighbours to the turbines considered in this assessment are those detailed in Table 12.9.

165. Considering the Development and the proposed Fraoch-Choile and Whiteside Burn turbines, the distances from each house to the nearest turbine are given in Table 12.23.

Table 12.23: Distances from Nearby Neighbours to Nearest Proposed Turbine

House Name	Distance (m)	Nearest Turbine
GARTAVAICH	2155	T1
ARDROWAN	2496	T11
MEADOWVIEW	2413	T11

[40] Fraoch-Choille, 2011, "Erection of dwellinghouse, shed and wind turbine and formation of access road", Planning Application reference 11/00167/PP, Jan 2011.
[41] Whiteside Burn, 2011, "Erection of wind turbine (60m to hub, 84m to blade tip), with associated substation, crane pad and temporary hardstanding and the upgrading of 550m of existing forestry track", Planning Application reference 11/00937/PP, June 2011.

House Name	Distance (m)	Nearest Turbine
GARTNAGRENACH LODGE	2447	T11
GARTNAGRENACH COTTAGE	2570	T11
GARTNAGRENACH FARM	2581	T11
GRASSFIELD FARM	1367	F1
LOCHVIEW	925	F1
LONLEA	805	F1
REDESDALE HOUSE	833	F1
ARIVORE FARM	705	F1
ARIVORE COTTAGE	650	F1
BIRCHFIELD	1963	F1
GLENREASDALE HOUSE	860	F1
KILCHAMAIG GATE	2012	F1
TIGH-NA-CNOC	541	F1
KILCHAMAIG COTTAGE	2405	F1
ASHNACLOED COTTAGE	2425	F1
SPION KOP	681	F1
ARIVORE LODGE	779	F1
THE MANSE	1830	F1
PINMORE COTTAGE	1772	F1
PINWHERRIE COTTAGE	1747	F1
KILCHAMAIG FARM	2861	F1
SOUTH LODGE	1137	F1
HOME FARM	1123	F1
GLENREASDELL FARM	1123	F1
THE SCHOOLHOUSE	1360	F1
THE OLD SCHOOL	1366	F1
LAPHROAIG	1524	F1
LAGAVULLIN HOUSE	1549	F1
1 LAGAVULLIN	1554	F1
ROSE COTTAGE	1554	F1
2 LAGAVULLIN	1564	F1
MILLWOOD CROFT	1599	F1
SMITHY HOUSE	1586	F1
GHRIANAIG	1583	F1
EDEN HOUSE	1578	F1
CRAIGARD	1573	F1
THE WEAVER	1567	F1
BRAESIDE	1555	F1
CNOC DON	1543	F1
TIGH NA CROIT	1534	F1
DOUGIES CROFT	1421	F1
CRAIG VIEW	575	F1
WHITEHOUSE	873	F1
ANCONEAS	1049	F1
BLUEBELL COTTAGE	1131	F1
THE RHINNS	1245	F1
HOUSING PLOT 1	1303	T11
HOUSING PLOT 2	1390	T11
HOUSING PLOT 3	1469	T11
GLENREASDELL MAINS	2543	T1
EAST OF AVIORE FARM	355	F1

Turbines prefixed “T” are the proposed Freasdail turbines
Turbines prefixed “F” are the consented Fraoch-Choile turbine
Turbines prefixed “X” are the proposed Whiteside Burn turbine

166. ETSU-R-97 recommends that the derived noise limits applicable at nearest house locations shall relate to the cumulative effects of noise from all wind turbines that may affect a particular location. This section describes the process by which noise limits, appropriate for use in noise conditions for the Development, have been derived such that the ETSU-R-97 derived limits at each nearby house shall be adhered to by the cumulative effect of all wind farms in the vicinity.

12.7.2 Methodology

12.7.2.1 Predictions of noise Levels at Receivers

167. The Fraoch-Choile turbine predicted noise levels are used in this analysis. These are calculated using the same methodology as stated in section 12.2.3.2.

168. The turbine that shall be employed at Fraoch-Choile has been assumed to be acoustically similar to an Evovo 10 kW type machine. Warranted acoustic data for this machine is taken from the manufacturer’s website[42] and an uncertainty of 1 dB has been included. Details assumed in this analysis are as follows:

- A hub height of 18 m;
- A rotor diameter of 9.7 m; and
- Assumed sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) as shown in Table 12.24.

