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Red John Pumped Storage Hydro Scheme

Volume 2, Chapter 16: Noise and Vibration

ILI (Highlands PSH) Ltd.

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Quality information

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16.1 Introduction

16.1.1 This chapter presents the assessment of potential noise and vibration effects during the construction, operational and decommissioning phases of the Development. The assessment has been undertaken following guidelines set out in the IEMA publication "*Guidelines for Environmental Impact Assessment*" (IEMA Guidelines), relevant British Standards and planning guidance.

16.1.2 The assessment methodology has been informed by the ECU Scoping Opinion for the Development (Appendix 4.3, Volume 5). Specifically the following amendments were made to the methodology proposed in the Development Scoping Report:

- Exclusion of construction traffic noise impacts from the assessment scope as per the Noise and Air Quality Assessments section of the Transport Scotland Consultation Response;
- Establishment of specific impact criteria for construction vibration and operational noise assessments as per the Noise section of THC's Scoping Response; and
- Incorporation of assessment of potential construction vibration impacts on underground services as per para 51 of Annex 1 of the Scottish Water Pre-Application Consultation Response.

16.1.3 This chapter is supported by the following Figures (Volume 3) and Technical Appendices, which are located in Volume 5:

- Figure 16.1: Noise Sensitive Receptors
- Figure 16.2: Noise Monitoring Locations
- Appendix 16.1: Acoustic Terminology
- Appendix 16.2: Measurement Summaries
- Appendix 16.3: Model Input Data
- Appendix 16.4: Uncertainty in Modelling

16.2 Legislation, Policy and Guidance

National Planning Policy

Scottish Planning Policy

16.2.1 Section 169 within the Scottish Planning Policy (SPP) (June 2014) states that:

"*Proposals for energy infrastructure developments should always take account of spatial frameworks for wind farms and heat maps where these are relevant. Considerations will vary relative to the scale of the proposal and area characteristics but are likely to include:…*

- *impacts on communities and individual dwellings, including visual impact, residential amenity, noise and shadow flicker*";

Planning Advice Note 1/ 2011 Planning and Noise

16.2.2 Current national guidance on noise is contained in Planning Advice Note (PAN) 1/2011 Planning and Noise (The Scottish Government, 2011). In para 2 PAN 1/2011 states that it *"promotes the principles of good acoustic design and a sensitive approach to the location of*

new development. It promotes the appropriate location of new potentially noisy development, and a pragmatic approach to the location of new development within the vicinity of existing noise generating uses, to ensure that quality of life is not unreasonably affected and that new development continues to support sustainable economic growth."

16.2.3 Para 3 of PAN 1/2011 states "*The Environmental Noise (Scotland) Regulations 2006 transposed the European Directive 2002/49/EC (the Environmental Noise Directive) into Scottish law… They require Scottish Ministers and airport authorities to manage noise through a process of strategic noise mapping and noise action plans. In the areas affected by the Regulations, planning authorities have a role in helping to prevent and limit the adverse effects of environmental noise.*" There are no Noise Action Plans in proximity to the Development site.

16.2.4 A Technical Advice Note (TAN 2011) (The Scottish Government, 2011) accompanies PAN 1/2011 and provides technical guidance on noise assessment.

Relevant Legislation

16.2.5 The provisions of Sections 60 and 61 of the Control of Pollution Act 1974 offer protection to those living in the vicinity of construction sites.

16.2.6 Section 60 enables a local authority to serve a notice specifying its noise control requirements which may include:

- Plant or machinery that is or is not to be used;
- Hours of working; and,
- Levels of noise or vibration that can be emitted.

16.2.7 Section 61 relates to prior consent, and is for situations where a contractor or developer takes the initiative and approaches the local authority before work starts to obtain approval for the methods to be used and any noise and vibration control techniques that may be required.

16.2.8 The term 'Best Practicable Means' (BPM) is defined in Section 72 of the Control of Pollution Act 1974, where 'practicable' means reasonably practicable having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications.

Local Planning Policy

16.2.9 The adopted Highland-wide Local Development Plan (HLDP) (Ref 1) Policy 67 'Renewable Energy Developments' states "*the Council will support proposals where it is satisfied that they are located, sited and designed such that they will not be significantly detrimental overall, either individually or cumulatively with other developments (see Glossary), having regard in particular to any significant effects on the following:…*

- *The safety and amenity of any regularly occupied buildings and the grounds that they occupy- having regard to visual intrusion or the likely effect of noise generation*".

16.2.10 Policy 72 'Pollution' of the HLDP states that:

"*Proposals that may result in significant pollution such as noise (including aircraft noise), air, water and light will only be approved where a detailed assessment report on the levels, character and transmission and receiving environment of the potential pollution is provided by the applicant to show how the pollution can be appropriately avoided and if necessary mitigated*."

16.2.11 Section 4.2, Hydro-Electricity of The Highland Council: Renewable Energy Strategy (THC, 2005) states it is a planning requirement that "*Developers will need to provide details of noise levels.*" Under guidance it states that "*Turbines can produce some noise but this can be mitigated relatively easily.*"

Chapter Specific Guidance

16.2.12 The following documents have been referred to as part of this assessment. Further details about the documents can be found in the assessment section.

- BS 4142:2014 Method for Rating and Assessing Industrial and Commercial Sound;
- BS 5228:2009+A1:2014 Noise and Vibration Control on Construction and Open Sites Parts 1 and 2 (with amendments, 2014);
- BS 6472-1: 2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting;
- BS 6472-2: 2008 Guide to evaluation of human exposure to vibration in buildings. Blast-induced vibration; and
- BS 8233: 2014 Guidance on sound insulation and noise reduction for buildings.

16.3 Methods

Assessment Scope

16.3.1 The scope of this assessment is to identify the significance of the potential effects identified in Section 16.1.

16.3.2 As mentioned in para 16.1.3, changes in road traffic flows on surrounding roads during the construction of the Development are not included in the scope of this assessment. Changes in road traffic flows due to the operation of the Development will be minimal and have also been excluded from the assessment scope on this basis.

16.3.3 Decommissioning, if required, would involve the drainage of water from the Headpond, the removal of equipment, blocking of Waterways and Tunnel entrances and the removal of above ground structures, as described in Section 2.16 of Chapter 2: Project and Site Description. No blasting, tunnelling or crushing will be required and it is considered that the effects will be negligible. Therefore it is not considered further.

16.3.4 The temporal scope of this assessment therefore includes consideration of the construction and operational phases of the Development.

16.3.5 The spatial scope of the assessment encompasses any areas where construction works are to be undertaken or operational noise sources will be located and extends to the closest noise and vibration sensitive receptors. Potential airborne noise impacts on ecological receptors are considered within Chapter 6: Terrestrial Ecology and Chapter 8: Ornithology. Potential underwater noise and vibration impacts on ecological receptors are considered within Chapter 7: Aquatic Ecology.

Assessment Guidance

BS 5228-1: 2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Part 1: Noise (with 2014 amendment)

16.3.6 Noise levels generated by demolition and construction activities are subject to Local Authority control under the Control of Pollution Act 1974. Supplementary advice is provided by British Standard BS 5228-1:2009 'Code of Practice for Noise and Vibration Control on

Construction and Open Sites' with respect to noise assessment and mitigation (**Error! Reference source not found.**).

16.3.7 BS 5228-1:2009 contains a noise emission database for individual construction plant, their associated activities, and methods of working. Unless noise level data is available from manufacturers, the BS 5228-1:2009 database is used when predicting noise levels associated with various construction activities.

16.3.8 With regard to acceptable noise levels, BS 5228 provides guidance within Annex E including the 'ABC Method' which enables the identification of potentially significant effects at dwellings. This proposes threshold values of $L_{Aeq,T}$ as a function of baseline sound levels at the receptors, as shown in Table 16.1 below.

Table 16.1 Example Threshold of Potential Significant Effect at Dwellings

Assessment Category and Threshold Value Period	Threshold Value $L_{Aeq,T}$ dB(A) façade		
	Category A [(a)]	Category B [(b)]	Category C [(c)]
Night-time (23:00 – 07:00)	45	50	55
Evenings and Weekends [(d)]	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75

NOTE 1: A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level.

NOTE 2 If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3 dB due to site noise.

NOTE 3: Applies to residential receptors only.

(a) Category A: Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.

(b) Category B: Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as Category A values.

(c) Category C: Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than Category A values.

(d) 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays, 07:00 – 23:00 Sundays.

16.3.9 For the appropriate period (night, evening / weekend, day), the ambient noise level is determined and rounded to the nearest 5 dB. The appropriate Threshold Value is then determined. The total construction noise level is then compared with this Threshold Value. If the total noise level exceeds the Threshold Value, then a potentially significant effect is deemed to occur.

16.3.10 Where construction activities involve large scale and long-term earth moving activities, BS 5228 recommends noise limits more akin to surface mineral extraction than conventional construction activities. For these activities the document recommends application of the Technical Guidance to the National Planning Policy Framework and suggests that a "*limit of 55 dB $L_{Aeq,1h}$* [free-field] *is adopted for daytime construction noise for these types of activities but only where the works are likely to occur for a period in excess of six months*".

BS 5228-2:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Part 2: Vibration (with 2014 amendments)

16.3.11 BS 5228-2:2009 addresses the need for the protection against vibration for persons living in the vicinity of construction sites and recommends procedures for vibration control. BS 5228-2:2009 recommends that:*'.... it is considered more appropriate to provide guidance in terms*

of the PPV (Peak Particle Velocity), since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage'.

16.3.12 BS 5228-2:2009 provides empirical formulae relating resultant PPV for vibratory compaction, percussive and vibratory piling, dynamic compaction, the vibration of stone columns and tunnel boring operations.

16.3.13 Table 16.2 (adapted from Table B.1, BS 5228-2:2009) details PPV levels and their potential effect on humans, and provides a semantic scale for description of vibration impacts on human receptors.

Table 16.2 Guidance on Effects of Vibration Levels

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

16.3.14 BS 5228-2:2009 provides the following criteria which are the maximum vibration levels to which underground services should be subjected:

- Maximum PPV for intermittent or transient vibrations 30 mm/s;
- Maximum PPV for continuous vibrations 15 mm/s.

16.3.15 It goes on to state that "*even a PPV of 30 mm/s gives rise to a dynamic stress which is equivalent to approximately 5 % only of the allowable working stress in typical concrete and even less in iron or steel*."

BS 6472-1: 2008. Guide to evaluation of human exposure to vibration in buildings. Part 1: Vibration sources other than blasting

16.3.16 BS 6472-1: 2008 provides guidance on the effects of human exposure to whole body vibration inside buildings, from internal sources such as footsteps or machinery, or external sources such as road traffic or railways. It specifically excluded consideration of blasting which is covered in BS 6472-2:2008. This Standard provides guidance on the levels of vibration that are likely to give rise to varying degrees of 'adverse comment'.

16.3.17 The vibration criteria are given in terms of the vibration dose value (VDV) indicator. The VDV is given by the fourth root of the time integral of the fourth power of the acceleration after it has been frequency-weighted. BS 6472-1:2008 states that the VDV is the best indicator to use when assessing human response to whole body vibration inside buildings.

16.3.18 The criteria contained within BS 6472-1:2008 are provided in Table 16.3.

Table 16.3 VDV Criteria from BS 6472-1:2008

Place and time	Low probability of adverse comment $m/s^{1.75}$	Adverse comment possible $m/s^{1.75}$	Adverse comment probable $m/s^{1.75}$
Residential buildings 16 h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6

Residential buildings 8 h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

16.3.19 For offices and workshops, multiplying factors of 2 and 4 respectively should be applied to the above vibration dose value ranges for a 16 h day.