[42] Evovo, 2012, “Evovo Wind Turbines Website”, http://www.evocoenergy.co.uk/wind-turbines/evoco-10.html

Table 12.24: Assumed Sound Power Levels for the Evovo 10 kW Wind Turbine

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	A-Weighted Sound Power Level (dB(A) re 1 pW)	
	Warranted noise levels	+1 dB uncertainty
4	84.4	85.4
5	89.2	90.2
6	93.3	94.3
7	95.8	96.8
8	96.4[43]	97.4
9	97.0	98.0
10	97.0	98.0
11	97.0	98.0
12	97.0	98.0

169. The Whiteside Burn turbine predicted noise levels are used in this analysis. These are calculated using the same methodology as stated in paragraph 12.2.3.2.

170. The turbine that shall be employed at Whiteside Burn has been assumed to be acoustically similar to an Enercon E48 800 kW type machine. Warranted acoustic data for this machine is taken from the manufacturer's website[44] and an uncertainty of 1 dB has been included. Details assumed in this analysis are as follows:

- A hub height of 60 m;
- A rotor diameter of 48 m; &
- Assumed sound power levels, LWA, for standardised 10 m height wind speeds (v_{10}) as shown in Table 12.25.

Table 12.25: Assumed Sound Power Levels for the Enercon E48 800 kW Wind Turbine

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	Assumed A-Weighted Sound Power Level (dB(A) re 1 pW)	Assumed A-Weighted Sound Power Level (dB(A) re 1 pW)
	Warranted Levels	+ 1dB uncertainty
4	89.9	90.9
5	94.7	95.7
6	98.8	99.8
7	101.3	102.3
8	101.9	102.9
9	102.5	103.5
10	102.5	103.5
11	102.5	103.5
12	102.5	103.5

171. Due to the cumulative number of turbines, and in accordance with the guidance of ETSU R 97, the most stringent 35dB(A) quiet waking hours lower limit has been adopted.

172. As detailed in section 12.5.1.3, the background noise survey results, i.e. derived ETSU-R-97 limits, inferred to be representative for each property are shown in Table 12.16.

173. As recommended in ETSU-R-97, the absolute lower noise limits may be increased up to 45 dB(A) if the occupant has a financial involvement in the Wind Farm. However, these limits have not been adopted in the presented results. Table 12.26 shows the predicted noise immission levels at the nearest neighbours at each wind speed considered, calculated from the operation of the proposed wind farms including the Development. The property with the highest predicted noise immission level is Lonlia at 37.2 dB(A) and is highlighted in bold.

Table 12.26: Predicted Noise Levels At Nearby Dwellings (dB(A) re 20 μPa)

House Name	Reference Wind Speed, **Standardised** v_{10} (ms^{-1})								
	4	5	6	7	8	9	10	11	12
GARTAVAICH	21.7	27.0	30.7	32.2	33.0	32.9	32.8	32.8	32.8
ARDROWAN	16.5	21.8	25.5	27.1	27.8	27.8	27.7	27.7	27.7
MEADOWVIEW	16.8	22.1	25.8	27.4	28.2	28.1	28.0	28.0	28.0
GARTNAGRENACH LODGE	16.7	21.9	25.6	27.3	28.0	28.0	27.9	27.9	27.9
GARTNAGRENACH COTTAGE	16.2	21.5	25.2	26.8	27.5	27.5	27.4	27.4	27.4
GARTNAGRENACH FARM	16.2	21.5	25.2	26.7	27.5	27.4	27.4	27.4	27.4
GRASSFIELD FARM	23.3	28.6	32.3	33.9	34.5	34.5	34.5	34.5	34.5
LOCHVIEW	23.4	28.7	32.4	34.0	34.8	34.8	34.8	34.8	34.8
LONLIA	25.7	30.9	34.7	36.4	37.1	**37.2**	37.1	37.1	37.1
REDESDALE HOUSE	25.5	30.7	34.5	36.2	36.9	37.0	37.0	37.0	37.0
ARIVORE FARM	22.8	28.0	31.8	33.5	34.2	34.4	34.3	34.3	34.3

[43] This SPL is the only level provided by the manufacturer. The variation of SPL with wind speed has been assumed to be similar to the Enercon E48 as shown in Table 12.25. The levels of noise produced by this turbine at low wind speeds will be very low and are included for conservatism only.
[44] Enercon, 2011, "Sound Power Level of the Enercon E-48 Operational Mode 1 (Data Sheet)", Document name SIAS-04-SPL E48 OM I Rev3_0-eng-eng.doc, Feb 2011.

House Name	Reference Wind Speed, **Standardised** v_{10} (ms^{-1})								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
ARIVORE COTTAGE	22.9	28.1	31.9	33.7	34.3	34.5	34.5	34.5	34.5
BIRCHFIELD	20.0	25.2	29.0	30.6	31.3	31.3	31.2	31.2	31.2
GLENREASDALE HOUSE	22.2	27.4	31.2	32.9	33.6	33.7	33.7	33.7	33.7
KILCHAMAIG GATE	19.7	24.9	28.7	30.4	31.1	31.0	31.0	31.0	31.0
TIGH-NA-CNOC	23.3	28.4	32.3	34.2	34.9	35.1	35.1	35.1	35.1
KILCHAMAIG COTTAGE	17.5	22.7	26.5	28.1	28.9	28.9	28.8	28.8	28.8
ASHNACLOED COTTAGE	17.4	22.6	26.4	28.0	28.7	28.8	28.7	28.7	28.7
SPION KOP	25.0	30.2	34.0	35.8	36.5	36.6	36.6	36.6	36.6
ARIVORE LODGE	21.8	27.0	30.8	32.6	33.3	33.5	33.4	33.4	33.4
THE MANSE	19.5	24.8	28.5	30.1	30.9	31.0	30.9	30.9	30.9
PINMORE COTTAGE	19.5	24.7	28.5	30.1	30.9	30.9	30.9	30.9	30.9
PINWHERRIE COTTAGE	19.9	25.2	28.9	30.6	31.3	31.4	31.4	31.4	31.4
KILCHAMAIG FARM	15.3	20.6	24.3	26.0	26.8	26.8	26.8	26.8	26.8
SOUTH LODGE	20.4	25.6	29.4	31.1	31.8	31.9	31.8	31.8	31.8
HOME FARM	20.3	25.5	29.3	31.0	31.7	31.8	31.8	31.8	31.8
GLENREASDELL FARM	20.3	25.5	29.3	31.0	31.7	31.8	31.8	31.8	31.8
THE SCHOOLHOUSE	19.5	24.7	28.5	30.2	30.8	31.0	30.9	30.9	30.9
THE OLD SCHOOL	19.4	24.6	28.4	30.1	30.8	30.9	30.9	30.9	30.9
LAPHROAIG	18.9	24.1	27.9	29.6	30.3	30.4	30.4	30.4	30.4
LAGAVULLIN HOUSE	18.8	24.0	27.8	29.5	30.2	30.3	30.3	30.3	30.3
1 LAGAVULLIN	18.8	24.0	27.8	29.5	30.2	30.3	30.3	30.3	30.3
ROSE COTTAGE	18.8	24.0	27.8	29.5	30.2	30.3	30.3	30.3	30.3
2 LAGAVULLIN	18.7	23.9	27.7	29.4	30.1	30.2	30.2	30.2	30.2
MILLWOOD CROFT	18.6	23.8	27.6	29.3	30.0	30.1	30.1	30.1	30.1
SMITHY HOUSE	18.6	23.8	27.6	29.3	30.0	30.1	30.1	30.1	30.1
GHRIANAIG	18.6	23.8	27.6	29.3	30.0	30.1	30.1	30.1	30.1
EDEN HOUSE	18.6	23.9	27.6	29.3	30.0	30.1	30.1	30.1	30.1
CRAIGARD	18.6	23.9	27.6	29.3	30.0	30.1	30.1	30.1	30.1
THE WEAVER	18.5	23.8	27.5	29.3	30.0	30.1	30.1	30.1	30.1
BRAESIDE	18.6	23.8	27.5	29.2	30.0	30.1	30.0	30.0	30.0
CNOC DON	18.6	23.8	27.6	29.2	30.0	30.0	30.0	30.0	30.0
TIGH NA CROIT	18.6	23.8	27.6	29.3	30.0	30.1	30.1	30.1	30.1
DOUGIES CROFT	18.8	24.0	27.8	29.5	30.2	30.3	30.3	30.3	30.3
CRAIG VIEW	21.0	26.1	30.0	32.1	32.8	33.1	33.1	33.1	33.1
WHITEHOUSE	19.0	24.1	27.9	29.9	30.6	30.8	30.8	30.8	30.8
ANCONEAS	18.9	24.1	27.9	29.8	30.5	30.7	30.7	30.7	30.7
BLUEBELL COTTAGE	18.2	23.3	27.1	29.1	29.8	30.0	30.0	30.0	30.0
THE RHINNS	17.7	22.9	26.7	28.6	29.3	29.5	29.5	29.5	29.5
HOUSING PLOT 1	24.5	29.8	33.5	35.1	35.8	35.8	35.8	35.8	35.8
HOUSING PLOT 2	24.1	29.3	33.1	34.6	35.3	35.3	35.2	35.2	35.2
HOUSING PLOT 3	23.2	28.5	32.2	33.7	34.4	34.4	34.4	34.4	34.4
GLENREASDELL MAINS	19.6	24.9	28.6	30.1	30.9	30.9	30.9	30.9	30.9
EAST OF AVIORE FARM	25.7	30.7	34.6	36.7	37.3	37.7	37.6	37.6	37.6