16.3.20 Vibration dose values below the ranges in Table 16.3 are rated as 'adverse comment not expected' and vibration above the ranges in Table 16.3 are rated as 'adverse comment very likely'.

16.3.21 These criteria apply to both the vertical and horizontal axes of vibration, although the two directions use different frequency weighting in the calculation of the VDV. The vertical direction uses the W_b weighting, while the horizontal axes use the W_d weighting. The definitions of the frequency weightings are given in BS 6472-1:2008.

16.3.22 The Standard also states that if the direction of the vibration is dominated by a single axis, it is only necessary to assess the vibration response in respect to the dominant axis.

Planning Advice Note PAN 50 'Controlling the Environmental Effects of Surface Mineral Workings'

16.3.23 As mentioned in para. 16.3.10 BS 5228-1:2014 references the Technical Guidance to the National Planning Policy Framework when considering noise from long-term construction sites involving large scale earth moving. This Technical Guidance does not apply in Scotland however Planning Advice Note PAN 50 'Controlling the Environmental Effects of Surface Mineral Workings' provides equivalent guidance in Annex A: The Control of Noise at Surface Mineral Workings.

16.3.24 PAN 50 states "*It will often be necessary to raise the noise limits to allow temporary but exceptionally noisy phases in the mineral extraction operation which cannot meet the limits set for routine operations. A prime example would be to allow for the construction of baffle mounds. Other activities which would also merit a temporary raised limit include soil-stripping, removal of spoil heaps, and construction of new permanent landforms. These activities are in themselves noisy, but can bring long term benefits… It is suggested that 70 dB $L_{Aeq,1h}$ (free field) for periods of up to 8 weeks in a year should be considered to facilitate this, but planning authorities and operators may also wish to weigh up the effects of shortening this period and allowing higher levels of noise, in order to get such temporary operations completed as quickly as possible. However, some operations may require longer than 8 weeks for completion, and in such cases, an increased limit up to 70 dB $L_{Aeq,1h}$ (free-field) may be allowed during these periods.*"

BS 6472-2: 2008. Guide to evaluation of human exposure to vibration in buildings. Part 2: Blast-induced vibration

16.3.25 BS 6472-2:2008 provides guidance on human exposure in buildings to blast-induced vibration and air overpressures. It is primarily applicable to blasting associated with mineral extraction but can also be applicable to explosives used within civil engineering and demolition.

16.3.26 BS 6472-2:2008 advises that to predict the likely vibration magnitude from a controlled blast, a series of measurements at several locations should be taken from one or more trial blasts. Using the formula provided in BS 6472-2:2008 and extrapolation of the trial blast results, the likely vibration magnitudes at a given distance (for a given maximum instantaneous charge) can be predicted to a given confidence level.

16.3.27 The standard suggests that accredited blasting contractors will appropriately design blasts to minimise effects at Noise (and vibration) Sensitive Receptors (NSRs).

16.3.28 For blast vibration occurring up to three times per day the standard states that for residential premises the probability of adverse comment is low if the peak particle velocity (PPV) is below 6.0 to 10.0 mm/s during the day. At night this reduces to 2.0 mm/s. It goes on to state that "*Doubling the suggested vibration magnitudes could result in adverse comment and this will increase significantly if the magnitudes are quadrupled.*"

16.3.29 The standard acknowledges that "*blast-induced vibration is highly variable*" and it qualifies that the above limits "*should not be exceeded by more than 10% of the blasts*" and that no blast should result in vibration that exceeds the limit by more than 50%. It goes on to state that "*working to a 90% confidence limit value means, in practice, that blasts need to be designed to ensure that the average level of vibration is approximately half of the specified limit. For example, if the satisfactory limit is required to be 6.0 mm/s at 90% confidence then blasts will be designed to produce vibration levels of approximately 3.0 mm/s, and in practice most will be below this level*".

16.3.30 Should more than three blasts be required per day, BS 6472-2:2008 provides information on the acceptable vibration limits.

16.3.31 BS 6472-2:2008 states that "*Accurate prediction of air overpressure (from blasting) is almost impossible due to the variable effects of the prevailing weather conditions and the large distances often involved*."

16.3.32 Whilst not providing specific air overpressure limits, BS 6472-2:2008 provides the following information on acceptable overpressure pressures: "*Windows are generally the weakest parts of a structure exposed to air overpressure. Research by the United States Bureau of Mines has shown that a poorly mounted window that is pre-stressed can crack at around 150 dB(lin), with most windows cracking at around 170 dB(lin). Structural damage would not be expected at air overpressure levels below 180 dB(lin).*"

16.3.33 The air overpressure levels measured at properties near quarries in the United Kingdom are generally around 120 dB(lin), which is 30 dB(lin) below, or only 3% of, the limit for cracking pre-stressed poorly mounted windows (150 dB(lin)).

BS 7385: Part 2: 1993 Evaluation and measurement for vibration in buildings. Part 2 Guide to damage levels from groundborne vibration

16.3.34 BS 7385-2:1993 provides guidance on the levels of groundborne vibration above which building structures could be damaged. For the purposes of BS 7385-2:1993, damage is classified as cosmetic (formation of hairline cracks), minor (formation of large cracks) or major (damage to structural elements). Guide values given in BS 7385-2:1993 are associated with the threshold of cosmetic damage only, usually in wall and / or ceiling lining materials.

16.3.35 BS 7385-2:1993 provides a frequency-based vibration criterion for transient vibration induced cosmetic damage, which is reproduced in Table 16.4.

Table 16.4 Transient vibration guide values for cosmetic damage

Type of Structure	Peak Component Particle Velocity in Frequency Range of Predominant Pulse[1 and 2]	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Un-reinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz[3]	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

1 Peak Component Particle Velocity is defined as the maximum value of any one of three orthogonal component particle velocities measured during a given time interval

2 - Values referred to are at the base of the building.

3 - At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

16.3.36 When considering continuous vibrations, even taking the precautionary approach of halving the guideline vibration values for transient vibration induced minor cosmetic damage to buildings (from BS 7385-2:1993), the resulting guidelines are still orders of magnitude above the threshold of perception and substantially higher than equivalent values likely to provoke complaint.

16.3.37 The guidance on acceptable vibration levels in structures provided in BS 5228-2:2009 recommends adopting the building damage vibration guidelines from BS 7385-2:1993.

Highland Council General Recommendations on Construction Noise

16.3.38 The Highland Council's general recommendations on construction noise include noise limits as shown in Table 16.5. This guidance has not been published but The Highland Council nevertheless ask that it is considered, primarily when setting limits within Section 61 Agreements with construction contractors under the Control of Pollution Act. A long-term construction site relates to any works ongoing for more than 6 months.

Table 16.5 Noise limits, Long-term construction sites

Days	Times	Maximum Noise Levels	
		L_{Aeq} (1 hour)	$L_{pA(max)}$
Mondays To Saturdays*	0800 to 1900 hours	55 dB(A)	-
If permitted	1900 to 2200 hours	<10 dB(A) above background	-
If permitted	2200 to 0800 hours	40 dB(A)	50 dB(A)
Sundays (if permitted)	0000 to 2400 hours	40 dB(A)	50 dB(A)

Notes:-

1. These standards are for guidance only. The duration of the construction works will have a significant bearing on whether limits can be relaxed or tightened. Where construction activities involve large scale and long-term earth moving activities the limits in [Table 16.5] should be applied.
2. The L_{Aeq} (1 hour) is the equivalent continuous A-weighted sound pressure level arising from work operations measured (on Fast weighting) or calculated over any continuous period of 60 minutes.
3. The $L_{pA(max)}$ is the maximum A-weighted sound pressure level (on Fast weighting) arising from work operations during the time period.

The L_{Aeq} (1 hour) and $L_{pA(max)}$ are free field measurements or calculations at the the boundary or external amenity area of any noise-sensitive premises**.

** Normal working hours for Saturdays are taken to be 0800 to 1300 hours.*

*** Noise-sensitive premises shall include dwellings, offices, schools, hospitals and similar establishments.*

16.3.39 Regarding vibration the guidance states: "*The peak particle velocity generated by the operations shall not exceed 5mm / second measured at the building nearest to the operations. This applies to all operations other than blasting*."

BS 4142:2014 'Methods for Rating and Assessing Industrial and Commercial Sound'

16.3.40 BS 4142:2014 contains a methodology for the assessment of the significance of effect of industrial and commercial noise in relation to the background sound level. The basis of BS 4142 is a comparison between the background sound level in the vicinity of residential locations and the rating level of the sound source under consideration, with penalties applied to the industrial sound to take account of characteristics which may cause annoyance to residents. The relevant parameters are as follows:

- *Background Sound Level* – $L_{A90,T}$ – defined in the Standard as the 'A' weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T, measured using time weighting F and quoted to the nearest whole number of decibels;
- *Specific Sound Level* – $L_{Aeq,Tr}$ – the equivalent continuous 'A' weighted sound pressure level produced by the *specific sound* source at the assessment location over a given reference time interval, T_r,
- *Residual Sound Level* - $L_{Aeq,T}$ - the equivalent continuous 'A' weighted sound pressure level at the assessment location in the absence of the *specific sound* source under consideration, over a given time interval, T; and
- *Rating Level* – $L_{Ar,Tr}$ – the *specific sound level* plus any adjustment made for the characteristic features of the noise.

16.3.41 The standard recognises that certain acoustic features of a sound source can increase the impact over that expected based purely on the sound level. The standard identifies the following features to be considered:

- Tonality – a penalty of 2 dB is applied for a tone which is just perceptible at the receptor, 4 dB where it is clearly perceptible and 6 dB where it is highly perceptible;
- Impulsivity - a penalty of 3 dB is applied for impulsivity which is just perceptible at the receptor, 4 dB where it is clearly perceptible and 6 dB where it is highly perceptible. An impulse is defined as the sudden onset of a sound;
- Intermittency – a penalty of 3 dB can be applied if the intermittency of the specific sound is readily identifiable against the residual acoustic environment at the receptor i.e. it has identifiable on / off conditions;
- Other sound characteristics – a penalty of 3 dB can be applied where the specific sound features characteristics that are neither tonal nor impulsive, but are readily distinctive against the residual acoustic environment.

16.3.42 Once any adjustments have been made, the background level and the rating levels are compared. The standard states that:

- *"Typically, the greater the difference, the greater the magnitude of impact.*
- *A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending upon the context.*
- *A difference of around +5 dB is likely to be an indication of an adverse impact, depending upon the context.*

- *The lower the rating level is to the measured background sound level, the less likely it is that the specific sound will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending upon the context."*

16.3.43 The standard emphasises the importance of taking context into consideration and identifies a range of pertinent factors including:

- The absolute level of the sound;
- The character and level of the residual sound compared to the character and level of the specific sound, for example, comparing the frequency spectrum and variation over time; and
- The sensitivity of the receptor.

16.3.44 The standard specifies the *specific sound level* as an L_{Aeq} with a one hour assessment period during the day (07:00-23:00) and a fifteen minute assessment period at night (23:00-07:00).

BS 8233:2014 'Guidance on sound insulation and noise reduction for buildings'

16.3.45 BS 8233:2014 provides guidance for the control of noise in and around buildings. It provides design guidance for noise generated inside or outside the building including noise level criteria and control measures, and a methodology for calculating internal noise levels depending on the performance of the building fabric.