Values in bold indicate the maximum predicted noise level
Shading indicates properties with predicted noise levels greater than 35 dB(A), refer to section 12.2.3.3

12.7.2.2 Acoustic Assessment

174. Table 12.27a-b shows a comparison of the predicted noise levels for the Development with the recommended quiet waking hours noise limits as derived in Paragraph 113 for the properties considered in section 12.2.3.1 as well as any locations with a cumulative predicted noise level in excess of 35 dB(A). The predicted noise levels and derived noise limits at 1 ms^{-1}, 2 ms^{-1}, and 3 ms^{-1} have been assumed as equal to 4 ms-1, though this is a conservative measure. The term ΔL is used to denote the difference between the predicted cumulative wind farm noise level and the recommended limit. A negative value indicates that the predicted noise level is within the limit. Table 12.28a-b shows a comparison with the recommended night-time noise limits.

175. The minimum margin of predicted noise levels below derived noise limits, for all wind speeds considered is -1.6 dB(A) during quiet waking hours. The minimum margin during night time periods, for all wind speeds considered, is -5.8 dB(A). The minimum margins are highlighted in the relevant tables.

Table 12.27a: Comparison of Predicted Noise Levels and Quiet Waking Hours Limits - (dB(A) re 20 μPa) (wind speeds 1 ms^{-1}-6 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	1			2			3			4			5			6		
	Lp	Limit	ΔL	Lp	Limit	ΔL	Lp	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	25.5	35.0	-9.5	25.5	35.0	-9.5	25.5	35.0	-9.5	25.5	35.0	-9.5	30.7	35.0	-4.3	34.5	36.3	-1.8
LONLIA	25.7	35.0	-9.3	25.7	35.0	-9.3	25.7	35.0	-9.3	25.7	35.0	-9.3	30.9	35.0	-4.1	34.7	36.3	-1.6
LOCHVIEW	23.4	35.0	-11.6	23.4	35.0	-11.6	23.4	35.0	-11.6	23.4	35.3	-11.9	28.7	37.4	-8.7	32.4	39.5	-7.1
HOUSING PLOT 1	24.5	35.0	-10.5	24.5	35.0	-10.5	24.5	35.0	-10.5	24.5	35.0	-10.5	29.8	35.0	-5.2	33.5	37.4	-3.9
HOUSING PLOT 2	24.1	35.0	-10.9	24.1	35.0	-10.9	24.1	35.0	-10.9	24.1	35.0	-10.9	29.3	35.0	-5.7	33.1	37.4	-4.3
GRASSFIELD FARM	23.3	35.0	-11.7	23.3	35.0	-11.7	23.3	35.0	-11.7	23.3	35.0	-11.7	28.6	35.5	-6.9	32.3	37.9	-5.6
TIGH-NA-CNOC	23.3	35.0	-11.7	23.3	35.0	-11.7	23.3	35.0	-11.7	23.3	35.3	-12.0	28.4	37.4	-9.0	32.3	39.5	-7.2
SPION KOP	25.0	35.0	-10.0	25.0	35.0	-10.0	25.0	35.0	-10.0	25.0	35.0	-10.0	30.2	35.0	-4.8	34.0	36.3	-2.3
EAST OF AVIORE FARM	25.7	35.0	-9.3	25.7	35.0	-9.3	25.7	35.0	-9.3	25.7	35.3	-9.6	30.7	37.4	-6.7	34.6	39.5	-4.9

The term L_p is used to denote the predicted noise level due to the operation of the developments under consideration
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit
The shaded value denotes the maximum quiet waking hours ΔL value

Table 12.27b: Comparison of Predicted Noise Levels and Quiet Waking Hours Limits - (dB(A) re 20 μPa) (wind speeds 7 ms^{-1}-12 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	36.2	39.8	-3.6	36.9	42.8	-5.9	37.0	45.0	-8.0	37.0	45.0	-8.0	37.0	45.0	-8.0	37.0	45.0	-8.0
LONLIA	36.4	39.8	-3.4	37.1	42.8	-5.7	37.2	45.0	-7.8	37.1	45.0	-7.9	37.1	45.0	-7.9	37.1	45.0	-7.9
LOCHVIEW	34.0	41.6	-7.6	34.8	43.3	-8.5	34.8	44.6	-9.8	34.8	45.3	-10.5	34.8	45.3	-10.5	34.8	45.3	-10.5
HOUSING PLOT 1	35.1	40.3	-5.2	35.8	43.5	-7.7	35.8	47.0	-11.2	35.8	50.7	-14.9	35.8	50.7	-14.9	35.8	50.7	-14.9
HOUSING PLOT 2	34.6	40.3	-5.7	35.3	43.5	-8.2	35.3	47.0	-11.7	35.2	50.7	-15.5	35.2	50.7	-15.5	35.2	50.7	-15.5
GRASSFIELD FARM	33.9	40.6	-6.7	34.5	43.5	-9.0	34.5	46.5	-12.0	34.5	49.5	-15.0	34.5	49.5	-15.0	34.5	49.5	-15.0
TIGH-NA-CNOC	34.2	41.6	-7.4	34.9	43.3	-8.4	35.1	44.6	-9.5	35.1	45.3	-10.2	35.1	45.3	-10.2	35.1	45.3	-10.2
SPION KOP	35.8	39.8	-4.0	36.5	42.8	-6.3	36.6	45.0	-8.4	36.6	45.0	-8.4	36.6	45.0	-8.4	36.6	45.0	-8.4
EAST OF AVIORE FARM	36.7	41.6	-4.9	37.3	43.3	-6.0	37.7	44.6	-6.9	37.6	45.3	-7.7	37.6	45.3	-7.7	37.6	45.3	-7.7

The term L_p is used to denote the predicted noise level due to the operation of the developments under consideration
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit
The shaded value denotes the maximum quiet waking hours ΔL value

Table 12.28a: Comparison of Predicted Noise Levels and Night Time Limits - (dB(A) re 20 μPa) (wind speeds 1 ms^{-1}-6 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	1			2			3			4			5			6		
	Lp	Limit	ΔL	Lp	Limit	ΔL	Lp	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	25.5	43.0	-17.5	25.5	43.0	-17.5	25.5	43.0	-17.5	25.5	43.0	-17.5	30.7	43.0	-12.3	34.5	43.0	-8.5
LONLIA	25.7	43.0	-17.3	25.7	43.0	-17.3	25.7	43.0	-17.3	25.7	43.0	-17.3	30.9	43.0	-12.1	34.7	43.0	-8.3
LOCHVIEW	23.4	43.0	-19.6	23.4	43.0	-19.6	23.4	43.0	-19.6	23.4	43.0	-19.6	28.7	43.0	-14.3	32.4	43.0	-10.6
HOUSING PLOT 1	24.5	43.0	-18.5	24.5	43.0	-18.5	24.5	43.0	-18.5	24.5	43.0	-18.5	29.8	43.0	-13.2	33.5	43.0	-9.5
HOUSING PLOT 2	24.1	43.0	-18.9	24.1	43.0	-18.9	24.1	43.0	-18.9	24.1	43.0	-18.9	29.3	43.0	-13.7	33.1	43.0	-9.9
GRASSFIELD FARM	23.3	43.0	-19.7	23.3	43.0	-19.7	23.3	43.0	-19.7	23.3	43.0	-19.7	28.6	43.0	-14.4	32.3	43.0	-10.7
TIGH-NA-CNOC	23.3	43.0	-19.7	23.3	43.0	-19.7	23.3	43.0	-19.7	23.3	43.0	-19.7	28.4	43.0	-14.6	32.3	43.0	-10.7
SPION KOP	25.0	43.0	-18.0	25.0	43.0	-18.0	25.0	43.0	-18.0	25.0	43.0	-18.0	30.2	43.0	-12.8	34.0	43.0	-9.0
EAST OF AVIORE FARM	25.7	43.0	-17.3	25.7	43.0	-17.3	25.7	43.0	-17.3	25.7	43.0	-17.3	30.7	43.0	-12.3	34.6	43.0	-8.4

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

Table 12.28b: Comparison of Predicted Noise Levels and Night Time Limits - (dB(A) re 20 μPa) (wind speeds 7 ms^{-1}-12 ms^{-1})