16.3.46 Of relevance to this assessment, for "*steady external noise sources*" it provides guideline values for internal ambient noise levels within dwellings. These are reproduced in Table 16.6.

Table 16.6 Indoor Ambient Noise Levels for Dwellings

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	35 dB $L_{Aeq,16hr}$	-
Dining	Dining Room	40 dB $L_{Aeq,16hr}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hr}$	30 dB $L_{Aeq,8hr}$

Criteria for Sensitivity of Receptors

16.3.47 The adopted assessment of noise and vibration effects is based on the sensitivity of the receptor and the magnitude of the exceedance of the relevant noise and vibration criteria.

16.3.48 In accordance with TAN 1/2011 and the IEMA Guidelines, the sensitivity of receptors to noise or vibration is based on their usage as defined in Table 16.7. This classification deviates from that defined in Chapter 4 Approach to EIA. According to the criteria in Chapter 4, individual residential properties would be classified as of medium sensitivity to noise impacts which would make this assessment less stringent and would not be in accordance with the relevant guidance. Therefore the below classification has been applied.

Table 16.7 Receptor Sensitivity

Sensitivity of Receptor	Description
Very high	Concert halls / theatres, specialist vibration sensitive equipment
High	Residential properties, educational buildings, medical facilities, care homes
Medium	Places of worship, community facilities, offices
Low	Other commercial / retail premises

16.3.49 The above criteria do not apply to underground services such as water mains or electricity cables, which are classified as sensitive to vibration but not noise. It is not considered necessary or appropriate to determine a specific sensitivity for this type of receptor.

Criteria for Impacts

Construction Noise

16.3.50 The magnitude of the impact of the construction noise is based on the difference between the likely construction noise level at the receptor and the Threshold Value for potentially significant effects derived using the methodology in BS 5228-1:2009 in Table 16.1, as shown in Table 16.8. The only exception to this is the Headpond construction which involves large-scale earth moving. For these works, in accordance with THC guidance and PAN 50, a Threshold Value of 55 dB L_{Aeq} has been applied.

Table 16.8 Construction noise magnitude of impact

Construction and Demolition Sound Level above Threshold Value (dB)	Magnitude of Impact
<1	Negligible
1>3	Minor
3>5	Moderate
5+	Major

16.3.51 Where short-term construction works are proposed for the purposes of mitigating the effects of the Development, consideration has been given to the likelihood that the construction noise levels will exceed the limit of 70 dB $L_{Aeq,1h}$ in PAN 50.

Construction Vibration

16.3.52 For all activities except blasting, construction vibration impact criteria at the nearest NSRs have been taken from BS 5228-2:2009 for this assessment as shown in Table 16.9.

Table 16.9 Magnitude of impact for construction vibration

Magnitude of Impact	PPV (mm/s)	Effect
Negligible	0.14 to < 0.3	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
Minor	0.3 to < 1	Vibration might be just perceptible in residential environments.
Moderate	1.0 to < 10	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation is given to residents.
Major	>= 10	Vibration is unlikely to be tolerable for any more than a very brief exposure to this level.

16.3.53 For blasting activities the guidance in BS 6472-2:2008 has been used. Daytime PPVs of up to 6 mm/s are classified as minor impact, between 6 and 10 mm/s are classified as moderate, and exceedances of 10 mm/s are a major impact. Night-time PPVs below 2 mm/s are classified as minor impacts, between 2 and 4 mm/s are classified as moderate, and exceedances of 4 mm/s are a major impact. As per the requirements of BS 6472-2:2008 these limits should not be exceeded by more than 10% of blasts, and no blast should exceed them by more than 50%.

16.3.54 To avoid the potential for damage to occur to underground services, the criteria stated in BS 5228-2:2009 should not be exceeded. For continuous vibration the limit to the PPV is 15 mm/s and for transient vibration it is 30 mm/s.

Groundborne Noise

16.3.55 The proposed tunnelling and the operation of the turbines have the potential to generate groundborne noise at nearby receptors. There are no UK legislative standards or criteria that define when groundborne noise becomes significant. The most relevant guidance is in 'Measurement and assessment of groundborne noise and vibration' (0), which described a number of published guidelines for assessing impacts of groundborne noise. This includes the guidelines published by the American Public Transit Association which suggest criteria for acceptable maximum levels of groundborne noise affecting various building types, including a criterion of 35 dB L_{Amax} for groundborne noise affecting residential properties, during the day or night. This criterion is increasingly being adopted (as 35 dB L_{ASmax}) by Local Authorities in the UK when defining acceptable groundborne noise levels for new developments. These criteria are typically applied to permanent groundborne noise sources, such as new underground railway lines, however in the absence of suitable alternative criteria these have also been applied to the assessment of groundborne noise during construction. The criteria are detailed in Table 16.10.

Table 16.10 Magnitude of impact for groundborne noise

Magnitude of Impact	Groundborne noise (dB L_{ASmax})
Negligible	30
Minor	35
Moderate	40
Major	45

Operation - Industrial Noise

16.3.56 With regard to operational airborne noise, the classification of magnitude of impacts is presented in Table 16.11 which is based upon the advice of BS 4142:2014 (levels during the operational phase and then subtracting the measured background noise level from the rating sound level).

Table 16.11 Magnitude of impact for operational sound

Difference Between Rating and Background Levels	Magnitude of Impact
≤ 0	Negligible
1 to +4	Minor
+5 to +9	Moderate
≥ +10	Major

16.3.57 The above criteria do not include consideration of the context, which is a requirement of BS 4142:2014.

Operation – Groundborne Vibration

16.3.58 With regard to operational groundborne vibration, the classification of magnitude of impacts is presented in Table 16.12 which is based upon the advice of BS 6472-1:2008 for the avoidance of adverse comment. Groundborne vibration is assessed separately for construction and operation because the source is effectively permanent and therefore has the potential to result in greater effects. The guidance in BS 6472-1:2008 relates to permanent sound sources as opposed to temporary sources which are covered in BS 5228:2009.

Table 16.12 Groundborne vibration magnitude of impact

Internal Vibration Level (VDV, $ms^{-1.75}$)		Magnitude of Impact
Day	Night	
< 0.2	< 0.1	Negligible
0.2 – 0.4	0.1 – 0.2	Minor
0.4 – 0.8	0.2 – 0.4	Moderate
> 0.8	> 0.4	Major

16.3.59 The power cavern is around 200 m below ground level. At this distance the vibration from the operation of the turbines will not exceed the limit of 15 mm/s at which damage to underground services may occur. Therefore the potential for damage to underground services by the operation of the Development is negligible and this has been excluded from the scope of the assessment.

Significance of Effects

16.3.60 Based on the derived magnitude of impact and the sensitivity of the receptor to noise and / or vibration, the significance of effects are as shown in Table 16.13.

Table 16.13 Significance Criteria

Sensitivity of Receptor	Magnitude of Impact			
	Major	Moderate	Minor	Negligible
Very High	Major	Major	Moderate	Minor
High	Major	Moderate	Minor	Negligible
Medium	Moderate	Minor	Negligible	Negligible
Low	Minor	Negligible	Negligible	Negligible

16.3.61 Table 16.14 puts the levels of the magnitude of adverse impacts and effect significance in context. This is based on the IEMA Guidelines for Environmental Noise Impact Assessment and the UK Government's Planning Practice Guidance (PPG) web based resource

Table 16.14 Magnitude of Impact and Significance of Effect

Magnitude of Impact	Description of Effect	Significance
Major	Disruptive, causes a material change in behaviour and / or attitude. Potential for sleep disturbance. Quality of life diminished due to change in character of the area	More likely to be significant ↑
Moderate	Intrusive, noise can be heard and causes small changes in behaviour and / or attitude. Potential for non-awakening sleep disturbance. Affects the character of an area such that there is a perceived change in the quality of life	↕
Minor	Non-intrusive, can be heard but does not cause any change in behaviour or attitude. Can slightly affect the character of an area but not such that there is a perceived change in the quality of life	↓ Less likely to be significant
Negligible	No discernible effect on the receptor	Not significant

16.3.62 The above significance derivation does not apply to the assessment of potential for damage to underground services. BS 5228-2:2009 does not provide significance of effect criteria for assessing vibration impacts on building services in the context of Environmental Impact Assessment (EIA). The significance of effect is therefore applied based upon whether the predicted vibration levels meet the BS 5228-2:2009 limits. Where the limits are not

exceeded, this has been classified as being Not Significant. Where they are exceeded, they are considered Significant.

16.4 Baseline Environment

16.4.1 Existing sound levels in the vicinity of the Development are dominated by agricultural grazing and forestry activities within the area and road traffic on the B852, B862 and local roads. The existing noise climate is therefore typical of a rural area.

Noise-Sensitive Receptors

16.4.2 The noise-sensitive receptors likely to be most exposed to the sound emissions from the Development have been identified, as shown in Table 16.15 below and illustrated in Figure 16.1: Noise Sensitive Receptors (Volume 3). Receptors R1 to R13 represent the properties closest to the Development and will therefore be exposed to the highest noise levels. This ensures that the worst-case impacts are considered, impacts at other properties in the vicinity will be of lower magnitude than those identified at these locations.

Table 16.15 Identified Noise-Sensitive Receptors

Receptor	Description	Receptor Type	Sensitivity of Receptor	Closest Distance to the Proposed Construction Operations (m)
R1	Kindrummond, The Byre, North Barn and South Barn	Residential	High	688
R2	Ach Na Sidhe	Residential	High	77
R3	West Town and The Steading	Residential	High	784
R4	Balnafoich House	Residential	High	330
R5	Balachladaich	Residential	High	239
R6	Athbhinn and Balnafoich Cottage	Residential	High	210
R7	Midtown, Lochview of Duntelachaig, Barravanish and Kentallen	Residential	High	872
R8	Park	Residential	High	125
R9	Ardmor	Residential	High	103
R10	Dirr View	Residential	High	296
R11	Dirr Cottage	Residential	High	502
R12	Mealishal	Residential	High	824
R13	Taigh Clainn ic Colla	Residential	High	734

16.4.3 Taigh Clainn ic Colla and Mealishal will experience the potential range of worst-case impacts to which the entire village of Dores may be exposed, therefore they are considered representative of the village. It is not considered necessary or commensurate with the potential scale of impact of the Development to identify every property within Dores as a potential NSR.

Baseline Sound Monitoring

16.4.4 Long-term baseline sound monitoring has been completed at three locations (L1 to L3) which were considered representative of the closest identified sensitive receptors (R1, R2, R4 to R6 and R8 to R11). In addition to these, short-term measurements have been carried

out at two locations (S1 and S2) in the vicinity of receptors R3 and R7, and R12 and R13. The monitoring locations are shown in Figure 16.2 (Volume 3).

16.4.5 Measurements have been conducted in accordance with the principles of BS 7445-1:2003 'Description and Measurement of Environmental Noise Part 1: Guide to Quantities and Procedures' and BS 4142:2014.

Instrumentation

16.4.6 The make and model of the equipment used to perform the measurements is detailed in Appendix 16.2: Measurement Summaries (Volume 5). The instrumentation was programmed to log L_{Aeq} and L_{A90} values over an 8 day period from 10 to 18 May 2018 in contiguous 15 minute intervals. The calibration levels of the instrumentation were checked prior to and after the monitoring periods and no significant changes (+/- 0.3 dB) were noted.

16.4.7 At each measurement location the microphone was mounted on a tripod 1.2 to 1.5 metres above the ground in free-field conditions.

Meteorological Conditions

16.4.8 Meteorological conditions for the Development Site over the monitoring period were supplied by the Met Office. Periods when precipitation occurred have been removed from the datasets. In addition, the wind speeds have been used to remove periods when wind-induced noise could have caused the background sound levels to be elevated. Periods when the wind speed exceeded 5 m/s have therefore been excluded from the data. These exclusions are shown in the measurement time histories in Appendix 16.2 (Volume 5).

Results

16.4.9 A summary of the baseline monitoring results is provided in Table 16.16. All measurements are free-field. Further details of the monitoring results are provided in Appendix 16.2. The equivalent sound levels in the Table have been derived from the logarithmic average of the measured $L_{Aeq,15min}$ values over the relevant time period. In accordance with the procedures in BS 4142: 2014, statistical analyses of the measured day (07:00 to 23:00) and night-time (23:00 to 07:00) *background sound levels* at locations L1 to L3 have been performed as shown in Appendix 16.2. On this basis professional judgement has been applied to determine the representative *background sound levels* and these are reported in the below Table. As can be seen from the statistical analysis Inserts in Appendix 16.2, the representative levels are either equal to or below the modal value which is a stringent interpretation of the methodology in BS 4142.

Table 16.16 Summary of Sound Monitoring Data

Measurement Location	Representative Receptor	Start Date and Time	End Date and Time	Period*	$L_{Aeq,T}$ (dB)	L_{A90} (dB)
L1	R2	10/05/18 – 13:45	17/05/18 – 18:15	Day	41	22
				Evening	39	
				Night	34	16
L2	R1, R4, R6 and R8 to R10	10/05/18 – 15:00	18/05/18 – 10:30	Day	52	29
				Evening	42	
				Night	41	19
L3	R5	10/05/18 – 15:13	18/05/18 – 08:58	Day	49	31
				Evening	45	
				Night	41	20
S1	R11 to R13	10/05/18 – 16:45	10/05/18 – 17:45	Day	46	44
S2	R3 and R7	18/05/18 – 09:31	18/05/18 – 10:31	Day	53	30

** Time periods defined in the 'ABC Method' of Appendix E of BS 5228 have been adopted:*
Day – weekdays 07.00 to 19.00 and Saturdays 07.00 to 13.00
Evening – weekdays 19.00 to 23.00, Saturdays 13.00 to 23.00 and Sundays 07.00 to 23.00.
Night – 23.00 to 07.00.

16.4.10 Given the similarity in the measured daytime sound levels between L3 and S1, and the proximity of the locations to nearby potential sound sources, the night-time *background sound levels* at R11 to R13 have been assumed to be the same as at measured at L3. Based on the proximity of the measurement locations, the night-time *background sound levels* at R3 and R7 have been taken to be the same as at L1.

Underground Services

16.4.11 The locations of underground services in the vicinity of the Development Site have been identified based on data supplied by Groundsure Premier Utilities (as shown on Figure 2.2, Volume 3). As mentioned in paragraph 16.3.49, these are not sensitive to noise but are sensitive to vibration due to the potential for damage to occur during construction of the Development.

Existing Vibration Levels

16.4.12 There are currently no significant sources of vibration in the area. Consequently, ambient vibration monitoring has not been undertaken. It should be noted that annoyance due to vibration is not related to the comparison of pre and post-development vibration levels, and pre-development vibration levels are not usually necessary to assess the likelihood of vibration damage or annoyance from any new vibration sources likely to be introduced into the area. Therefore consideration of existing vibration levels is excluded from the assessment.

16.5 Assessment of Effects

Construction Noise - Surface Plant All Works

16.5.1 Construction work of any type that involves heavy plant activity will generate noise, which may result in complaints if appropriate scheduling and control of works is not exercised. Noise levels generated by construction activities and experienced by NSRs, depends upon a number of variables, the most significant of which are:

- The level of noise generated by plant or equipment used on-site, generally expressed as the sound power level;
- The periods of operation of the plant on the Development Site, known as its 'on-time';
- The distance between the noise source and the NSR; and,
- The attenuation of sound due to ground absorption, air absorption and barrier effects.

16.5.2 To evaluate noise effects during the construction phases it is necessary to have knowledge of the variables listed above. Construction Contractors may use different working methods and plant to achieve the same ends. An accurate construction noise and vibration effect assessment is not possible until after the appointment of an approved Construction Contractor with knowledge of the exact working routine and plant schedule to be implemented.

16.5.3 It must be emphasised that the information used within the assessment is unlikely to be adopted exactly by any contractor and therefore the outcomes of the construction assessment should be viewed in this context. The assessment has adopted a worst-case approach by assuming all plant will operate simultaneously. In practice the actual levels at receptors are likely to be lower than calculated.

16.5.4 The use of construction plant and the likely noise effect from its use is determined using the guidance detailed in BS 5228. Where necessary, mitigation methods may be required to attenuate noise to acceptable levels at NSRs. Should complaints be received from local residents, THC would determine whether BPM is being applied. Should this not be the case, action under the Control of Pollution Act 1974 may be taken.

16.5.5 The anticipated activities with the potential to generate significant levels of noise at receptors are as follows:

- Mobilisation, including the following activities:
  - Construction of Access Tracks;
  - Compounds 1 and 3 setup;
- Headpond construction, including the following activities:
  - Site clearance;
  - Headpond construction, including:
    - Headpond excavation works;
    - Trench excavation;Embankment construction works;
  - Landscape Embankment construction; and
  - Inlet / Outlet works including housing.
- Tailpond Inlet / Outlet Structure construction, including the following activities:
  - Temporary works in Loch Ness; and
  - Tunnel Boring Machine (TBM) preparation.

- Tunnelling, including the following activities:
  - Access Tunnel construction;
  - Construction Tunnel construction;
  - Waterways Tunnel construction; and
  - TBM removal.

16.5.6 Predictions have only included equipment anticipated to be located above ground or within the launch pit. The airborne sound of equipment within the tunnels will not generate significant noise levels at receptors.

16.5.7 Predictions have been performed of the sound emissions from a number of different construction phases to give representative noise levels throughout the construction phase at the identified NSRs. The following phases have been identified from the Construction Programme (Insert 2.1 in Chapter 2: Project and Site Description) when multiple activities may occur simultaneously (duration of the phase also provided), thereby representing a worst-case:

- Phase 1 (1 month): Construction of Access Tracks – site clearance and Compound 3 setup;
- Phase 2 (1 month): Construction of Access Tracks – road construction and Compound 3 setup;
- Phase 3 (4 months): Construction of Access Tracks – site clearance, temporary works in Loch Ness, Inlet / Outlet Structure construction and tunnelling activities;
- Phase 4 (4 months): Construction of Access Tracks – road construction, temporary works in Loch Ness, Inlet / Outlet Structure construction and tunnelling activities;
- Phase 5 (2 months): Temporary works in Loch Ness, Tailpond Inlet / Outlet Structure construction, tunnelling activities and Headpond site clearance;
- Phase 6 (3 months): Temporary works in Loch Ness, Tailpond Inlet / Outlet Structure construction, tunnelling activities, TBM preparation, Headpond site clearance, Headpond excavation works and Compound 1 setup;
- Phase 7 (4 months): Tailpond Inlet / Outlet Structure construction, tunnelling activities, TBM setup, Headpond excavation works, Headpond Embankment construction works, Landscape Embankment construction, Access and Construction Tunnel construction;
- Phase 8 (2 months): Tailpond Inlet / Outlet Structure construction, tunnelling activities, Headpond excavation works, Headpond Embankment construction works, Landscape Embankment construction, Headpond trench excavation, Access and Construction Tunnel construction;
- Phase 9 (2 months): Tailpond Inlet / Outlet Structure construction, tunnelling activities, Headpond excavation works, Headpond Embankment construction works, Landscape Embankment construction, Headpond trench excavation, Headpond Inlet / Outlet works and Construction Tunnel construction;
- Phase 10 (1 month): Tailpond Inlet / Outlet structure construction, tunnelling activities, Headpond excavation works, Headpond embankment construction works, Landscape Embankment construction, Headpond trench excavation, Headpond Inlet / Outlet works;

- Phase 11 (2 months): Tailpond construction, tunnelling activities, Headpond excavation works, Headpond embankment construction works, Landscape Embankment construction, Headpond trench excavation, Headpond Inlet / Outlet works;
- Phase 12 (2 months): Tailpond Inlet / Outlet structure construction, tunnelling activities, Landscape Embankment construction;
- Phase 13 (10 months): Tailpond Inlet / Outlet Structure construction, tunnelling activities, Waterways Tunnel construction; and
- Phase 14 (6 months): Tailpond Inlet / Outlet Structure construction, tunnelling activities and TBM decommissioning.

16.5.8 Predictions have been performed of the potential construction noise levels during each of the above phases assuming all of the activities identified within the phase occur simultaneously. Whilst the actual phasing of the works may change depending on the Construction Contractor's proposals, it is highly unlikely that more activities will be undertaken or equipment operated simultaneously than has been assumed. Therefore the modelling considers a worst-case scenario.

16.5.9 The ground heights at the Headpond will change as the works progress and the excavation deepens, which will introduce barrier effects to nearby receptors. Existing ground heights have been used in the modelling of Phases 1 to 11; ground heights once the excavation is complete have been used in the modelling of Phases 12 to 14.

16.5.10 The modelling has not included the proposed earth bunds to the south-west of the Headpond shown in Figure 3.2.1 (within Appendix 3.2: Landscape and Ecology Management Plan, Volume 5) as the design is not yet complete. For this reason the plant required to construct these bunds have also not been included in the predictions. Given the distance of the bund from the nearby properties (around 80 m) and based on experience of similar projects it is considered unlikely that noise levels due to construction of the earth bunds would exceed the short-term limit of 70 dB $L_{Aeq,1h}$. Hence the significance of effects of noise from these works is Not Significant.

16.5.11 Sound power levels for each item of equipment for each construction activity have been sourced from BS 5228-1, which gives measured noise levels for various items of construction plant. The source data input into the noise model are given in Appendix 16.3 (Volume 5).

16.5.12 The inherent uncertainty in the modelling procedures and the processes implemented to minimise the uncertainty are discussed in Appendix 16.4 (Volume 5).

16.5.13 Where the construction equipment required for an activity will be located within a specific area, the sound power levels of the equipment have been summed and the overall level has been assigned to an area source. Where mobile plant are required to move between areas these have been modelled as moving point sources at a typical speed of 20 km/h.

16.5.14 Construction noise levels have been predicted using the noise modelling software package SoundPlan v8.0, which implements the standard noise prediction methodology given in BS 5228-1+A1:2014. The model includes the ground topography of the Development Site and surrounding area, ground absorption properties and the closest existing residential properties around the Development.

16.5.15 During construction, it is expected that the noisiest activities will be the drilling, blasting for the Headpond excavation and construction. The noise from blasting has been assessed separately.

16.5.16 At close proximity to the tunnel excavation, airborne noise from this equipment is likely to be high. However for the majority of this tunnelling activity, the excavation will be underground and will therefore be screened from NSRs. Noise effects from ancillary plant to the TBM or drill and blast (ventilators, generators and conveyors) have been considered within this assessment.