House Name	Reference Wind Speed, v_{10} (ms^{-1})																	
	7			8			9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
REDESDALE HOUSE	36.2	43.0	-6.8	36.9	43.0	-6.1	37.0	43.0	-6.0	37.0	43.0	-6.0	37.0	43.0	-6.0	37.0	43.0	-6.0
LONLIA	36.4	43.0	-6.6	37.1	43.0	-5.9	37.2	43.0	-5.8	37.1	43.0	-5.9	37.1	43.0	-5.9	37.1	43.0	-5.9
LOCHVIEW	34.0	43.0	-9.0	34.8	43.8	-9.0	34.8	46.5	-11.7	34.8	48.8	-14.0	34.8	48.8	-14.0	34.8	48.8	-14.0
HOUSING PLOT 1	35.1	43.0	-7.9	35.8	43.0	-7.2	35.8	45.7	-9.9	35.79	48.2	-12.4	35.79	48.2	-12.4	35.79	48.2	-12.4
HOUSING PLOT 2	34.6	43.0	-8.4	35.3	43.0	-7.7	35.3	45.7	-10.4	35.23	48.2	-13	35.23	48.2	-13	35.23	48.2	-13
GRASSFIELD FARM	33.9	43.0	-9.1	34.5	43.0	-8.5	34.5	44.6	-10.1	34.5	45.7	-11.2	34.5	45.7	-11.2	34.5	45.7	-11.2
TIGH-NA-CNOC	34.2	43.0	-8.8	34.9	43.8	-8.9	35.1	46.5	-11.4	35.1	48.8	-13.7	35.1	48.8	-13.7	35.1	48.8	-13.7
SPION KOP	35.8	43.0	-7.2	36.5	43.0	-6.5	36.6	43.0	-6.4	36.6	43.0	-6.4	36.6	43.0	-6.4	36.6	43.0	-6.4
EAST OF AVIORE FARM	36.7	43.0	-6.3	37.3	43.8	-6.5	37.7	46.5	-8.8	37.64	48.8	-11.2	37.64	48.8	-11.2	37.64	48.8	-11.2

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

12.7.3 Cumulative Construction Noise Assessment

176. It is considered unlikely that the construction of the three developments is likely to overlap, with the Fraoch-Choile and Whiteside Burn turbines likely to be constructed prior to the Development. Should the construction timescales overlap however, given the distance between the Development and the Fraoch-Choile and Whiteside Burn turbines, it is highly unlikely that a significant cumulative effect would arise.

12.8 STATEMENT OF SIGNIFICANCE

177. The acoustic effects during the operation of the Development on nearby neighbours has been assessed in accordance with the guidance on wind farm noise as issued in the DTI publication 'The Assessment and Rating of Noise from Wind Farms'[2], otherwise known as "ETSU-R-97", as recommended for use by relevant planning policy.

178. The predicted noise immision levels at the closest residential properties has been assessed against measured background noise levels and compared with noise limits derived in line with ETSU-R-97. The predicted operational noise levels at all properties are within the derived noise limits at all considered wind speeds.

179. The proposed wind farm therefore complies with the relevant guidance on wind farm noise and the effect on the amenity of all nearby properties would be regarded as acceptable. This remains the case when the cumulative developments of Fraoch-Choile and Whiteside Burn turbines are included in the assessment.

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

12.9 GLOSSARY

Broadband Noise

Noise which covers a wide range of frequencies (e.g. from 10 Hz to 5 kHz).

dB(A)

The decibel (dB) is a logarithmic unit used in acoustics to quantify sound levels relative to a 0 dB reference (a sound pressure level of $2*10^{-5}$ Pa). The 'A' signifies A-weighting which is a frequency-response function that applies an international weighted scale of sound levels in each frequency band (octave band or third octave band) providing a good correlation with the sensitivity of the human ear which is less sensitive to very high and very low frequencies.

Frequency

The pitch of a sound in Hz or kHz. See Hz.

Hz

Sound frequency refers to how quickly the air vibrates, or how close the sound waves are to each other (in cycles per second, or Hertz (Hz)).

L_{eq}

The equivalent continuous noise level is a notional steady noise level, which over a given time, would provide the same energy as the intermittent noise. Noise standards often specify the length of time over which noise should be measured.

L_{90}

Sound pressure level exceeded for 90% of the time for any given time interval. For example, $L_{(A)90,10min}$ means the A-weighted level that is exceeded for 90% of a ten minute interval. This indicates the noise levels during quieter periods, or the background noise level. It represents the lower estimate of the prevailing noise level, and is useful for excluding the effects of, for example, aircraft or dogs barking on background noise levels.

L_W

Sound power level is the acoustic power (W) radiated from a sound source. This power is essentially independent of the surroundings, while the sound pressure depends on the surroundings (reflecting surfaces) and distance to the receiver.

Noise Emission

The noise energy emitted by a source (e.g. a wind turbine).

Noise Immission

The sound pressure level detected at a given location (e.g. nearest dwelling).

Octave Band

Range of frequencies between one frequency ($f_0*2^{-1/2}$) and a second frequency ($f_0*2^{+1/2}$). The quoted centre frequency of the octave band is f_0.

Sound Frequency

Refers to how quickly the air vibrates, or how close the sound waves are to each other (in Hertz). Frequency is subjectively felt as the pitch of the sound. The lowest frequency audible to humans is 20 Hz and the highest is 20,000 Hz. The human ear is most sensitive to the 1 kHz, 2 kHz and 4 kHz octaves and much less sensitive at the lower audible frequencies.