16.5.17 The measured baseline sound levels at all receptors, rounded to the nearest 5 dB, are 5 dB or more below the Category A Threshold Values within BS 5228-1 shown in Table 16.1. On this basis the applicable Threshold Values for the construction noise assessment at all receptors are 65 dB(A), 55 dB(A) and 45 dB(A) during the day, evening and night-time respectively.

16.5.18 The assessment of the construction noise effects has been undertaken at the thirteen NSR locations identified in Table 16.15.

16.5.19 Noise levels have been predicted using a 12 hour construction working day, based on 07:00 - 19:00. For assessment purposes, it is assumed that all the equipment listed for each activity would be operating during the same working day. Therefore based upon the proposed working hours, $L_{Aeq,1h}$ noise levels have been predicted for a theoretical 'worst-case day'.

16.5.20 Table 16.17 shows the predicted construction noise levels at each receptor for each construction phase.

Table 16.17 Construction Noise Levels

Construction Phase	Predicted Construction Noise Level at Receptor $L_{Aeq,1h}$ (dB)												
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
1	49	68	48	62	60	67	51	71	71	65	60	47	44
2	57	77	47	64	58	67	51	70	70	64	60	49	42
3	49	68	48	62	62	61	51	71	71	64	60	50	44
4	57	77	48	64	61	67	51	69	70	64	60	51	42
5	47	57	53	55	59	67	55	53	54	52	53	48	35
6	52	61	58	57	59	67	59	57	56	54	56	49	40
7	55	61	59	55	53	66	60	62	61	59	61	46	44
8	55	62	59	55	53	57	61	62	61	59	61	46	44
9	58	66	63	57	54	59	65	61	63	60	61	46	46
10	53	61	59	55	53	59	60	61	61	58	56	43	40
11	53	62	59	55	53	59	60	61	61	58	56	43	40
12	49	57	55	50	52	62	56	52	54	53	51	42	36
13	47	55	53	50	52	62	54	52	54	53	51	41	36
14	39	61	33	48	52	62	38	49	51	48	48	40	30

16.5.21 The worst-case noise impacts and resultant effects are shown in Table 16.18, based on the predicted exceedance of the applicable Threshold Value (65 dB $L_{Aeq,1h}$). The receptor sensitivity is high.

16.5.22 There have been further design iterations since the noise modelling was conducted, but these moved Development components further away from receptors, reducing potential

noise/ vibration effects, therefore the noise model and the predictions above are considered to provide an accurate worst-case assessment.

Table 16.18 Worst-case Construction Noise Effects

Receptor	Exceedance of Threshold Value $L_{Aeq,1h}$ (dB)	Magnitude of Impact	Significance of Effect
R1	-7	Negligible	Negligible
R2	12	Major	Major
R3	-2	Negligible	Negligible
R4	-1	Negligible	Negligible
R5	-3	Negligible	Negligible
R6	2	Minor	Minor
R7	0	Negligible	Negligible
R8	6	Major	Major
R9	6	Major	Major
R10	0	Negligible	Negligible
R11	-4	Negligible	Negligible
R12	-14	Negligible	Negligible
R13	-17	Negligible	Negligible

16.5.23 At the majority of receptors the significance of effects would be a **localised, temporary, negligible** effect at high sensitivity NSRs.

16.5.24 At NSR R2 – Ach Na Sidhe during construction phases 2 and 4 the significance of effects would be a **localised, temporary, major adverse** effect at a high sensitivity NSR, which is considered to be a Significant effect without mitigation. The activity responsible for these effects is the proposed resurfacing of the C1064 to the west of the proposed Headpond when it is in close proximity to the NSR. During construction phases 1 and 3 the significance of effects would be a **localised, temporary, moderate adverse** effect which is considered to be a Significant effect without mitigation. These effects are due to the proposed site clearance works for the construction of Permanent Access Track between Compound 1 and 4 when it is in close proximity to the NSR.

16.5.25 At NSR R6 – Athbhinn during construction phases 1 to 4 the significance of effects would be a **localised, temporary, minor adverse** effect at a high sensitivity NSR, which is not considered to be a Significant effect. The activity responsible for these effects is the proposed temporary Access Track construction (site clearance and surfacing) to the west of the proposed Compound 3.

16.5.26 At NSR R8 – Park Cottage during construction phase 3 the significance of effects would be a **localised, temporary, major adverse** effect at a high sensitivity NSR, which is considered to be a Significant effect without mitigation. At this location, during construction phases 1, 2 and 4 the significance of effects would be a **localised, temporary, moderate adverse** effect at a high sensitivity NSR, which is considered to be a Significant effect without mitigation. The activity responsible for these effects is the proposed Temporary Access Track construction (site clearance and surfacing) to the east of the proposed Compound 3.

16.5.27 At NSR R9 – Ardmor during construction phases 1 to 4 the significance of effects would be a **localised, temporary, major adverse** effect at a high sensitivity NSR, which is considered to be a Significant effect without mitigation. The activity responsible for these effects is the proposed Temporary Access Track construction (site clearance and surfacing) to the east of the proposed Compound 3.

16.5.28 As construction phases 1 to 4 progress, and equipment for site clearance and road surfacing moves along the road corridors, noise from construction will reduce at these NSRs.

Construction Noise – Headpond Works only

16.5.29 The predicted noise levels due to the proposed Headpond construction works only are shown in Table 16.19. To identify the range in potential construction noise levels, separate calculations have been performed with the ground heights as existing, and with the ground heights once the excavation is completed.

Table 16.19 Headpond Construction Noise Effects

Receptor	Range of Headpond Construction Free-field Noise Levels $L_{Aeq,1h}$ (dB)	Exceedance of Threshold Value (55 dB $L_{Aeq,1h}$) (dB)	Magnitude of Impact	Significance of Effect
R1	49 to 50	-6 to -5	Negligible	Negligible
R2	56 to 58	1 to 3	Minor to Moderate	Minor to Moderate
R3	51 to 56	-4 to 1	Negligible to Minor	Negligible to Minor
R4	45 to 47	-11 to -8	Negligible	Negligible
R5	40 to 42	-15 to -13	Negligible	Negligible
R6	48 to 50	-7 to -6	Negligible	Negligible
R7	54 to 57	-1 to 2	Negligible to Minor	Negligible to Minor
R8	47 to 52	-8 to -4	Negligible	Negligible
R9	49 to 52	-6 to -3	Negligible	Negligible
R10	46 to 52	-9 to -3	Negligible	Negligible
R11	45 to 50	-10 to -5	Negligible	Negligible
R12	36 to 37	-19 to -18	Negligible	Negligible
R13	35 to 36	-20 to -19	Negligible	Negligible

16.5.30 At the majority of receptors the significance of effects would be a **localised, temporary, negligible** effect at high sensitivity NSRs.

16.5.31 At NSR R2 – Ach Na Sidhe during Headpond construction works the significance of effects would be a **localised, temporary, moderate adverse** effect at a high sensitivity NSR, which is considered to be a Significant effect without mitigation.

16.5.32 At NSRs R3 – West Town and R7 – Midtown during Headpond construction works the significance of effects would be a **localised, temporary, minor adverse** effect at high sensitivity NSRs, which are not considered to be Significant effects.

Construction Vibration - Surface Plant Except Piling

16.5.33 Research by the Transport and Road Research Laboratory (Ref 2) found that the levels of groundborne vibration from tracked earth moving equipment (such as a bulldozer or excavator) are imperceptible to humans at a distance of approximately 20 metres, and those generated by vehicles with rubber tyres (e.g. a heavy lorry or dump truck) would be imperceptible at more than 10 metres from the haul road. Mobile plant may occasionally come within 10 or 20 metres of an identified sensitive receptor; hence vibration may be perceptible but is highly unlikely to be of a magnitude that could cause complaint. It is concluded that the magnitude of vibration impacts for surface plant would be no worse than **minor** at the closest NSRs (R2, R6, R8 and R9). Accordingly, the worst-case significance of effects is a **localised, temporary, minor adverse** effect for all **high sensitivity** NSRs, which is considered to be a Not Significant.

16.5.34 Hydraulic hammers and breakers that are mounted on excavators will cause groundborne vibration from their impulsive percussive action. Typical safe working distances from this type of equipment are shown in Table 16.20. This table has been taken from the Australian document "*Construction Noise Strategy (Rail Projects)*" (NSW Transport Construction Authority) as indicative advice for safe working distance to comply with the vibration criterion levels published within BS 6472-1:2008 and BS 7385-1:1993.

Table 16.20 Recommended safe working distances for Hydraulic Hammers

Plant	Rating/Description	Safe Working Distance	
		Cosmetic Damage	Human Response
Small Hydraulic Hammer	300 kg / 5-12 t excavator	2 m	7 m
Medium Hydraulic Hammer	900 kg / 12-18 t excavator	7 m	23 m
Large Hydraulic Hammer	1,600 kg / 18-34 t excavator	22 m	73 m

16.5.35 NSRs are more than 200 m from the Headpond where hydraulic hammer rock breaking may occur. As such the values provided within Table 16.20 demonstrate that all identified **high sensitivity** NSRs are unlikely to perceive the vibration from hydraulic hammer rock breaking. Accordingly, the magnitude of impact is predicted to be negligible and therefore the significance of effects is a **negligible** effect which is not Significant.

Construction Vibration - Piling

16.5.36 Sheet piling is anticipated to be required during the construction of the cofferdam at the Tailpond. Piling noise has been included in the predictions of construction noise.

16.5.37 Predictions of the groundborne vibration generated by the piling have been performed using the methodology in BS 5228-2:2009+A1:2014. It is understood that that all piles will be driven to refusal and that the maximum pile driver hammer energy is likely to be around 225 kJ. This is greater than the stated range of hammer energy in the prediction method, which is 1 to 85 kJ. BS 5228-2:2009+A1:2014 doesn't state an applicable distance range for the prediction methodology, however the research on which it is based (Groundborne vibration caused by mechanised construction works, Hiller and Crabb, 2000) validated the equation with measured levels at distances of up to 120 m.

16.5.38 The closest NSR to the piling location is Balachladaich (R5) at a distance of 239 m. At this distance the predicted vibration level is 1.9 mm/s. However, on the basis that the hammer energy levels and distance from the source exceed the range of accuracy of the standard,

the potential levels at the receptor have been considered further by examining the historic case study data in BS 5228-2:2009. There are seven reported measurements of vibration levels generated by sheet steel piling at distances in excess of 100 m and these are shown below in Table 16.21.

Table 16.21 BS 5228-2:2009 relevant historic data on vibration from driven sheet steel piling

Soil conditions	Theoretical Energy Per Blow (kJ)	Distance (m)	PPV (mm/s)
Fill / 6 m alluvium / 4 m to 6 m peat, clay, sand and silt / 1.3 m sand and gravel / 5 m stiff clay / 9 m dense sand / hard chalk	71.6 to 143.2	130	0.1
		250	0.015 to 0.025
Not recorded	Not recorded	300	0.015

16.5.39 It should be noted that the data in Table 16.21 are for lower energies per blow than proposed, and that it may not have been the case that piles were driven to refusal. Nevertheless, given that the limit of 1mm/s (at which impact magnitudes become moderate) is 10 times the highest of the measured levels, it is considered highly likely that the actual levels will be below this. Accordingly, the magnitude of impact is predicted to be no worse than **minor** and therefore the significance of effects is a **localised, temporary, minor adverse** effect for all **high sensitivity** NSRs, which is not Significant.

16.5.40 Further calculations have been carried out to determine potential vibration damage to underground services. The Tailpond cofferdam is approximately 50 m from the nearest underground services (BT Openreach cables). Using the prediction method in BS 5228-2:2009, the vibration levels at this distance are calculated to be around 15 mm/s which is below the limit of 30 mm/s for transient vibration. Hence the effect on the underground services will be not significant.

16.5.41 Regarding the accuracy of these predictions BS 5228-2 states:

"The various formulae which have been developed empirically to predict vibration levels at a receiving point do not take into account variability of ground strata, the pile-soil interaction process, coupling between the ground and the foundations, etc. Hence these formulae can only provide a first assessment of whether or not the vibrations emanating from a site are likely to constitute a problem.

More accurate assessment can be achieved by the calibration of the site, i.e. the establishment of a site-specific formula. In the case of impact pile driving, the data necessary for the derivation of the formula can be obtained from one or more trial drive(s) using a piling rig, and recording the vibration levels at various distances from the pile position."

Construction Groundborne Noise and Vibration - Tunnelling

16.5.42 A TBM is anticipated to be used to excavate the Low- and High-Pressure Tunnels. BS 5228-2:2009 provides guidance on calculating first estimates of potential groundborne vibration and noise levels from tunnel boring (Annex E.1). The empirical formulae within Table E.1 of the standard used to calculate groundborne vibration and noise from tunnelling are limited to the distance range of 10 m to 100 m. The closest NSR to the Waterway route is Athbhinn (R6), which is approximately 170 m from the Low-pressure Tunnel.

16.5.43 The formulae have been employed to gain an indication of the groundborne vibration and noise at a nominal distance of 100 m. For an NSR at this distance, the groundborne

vibration is predicted to be PPV 0.45 mm/s. The groundborne noise level is predicted to be a sound pressure level of 19 dB. The groundborne noise level generate by the TBM is anticipated to be very steady and hence it is considered that this level equates to a value of 19 dB L_{ASMax}.

16.5.44 These results indicate that for distances of 100 m from the tunnelling, groundborne vibration and noise impacts are expected to be minor and negligible respectively. For **high sensitivity** NSRs (R6) the effects of groundborne vibration are therefore of **localised, temporary minor adverse** effect and those of groundborne noise are of **localised, temporary negligible** effect. Both effects are Not Significant.

16.5.45 All NSRs are at distances greater than 100 m from the tunnelling and it would be expected that groundborne vibration and noise effects would decrease with increasing distance. While this may be true, the authors of the original document cited by BS 5228:2009: '*Groundborne vibration caused by mechanised construction works'* (Traffic and Transport Research Laboratory) warn that due to the formulae being derived from TBM activities over a limited range of materials, it is possible that formulae may underestimate predicted values for tunnelling in stronger rock. They also caution against the extrapolation of the formulae for distance greater than 100 m. For this reason it is recommended that, to verify the predictions, measurements are performed at nearby receptors at commencement of these works.

16.5.46 Further calculations have been carried out to determine potential vibration damage to underground services. The TBM will travel underneath (at approx. 85 m below ground level) BT Openreach cables (typically laid at 0.25 to 0.35 m below ground level) which run alongside the B852. It will also travel underneath (at approx. 25 m below ground) the Scottish Water main (typically laid at 0.75 m below ground level) which will run alongside the realigned route of the C1064. Using the prediction method in BS 5228-2:2009, the tunnelling must be performed at least 7 m from the services to avoid exceeding the limit of 15 mm/s for continuous vibration. Figure 2.14: Cross-section of the Development (Volume 3) shows that the tunnelling will not be within 7 m of the services; hence the effect of tunnelling vibration on the underground services will be not significant.

Blasting – Air Overpressure and Vibration

16.5.47 It is proposed to use the drill and blast method to excavate the TBM Launch Pit / Shaft, powerhouse cavern, surge shafts and construction and access tunnels. Some areas of hard rock are anticipated to be encountered during the excavation of the Headpond which may also require blasting.

16.5.48 Open air blasting activities (i.e. excavation of the TBM Launch Pit / Shaft and the Headpond) would be scheduled for daytime periods only, within the proposed Monday to Friday working hours of 07:00 - 19:00. Underground blasting (at the powerhouse cavern, surge shafts and construction and access tunnels) may be a 24-hour operation, with an anticipated blast cycle of 2 per 24 hours. It is inevitable that air overpressure and vibration effects will be produced from any blasting.

16.5.49 At this stage of the Development design, the detail of blasting (such as mass of charge, site location, hole spacing, detonation delay) is currently unknown and is reserved for the detailed design stage.

16.5.50 Australian Standard AS2187.2-2006 'Explosives-Storage and Use, Part 2: Use of explosives' provides guidance on calculating first estimates of potential vibration levels from blasting. Using the distances to the closest NSRs to the blasting works, a maximum

instantaneous charge (MIC) can be calculated for a mean PPV limit to be achieved as shown in Table 16.22. The stated limits are taken from BS 6472-2 and should not be exceeded by 90 % of all blasts.

Table 16.22 Maximum allowable charge sizes for different blasting locations

Location	Timing of Works	Applicable limit (PPV, mm/s)	Closest Receptor	Distance (m)	Allowable MIC (kg)
TBM launch pit/shaft	Daytime	6	R5	410	238
Headpond			R2	282	112
Powerhouse cavern	Night-time	2	R8	422	63
Construction tunnel			R2	351	44
Access tunnel			R8	215	16
Low-pressure Tunnel Surge Shaft			R8	441	69
High-pressure Tunnel Surge Shaft			R8	549	108

16.5.51 If the Construction Contractor desires the flexibility, it is possible to identify different allowable MICs for the day and night-time periods for those works planned to be undertaken 24 hours a day.

16.5.52 Table 16.22 is a first estimate of possible maximum instantaneous charges to demonstrate that through appropriate design, blasting can achieve imposed limits. However the above prediction method does not allow for the specific rock conditions at the Development Site and explosive packing by the Construction Contractor. BS 6472-2:2008 states *"In order to predict the likely vibration magnitude, a series of measurements at several locations should be taken from one or more trial blasts*" It also provides a method for determining likely site specific vibration levels with a 90 % confidence limit at receptors using a scaled distance graph, based on measurements of trial blasts at that location.

16.5.53 Note that BS 5228-2:2009+A1:2014 provides the following guidance regarding air overpressure from blasting operations and the effects of screening and weather conditions:

- *"The attenuation effects due to the topography, either natural or manufactured, between the blast and the receiver are much greater on the audible component of the pressure wave, whereas the effects are relatively slight on the lower frequency concussive component. The energy transmitted in the audible part of the pressure wave is much smaller than that in the concussive part and therefore baffle mounds or other acoustic screening techniques do not significantly reduce the overall air overpressure intensity."*
- *"Meteorological conditions, over which an operator has no control, such as temperature, cloud cover, humidity, wind speed, turbulence and direction, all affect the intensity of air overpressure at any location and cannot be reliably predicted. These conditions vary in time and position and therefore the reduction in air overpressure values as the distance from the blast increases might be greater in some directions than others."*

16.5.54 As such it is very difficult to provide a quantitative prediction of absolute levels of air overpressure from blasting works. In lieu of this, it is preferential to carry out blasting

operations using the BPM available to ensure that the resultant noise, vibration and air overpressure are minimised.

16.5.55 With appropriate design by suitably qualified blasting contractors, the worst-case magnitude of impacts due to blasting is predicted to be minor and the significance of effects is predicted to be **localised, temporary, minor adverse** effect for all **high sensitivity** NSRs, which is not Significant.

16.5.56 It will be necessary for the contractor to consider potential impacts on nearby underground services when determining the allowable MICs for blasting. The allowable MIC will be determined in order to provide a 90 % confidence level that the limit of 30 mm/s identified in BS 5228-2:2009 will not be exceeded; hence the effect of blasting vibration on the underground services will be not significant.

Operational Airborne Noise

16.5.57 Potential operational airborne noise sources associated with Development are as follows:

- Turbines & Generators;
- Transformers & Switchgear;
- Emergency Generators; and
- Substation.

Underground Equipment

16.5.58 The turbines, generators, transformers, switchgear and emergency generators will be located within the powerhouse cavern, which will be around 200 m below ground. The emergency generators will only operate in the event of a power cut to the Development Site, which is highly unlikely to occur.

16.5.59 The sound power levels of the turbines, generators, emergency generators and associated equipment are not yet known. Modern gas insulated switchgear equipment emits very low noise levels during operation. At this stage, no detailed information is available regarding the sound power level or acoustic character of sound from the proposed transformers; however these commonly produce a strong tonality at levels of 50 and / or 100 Hz due to the frequency of mains electricity. Given the depth of the cavern it is highly unlikely that there will be any audible operational noise from the below ground equipment at the surface.

Operational Airborne Noise Limits

16.5.60 Operational airborne noise limits have been determined using the BS 4142:2014 assessment methodology, based on the measured daytime and night time background noise level at the representative NSRs.

16.5.61 As per the THC Scoping Opinion response, a difference of +5 dB between the background and rating sound levels has been set as a target. This will result in a magnitude of impact no greater than minor adverse. The THC Scoping Opinion response also provided an alternative limit to the operational noise of not exceeding NR (noise rating curve) 20 inside any residential property.

16.5.62 Note that as per BS 4142:2014, the target *rating level* includes any potential character corrections (due to characteristics such as tonality, impulsivity and intermittency) to the *specific sound level*. At this stage information on the characteristics of the sound sources (e.g. any tonal features) are yet to be determined, however these will be considered during detailed design.

16.5.63 Table 16.23 presents recommended operational limits for the power house (which includes any correction for characteristics such as tonality, impulsivity and intermittency), with recognition that the main noise generating equipment is beneath ground at depth. Although the recommended *rating level* limits have been determined using the representative *background sound levels* (as shown in Table 16.16 and discussed in paragraph 16.4.10), these will be refined during detailed design stage. Specific consideration will be given to the context, in particular, as the absolute levels are considered very low and such low limits may not be necessary to avoid effects on NSRs.

Table 16.23 Recommended Operational Noise Limits *

Receptor	Daytime 07:00 – 23:00		Night-time 23:00 – 07:00	
	Representative *Background sound level* dB ($L_{A90,T}$)	Operational Limit (*Rating level*) dB ($L_{Ar,1\ h}$)	Representative *Background sound level* dB ($L_{A90,T}$)	Operational Limit (*Rating level*) dB ($L_{Ar,15\ min}$)
R1, R4, R6 and R8 to R10	29	34	19	24
R2	22	27	16	21
R3 and R7	30	35	16	21
R5	31	36	20	25
R11 to R13	44	49	20	25

* All values are in dB re 20µPa, Free-field, fast time-weighting.

16.5.64 Any necessary noise control design measures will be finalised during detailed design to ensure appropriate operational noise limits are achieved, therefore impacts no greater than minor magnitude will occur. The worst-case significance of effect on all identified **high** sensitive NSRs (i.e. residential properties) is a **localised, minor adverse** effect, which is not Significant.

16.5.65 There may be potential for low frequency noise (LFN) from the operation of the turbines but this is deemed unlikely due to the depth of the turbines below ground level and the incorporated attenuation and building design.

16.5.66 BS4142:2014 makes reference to the University of Salford 'Procedure for the assessment of low frequency noise complaints - NANR45' (2005) for the assessment of LFN.

16.5.67 LFN can be very difficult to predict with a high level of certainty and similarly hard to identify and resolve if present. This is because it can be generated by the unexpected interactions between system components and can be amplified by the geometry of the Development Site and receptor buildings. However there are several risk factors that are known to make the generation of LFN more likely. The potential issue of LFN will be considered throughout the detailed design for the Development and mitigated through design.