Spectrum

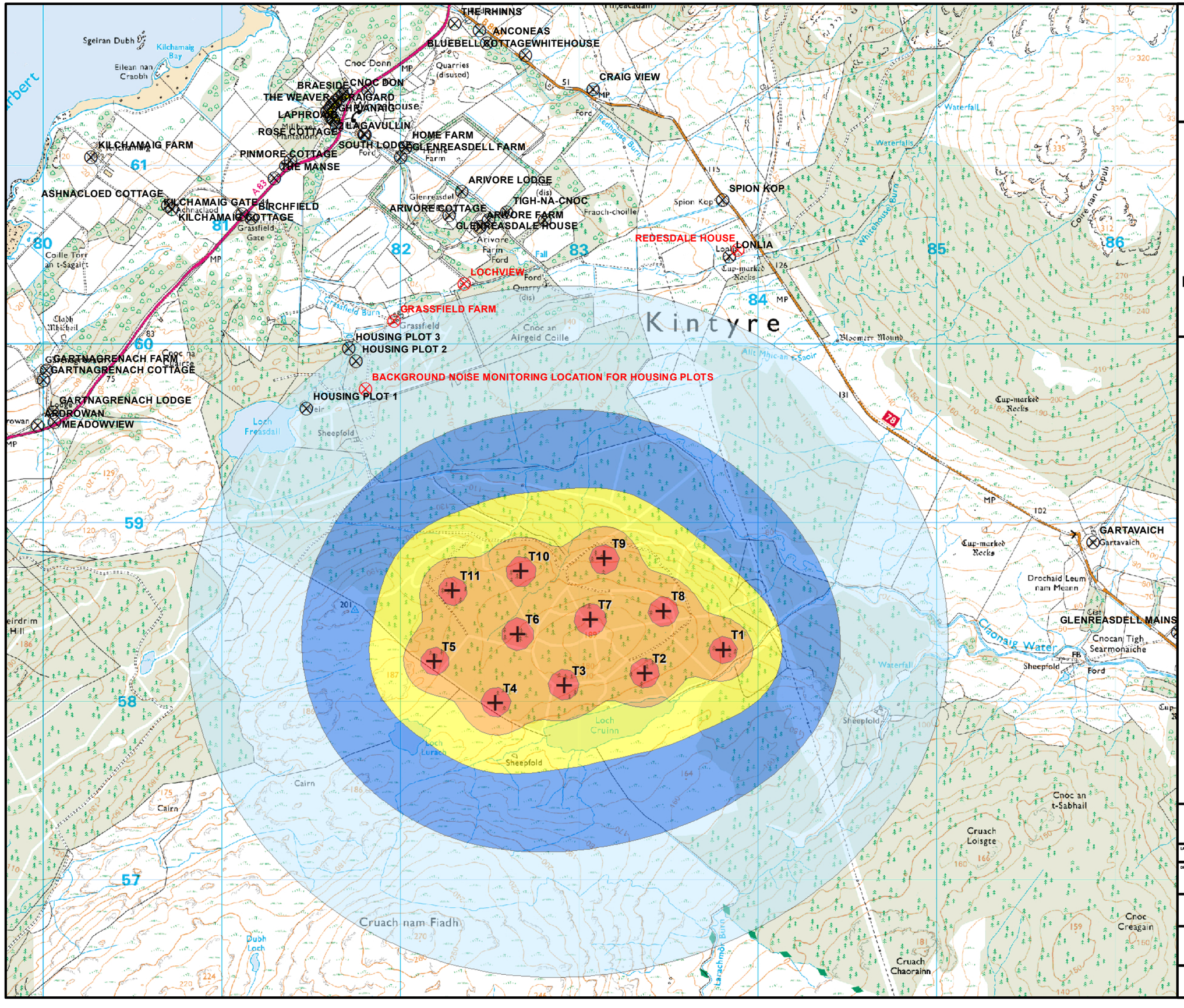
Description of the sound pressure level of a source as a function of frequency.

Third Octave Band

The range of frequencies between one frequency ($f_0*2^{-1/6}$) and a second frequency equal to ($f_0*2^{+1/6}$). The quoted centre frequency of the third octave band is f_0.

Tonal Noise

Noise which covers a very restricted range of frequencies (e.g. a range of <=20 Hz). This noise is more annoying than broadband noise.



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FREASDAIL WIND FARM

FIGURE 12.1

PREDICTED NOISE FOOTPRINT

Legend

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

Grid intervals at 1 km

The LA90,10min descriptor has been used

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

Red receiver icons indicate background noise measurements made at those locations.