Above Ground Equipment

16.5.68 The proposed substation will be located in the permanent arrangement of Compound 1. It is understood that this will generate sound pressure levels of no greater than 70 dB(A) at 5 m from the substation fence. The proposed battery housing is not anticipated to emit sound which would be audible at NSRs.

16.5.69 The assessment of potential substation noise at NSRs has been undertaken by modelling the substation as an area source inside the fence at a distance of 1 m. The sound power

level of the area source has been calculated so that the predicted sound pressure level at 5 m is 70 dB(A). The frequency spectrum of the source has been taken to be the same as a transformer, taken from Engineering Noise Control, Theory and Practice (Ref 3).

16.5.70 Predictions have been performed using the same computational sound model as for the construction noise assessment. However the prediction methodology has been changed to ISO 9613: Acoustic – Attenuation of sound during propagation outdoors – Part 2: General method of calculation as per the requirements of BS 4142:2014. Predictions have been performed of the free-field *specific sound level* at heights of 1.5 and 4 m above ground, to represent the ground and first floor of the NSRs.

16.5.71 Compound 1 is to be levelled at the start of the proposed construction works and this has been incorporated into the model of the operational noise emissions. Landscaping bunds are proposed on the northern and southern edge of the substation, and outside the northern boundary of the Compound, which will also be reduced in size from that installed at the construction phase. The design of these has not been finalised and hence they have not been included within the predictions, however they are likely to reduce the impacts at some receptors.

16.5.72 In order to identify the *rating level* of the *specific sound*, the characteristics have to be considered. Based on AECOM's experience of similar sound sources, the sound of the substation is highly unlikely to be impulsive or intermittent, but the sound of the transformers typically contains a tonality at 50 and / or 100 Hz. To account for this tonality a correction of +4 dB has been applied to the *specific sound level* to determine the *rating level* as per the guidance in Section 9.2 'Rating sound level – Subjective method' of BS 4142:2014. Table 16.24Table 16.24 presents an assessment of the predicted *rating level* against the *background sound levels*. The maximum predicted *specific sound level* at the NSR has been provided in the Table irrespective of floor height.

Table 16.24 Operational Noise Assessment

Receptor	Predicted *Specific sound level* dB ($L_{Aeq,Tr}$)	*Rating level* dB ($L_{Ar,T}$)	Daytime 07:00 – 23:00			Night-time 23:00 – 07:00		
			Background sound level dB (L_{A90})	Difference dB	Magnitude of Impact	*Background sound level* dB (L_{A90})	Difference dB	Magnitude of Impact
R1	21	25	29	-4	Negligible	19	6	Moderate
R2	15	19	22	-3	Negligible	16	3	Minor
R3	16	20	30	-10	Negligible	16	4	Minor
R4	16	20	29	-9	Negligible	19	1	Minor
R5	5	9	31	-22	Negligible	20	-11	Negligible
R6	24	28	29	-1	Negligible	19	9	Moderate
R7	18	22	30	-8	Negligible	16	6	Moderate
R8	26	30	29	1	Minor	19	11	Major
R9	19	23	29	-6	Negligible	19	4	Minor
R10	17	21	29	-8	Negligible	19	2	Minor
R11	25	29	44	-15	Negligible	20	9	Moderate
R12	11	15	44	-29	Negligible	20	-5	Negligible
R13	10	14	44	-30	Negligible	20	-6	Negligible

16.5.73 During the daytime periods, the *rating level* is predicted to be between 30 dB below and 1 dB above the *background sound level*. The magnitude of impact at the majority of receptors is predicted to be negligible except for one receptor (R8) where it will be minor. During the night-time periods, the *rating level* is predicted to be between 11 dB below and 11 dB above the *background sound level*. The magnitude of impacts at three receptors is predicted to be negligible, at five receptors it is predicted to be minor, at four receptors it is predicted to be moderate, and at one receptor it is predicted to be major.

16.5.74 As per the guidance in BS 4142:2014, to determine the significance of the effects it is necessary at this point to consider the context. Of particular relevance in this situation are the absolute sound levels. BS 8233:2014 states that for a partially open window, internal noise levels will be around 15 dB below the external free-field noise level. The maximum predicted *specific sound level* at any receptor is 26 dB L_{Aeq}, which equates to an internal sound level of 11 dB L_{Aeq}. This is substantially below the recommended internal noise levels in BS 8233:2014 (shown in Table 16.6) during the day or night. The predicted frequency spectrum of the *specific sound level* has also been identified, and the external NR level has been calculated to be NR 14. The internal level will therefore be below the alternative internal noise limit of NR 20 provided by THC.

16.5.75 At those **high sensitivity** NSRs (R5 and R11 to R13) where operational noise impacts are shown to be of negligible magnitude in Table 16.24, the effects are determined to be of **localised negligible** effect. At the remaining **high sensitivity** NSRs (R1 to R4 and R6 to R10) effects are of **localised minor adverse** effect, which is not Significant.

16.5.76 Operational noise impacts will be considered during the detailed design. It may be necessary to update the above calculations with the sound of equipment associated with the battery housing once it is known. It will be necessary for the cumulative sound of all the proposed equipment during operation to be designed such as not to exceed the limits imposed by THC.

Operational Groundborne Noise and Vibration

16.5.77 The operation of the turbines can generate groundborne noise and vibration. However these are unlikely to be an issue due to the distance between the source of the vibration (the turbines) and the nearest NSR (R4 – Park, greater than 400 m). At this distance the levels at which minor adverse impacts would occur (0.1 mm/s for night-time groundborne vibration and 30 dB L_{ASmax} for groundborne noise) are highly unlikely to be exceeded. As with LFN, groundborne noise and vibration will be mitigated through design. On this basis, impacts of no greater than **negligible** magnitude are expected. The significance of effect on **high** sensitive NSRs (i.e. residential properties) is a **localised, negligible** effect.

16.6 Inter-relationship effects

16.6.1 The developments which may result in cumulative effects are identified in Chapter 4. The minimum distance between these developments and the Development is 1.2 km. At this distance no receptors are anticipated to experience inter-project cumulative noise effects.

16.6.2 The construction noise levels at receptors have been predicted based on the current understanding of which construction activities may occur simultaneously. This includes consideration of potential impacts of separate simultaneous activities impacting upon receptors; hence intra-cumulative noise effects have been assessed appropriately.

16.6.3 Vibration levels have been predicted at receptors separately for different activities. It is anticipated that some of these activities will overlap, however this is highly unlikely to occur

whilst these activities are in close proximity to the same receptors. Hence intra-cumulative vibration effects will not be significant.

16.6.4 Noise is an amenity issue and other impacts, such as air quality and landscape and visual, can also affect residential amenity. As the Development will inevitably result in impacts in a variety of areas which can influence residential amenity inter-relationship effects may occur. As this is not solely a noise or vibration effect it is outside the scope of this assessment to consider inter-relationship effects on residential amenity any further.

16.7 Mitigation and Monitoring

Construction Noise and Vibration

16.7.1 The best available construction methods shall be employed at all times, having regards to the principles of BPM to minimise noise and vibration impacts during the construction of the Development.

16.7.2 With regard to construction activities, agreement on operational hours and working methods will be sought from THC to minimise noise effects at NSRs. Working hours will be subject to agreement between the Contractor and THC. In addition, adherence to working hours will be contractually implemented within any subsequent enforcement to be regulated by THC via planning conditions and also via the CEMP.

16.7.3 Based on the construction assumptions presented within the assessment section, the results from the construction predictions show that for the majority of the receptors the effects will be negligible. Without mitigation, major adverse effects at R2 are anticipated due to the proposed resurfacing of the C1064 to the west of the proposed Headpond. The proposed temporary Access Track construction in the vicinity of the proposed Compound 3is anticipated to result in major adverse effects at R8 and R9 and minor adverse effects at R6.

16.7.4 The identified potential noise impacts are due to site clearance and road surfacing activities. Site clearance activities would be carried out along the proposed access routes and road surfacing activities would take place on both public roads to the west of the proposed Headpond and on proposed access routes. Therefore identified impacts are expected to be temporary and localised due to the linear nature of these activities. Noise levels will be lower as the construction works move further from receptor. Irrespective of this, to mitigate the noise emissions from construction of Access Tracks, use of Development Site or activity boundary acoustic barriers to screen neighbouring receptors is proposed along the proposed temporary Access Track between Tailpond and Compound 1, and along the public road to the west of the proposed Headpond. The use of Development Site boundary or activity boundary temporary noise barriers can reduce construction noise levels by around 10 dB if line of sight from the plant to the receptor is blocked.

16.7.5 The proposed earth bund to the south-west of the Headpond shown in Figure 3.2.1 (Appendix 3.2, Volume 5) will reduce the noise levels at R2 associated with Headpond construction. It is anticipated that the embankment will break line of sight between the receptor and those works at the closest approach, thereby reducing noise levels by around 10 dB.

16.7.6 BS 5228 gives detailed advice on methods of minimising nuisance from construction noise. This can take the form of reducing source noise levels, control of noise spread and, in areas of very high noise levels, insulation at receptors. It is likely to be a requirement of any construction contract that any constructors at the Development Site comply with the recommendations in BS 5228.

16.7.7 Where possible, alternative piling methods (such as rotary bored piling) are generally preferable to impact piling, due to their reduced noise and vibration emissions. The contractor will consider all possible piling methods when determining the most appropriate method for construction of the cofferdam, and select low noise and vibration methods where feasible.

16.7.8 Mitigation measures to achieve BPM (as required by the Control of Pollution Act 1974) may include the following provisions:

- Ensure all processes are in place to minimise noise before works begin and should ensure BPM are being achieved throughout the construction programme;
- The appropriate use of plant with respect to minimising noise emissions and regular maintenance. All vehicles and mechanical plant used for the purpose of the works would be fitted with effective exhaust silencers and would be maintained in good efficient working order;
- Ensure that modern plant is used, complying with the latest EC noise emission requirements;
- Selection of inherently quiet plant where appropriate. Use of electrical items of plant instead of diesel plant; especially in sensitive locations. All major compressors should be 'sound-reduced' models fitted with properly lined and sealed acoustic covers which would be kept closed whenever the machines are in use and all ancillary pneumatic percussive tools would be fitted with mufflers or silencers of the type recommended by the manufacturers;
- Machines in intermittent use would be shut down in the intervening periods between work or throttled down to a minimum;
- All ancillary plant such as generators, compressors and pumps would be positioned so as to cause minimum noise disturbance. If necessary, acoustic barriers or enclosures will be provided;
- Loading / unloading sites should be located away from residential properties and shielded from those properties where practicable;
- Arrange the site operations and vehicle routes to minimise the need for reversing movements, and to take advantage of rises in natural terrain to screen NSRs;
- No employees, subcontractors and persons employed on the Development Site should cause unnecessary noise from their activities e.g. excessive 'revving' of vehicle engines, music from radios, shouting and general behaviour etc. All staff inductions at the Development Site should include information on minimising noise and reminding them to be considerate of the nearby residents;
- Where possible, the hours of noisy operations should be planned considering the effects of noise upon nearby NSR, taking into account the duration of work and the potential consequence of any lengthening of periods of noisy work;
- Where possible, the items of plant should be located furthest from the nearby NSR buildings or in locations where acoustic screening is provided by site cabins, buildings, or barriers. Plant known to emit noise strongly in one direction should, when possible, be orientated so that the noise is directed away from the nearest NSR;
- Materials should be lowered whenever practicable and not dropped. Any chutes and skips should be lined with sound attenuating material to reduce effect noise; and
- Care should be taken when loading / unloading vehicles and dismantling scaffold.

16.7.9 The appointed Contractor will identify potential effects of works noise and vibration once precise working methods (including underground works) and required plant have been confirmed, and in turn appropriate mitigation measures will be implemented.

16.7.10 The Construction Environment Management Plan (CEMP) and Construction Traffic Management Plan (CTMP) will be prepared in accordance with good practice and relevant British Standards. These will help to minimise effects of construction works and will include consideration of the construction phasing of the Development. The proposed construction of appropriately located earth / excavated material bunds during the early phase of the construction programme will help to increase the acoustic screening of construction noise.

16.7.11 In order to verify the predictions which have been performed and identify actual levels at nearby receptors, measurements of vibration are recommended at nearby receptors at the start of the proposed piling and tunnelling activities. If these levels are found to exceed the limits agreed with THC, the contractor may be required to identify alternative methods of working which generate less vibration and/or restrict working hours for these activities.

16.7.12 Consultation and communication with the local community will be covered in the CEMP and undertaken throughout the construction period. This will serve to publicise the works schedule, giving warning to residents regarding periods when higher levels of noise may occur during specific operations, and providing them with lines of communication where complaints can be addressed. Dissemination of such information is likely to encourage the community to be more tolerant of any disturbance considering the perceived long term benefits of the Development.

Blasting Overpressure and Vibration

16.7.13 The air overpressure and vibration effects of blasting can be reduced through good blast design, although this may come at the expense of higher drilling and detonator costs. Smaller, more frequent blasts lead to smaller but more frequent effects, and the balance between these factors will need to be discussed with THC.

16.7.14 Methods employed to control air overpressure and vibration from blasting operations will need to be agreed with THC prior to any blasting, as well as the frequency of blasting and a 90% confidence limit for blast PPV values at NSRs. The PPV blasting vibration limit should follow the guidance provided within BS 6472-2:2008 of between 6.0 and 10.0 mm/s during the daytime and 2.0 mm/s at night.

16.7.15 Above ground blasting should not be undertaken in the early morning, late afternoon or evening. The local community will be given advance notice prior to any blasting.

16.7.16 An air overpressure limit at NSRs should follow the guidance provided within BS 6472-2:2008 (120 - 150 dB(lin)) and be agreed with THC.

16.7.17 It is recommended that a blast monitoring scheme for air overpressure and vibration be implemented. Any scheme should include details on the location of monitoring points and vibration sensitive properties, and the equipment to be used. This should include a series of representative initial trial blasts at the start of the blasting to accurately identify allowable MICs to prevent exceedance of the identified limits at nearby receptors.

16.7.18 All blasts at the Development Site should be monitored and records maintained so that the historical peak particle velocity from blasts can be produced as required.

16.7.19 A close working relationship between the construction / blasting operator and the local planning authority will be required for the exchange of information regarding blasting events.

16.7.20 All blasting should be carried out using BPM where available, to ensure that the resultant noise, vibration and air overpressure are minimised in accordance with current British Standards and guidelines.

16.7.21 Blast designs should be developed with the aid of regression lines determined from a logarithmic plot of Peak Particle Velocity against scaled distances. The regression lines should be regularly updated using the blasting monitoring information. The regression lines should be made available for inspection upon request.

16.7.22 Fly rock requirements will be controlled through Health and Safety legislation.

Operational Noise and Vibration

16.7.23 The best available operational methods should be employed at all times, having regard to the principles of BPM to minimise noise and vibration from the development.

16.7.24 Control measures to prevent underground plant noise from exceeding appropriate operational noise limits will be finalised during detailed design. These control techniques may include measures such as orientation away from NSRs, vent attenuators, acoustic lining within the vent shaft, and acoustic louvres at intake and extract terminals.

16.7.25 If required, mitigation for LFN and groundborne noise and vibration could include vibration isolation, mufflers, attenuators, etc. and will be considered during the detailed design stage.

16.7.26 Earth bunds are proposed for inclusion on the boundary of Compound 1 and surrounding the substation, which will further reduce operational noise levels at receptors. As the design has not been finalised these have not been included in the predictions. If they block line of sight from the main substation sound sources to the receptors then the *specific sound level* would be reduced by around 10 dB.

16.8 Residual effects

Construction Works Noise and Vibration

Surface Plant - Noise from all Works

16.8.1 With the implementation of the mitigation proposed, namely the barriers to prevent line of sight between R2, R6, R8 and R9 and the road construction activities, impacts are anticipated to be of minor magnitude at R2 and negligible magnitude at remaining NSRs. Worst-case residual effects at all **high sensitivity** NSRs will therefore be of **localised, temporary minor** effect, and therefore not Significant.

Surface Plant from Headpond Construction only

16.8.2 With the implementation of the mitigation proposed, namely the earth bunds to prevent line of sight between R2 and the Headpond construction activities, impacts are anticipated to be reduced to negligible magnitude at R2. Impacts at other NSRs will not change from those identified in Section 16.5. Worst-case residual effects at all **high sensitivity** NSRs will therefore be of **localised, temporary minor** effect, and therefore not Significant.

Surface Plant except Piling - Vibration

16.8.3 The proposed mitigation does not alter the residual effects which remain of **localised, temporary, negligible** effect for all **high sensitivity** NSRs, and therefore not Significant.

Piling – Vibration

16.8.4 The proposed mitigation does not alter the worst-case residual effects which remain of **localised, temporary, minor adverse** effect for all **high sensitivity** NSRs, and therefore not significant. Residual effects upon underground services also remain not Significant.

16.8.5 If the contractor determines that alternative low noise or vibration methods are BPM, effects may be reduced to **negligible** effect. Therefore the effects of piling vibration are not Significant.

Tunnelling

16.8.6 The proposed mitigation does not alter the residual effects of groundborne vibration from tunnelling which remain of **localised, temporary minor adverse** effect at **high sensitivity** NSRs. Residual effects upon underground services also remain not Significant.

16.8.7 The residual effects of groundborne noise are of **localised, temporary negligible** effect. Therefore the effects of tunnelling are not Significant.

Blasting

16.8.8 Air overpressure and vibration effects from blasting are inevitable. Methods to control air overpressure and vibration from blasting operations will be agreed with THC prior to any blasting.

16.8.9 Blasting will be carried out using the BPM available to ensure that the resultant noise, vibration and air overpressure are minimised in accordance with current British Standards and guidelines, as required by the Control of Pollution Act 1974.

16.8.10 However they will be temporary in nature and a liaison group will be set-up to notify the local community in advance of works. The residual effect at **high sensitivity** NSRs remains of **localised, temporary, minor adverse** effect and is therefore not Significant. Residual effects upon underground services also remain not Significant.

Operation

Airborne Noise – Underground Plant

16.8.11 With appropriate consideration of the airborne noise emissions during the detailed design phase the operational noise impacts are anticipated to comply with the limits defined in Table 16.23. Hence impacts will be no greater than minor adverse at **high sensitivity** NSRs resulting in effects which are no worse than **localised, temporary, minor adverse** effect and therefore not Significant.

Airborne Noise – Above Ground Plant

16.8.12 The proposed mitigation is unlikely to block line of sight from the substation to all nearby receptors. Hence the worst-case residual effects remain of **localised, temporary minor adverse** effect at **high sensitivity** NSRs, which is not Significant.

Groundborne Noise and Vibration

16.8.13 The building design of the transformers, switchgear, workshop and pumping station will have appropriate noise attenuation measures which will mitigate any effects to no worse than **minor** effect and therefore not Significant.

Evaluation of Significance

16.8.14 A summary of the significance of effects from the various noise and vibration effects contained within this chapter is provided in Table 16.25.

Table 16.25 Summary of Effects

Receptor	Description of Effect	Effect	Additional Mitigation	Residual Effects	Significance
Construction					
Occupants of Residential Dwellings	Disturbance / annoyance due to temporary elevated noise levels from surface plant associated with all proposed construction works	The majority of the proposed works will result in noise effects of negligible significance. The only exception is the road construction activities which result in major adverse effects at R2 (Ach Na Sidhe), R9 (Ardmor), and R8 (Park Cottage) and minor adverse effects at R6 (Athbhinn).	Implementation of BPM and barriers where required Noise will decrease over distance and as the works enter the Headpond at depth.	Localised, temporary, minor adverse	Not Significant
	Disturbance / annoyance due to temporary elevated noise levels from surface plant associated with Headpond construction only	At the majority of the receptors, the Headpond construction works will result in noise effects of negligible significance. The only exception to this is moderate adverse effects at R2 (Ach Na Sidhe) and minor adverse effects at R3 (West Town) and R7 (Midtown).	Implementation of BPM and construction of earth bunds	Localised, temporary, minor adverse.	Not Significant
	Disturbance / annoyance due to temporary vibration from surface plant except piling	Vibration levels at receptors are anticipated to be imperceptible hence effects are negligible.	Implementation of BPM	Negligible	Not Significant
	Disturbance / annoyance due to temporary vibration from piling works	Vibration levels at receptors are anticipated to be below the threshold at which adverse complaints become likely hence worst-case effects are minor adverse.	Implementation of BPM and vibration monitoring during trial drives	Localised, temporary, minor adverse	Not Significant
	Disturbance / annoyance due to temporary groundborne noise and vibration from tunnelling	Groundborne noise and vibration levels at receptors are anticipated to be below the threshold at which adverse complaints become likely hence worst-case effects are minor adverse.	Vibration monitoring at commencement of works Groundborne noise and vibration levels at receptors will decrease with distance.	Localised, temporary, minor adverse	Not Significant
	Disturbance / annoyance due to temporary air	Allowable MICs will be determined to provide a 90% confidence level that the air	Implementation of BPM and monitoring	Localised, temporary,	Not Significant

Receptor	Description of Effect	Effect	Additional Mitigation	Residual Effects	Significance
	overpressure and vibration from blasting	overpressure and vibration levels at receptors will not exceed acceptable levels at receptors; hence worst-case effects are minor adverse.	during trial blasts Air overpressure and vibration levels at receptors will decrease with distance.	minor adverse	
Underground Services	Damage due to vibration from piling or tunnelling	Vibration levels are not anticipated to result in damage hence effects are Negligible.	None specific	Negligible	Not Significant
	Damage due to vibration from blasting	Allowable MICs will be determined to provide a 90% confidence level that the vibration levels will not exceed the limit at which damage may occur to underground services; hence effects are Negligible.	None specific	Negligible	Not Significant
Operation					
Occupants of Residential Dwellings	Disturbance / annoyance due to airborne noise from underground equipment	Operational sound level limits have been determined which should not be exceeded, hence worst-case effects will be minor adverse.	Depth of turbine hall plus appropriate building and ventilation shaft design	Localised, temporary, minor adverse	Not Significant
	Disturbance / annoyance due to airborne noise from above ground equipment	Operational sound levels at receptors will be very low and internal sound levels are anticipated to be within the criteria set by THC; hence worst-case effects will be minor adverse.	None specific	Localised, temporary, minor adverse	Not Significant
	Disturbance / annoyance due to groundborne noise and vibration from underground equipment	Operational sound level limits have been determined which should not be exceeded, hence worst-case effects will be minor adverse.	Depth of turbine hall plus appropriate building design	Localised, temporary, minor adverse	Not Significant

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