Turbines prefixed 'T' are the proposed Freasdail wind turbines

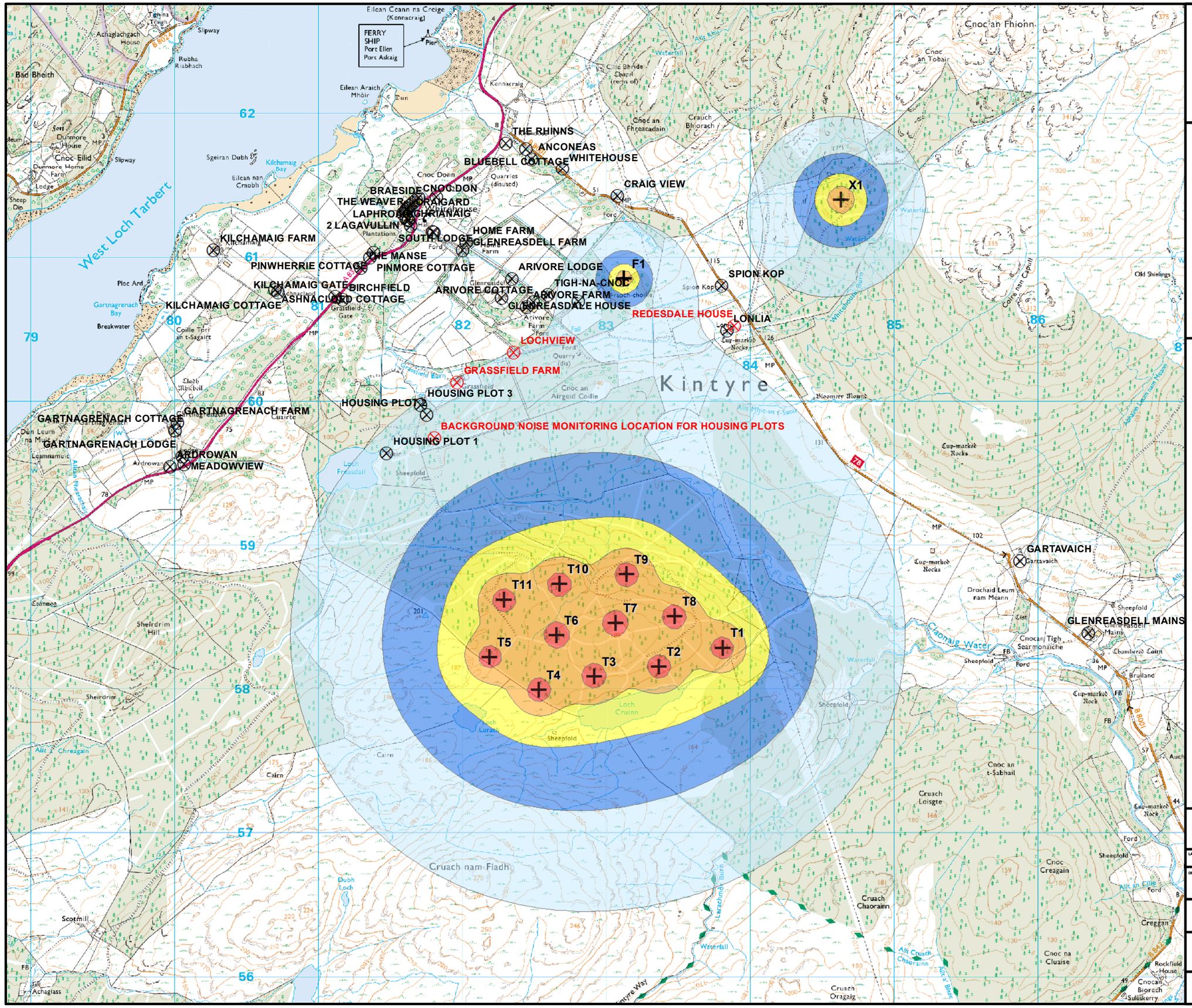
N

LAYOUT DWG	T-LAYOUT NO.
02564D0001-09	PSCOfre019

DRAWING NUMBER: 02564D2221-01

SCALE - 1:20,000 @ A3

ENVIRONMENTAL STATEMENT 2012



FREASDAIL WIND FARM

FIGURE 12.2

PREDICTED CUMULATIVE NOISE FOOTPRINT

Legend

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

Grid intervals at 1 km

The LA90,10min descriptor has been used

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

Red receiver icons indicate background noise measurements made at those locations.

Turbines prefixed 'T' are the proposed Freasdail wind turbines
Turbines prefixed "F" are the consented Fraoch-Choile turbine
Turbines prefixed "X" are the proposed Whiteside Burn turbine

N

LAYOUT DWG	T-LAYOUT NO.
02564D0001-09	PSCOfre019

DRAWING NUMBER

02564D2222-01

SCALE - 1:25,000 @ A3

ENVIRONMENTAL STATEMENT 2012