Chapter 10(a):

Vibration

10(a).1 Introduction

10(a).1.1. Overview

Vibration may be defined as regularly repeated movement of a physical object about a fixed point. The magnitude of vibration is expressed in terms of Peak Particle Velocity (PPV) expressed in millimetres per second (mm/s). It is characterised, like noise, in terms of its frequency and amplitude of the motion. Vibration can be continuous, such as that experienced close to certain large industrial machinery, or transient, such as that caused by a passing train movement. The effects of vibration can vary according to a number of factors including: the magnitude of the vibration source, the particular ground conditions, path distance between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of age and design (e.g. dimensions, materials, type and quality of construction, and footing conditions). The intensity, duration, frequency and number of occurrences of a vibration all play an important role in both the annoyance levels caused and the strains induced in structures.

People's sensitivity to and tolerance of vibration depends on the setting. Vibration is noticed sooner and tolerated less in a person's home than in for example a large commercial building or warehouse. Vibration is rarely experienced as annoying in the outdoor environment. Building vibrations caused by road traffic are not a health and safety concern; they are more a problem of annoyance. Vibrations may be unacceptable to occupants because of annoying physical sensations produced in the human body, interference with activities such as sleep and conversation, rattling of window panes and loose objects, and fear of damage to the building and its contents. Experience has shown that people living in houses are likely to complain if vibration levels are only slightly above the perception threshold, the major concern being fear of damage to the building or its contents. The tolerance level varies widely from person to person and from area to area.

Ground vibration effects may:

- Disturb occupants of buildings – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed (human exposure)
- Disturb contents of buildings – vibration where the building contents may be affected (i.e. rattling, shaking or movements)
- Affect structural integrity of the building – vibration in which the integrity of the building or structure itself may be compromised.

Any movement of ground or structures which can potentially cause structural damage, nuisance or a deterioration of amenities or quality of life is examined in this chapter. Where the main effect of transmitted vibration is the generation of audible sound in or at a sensitive location, this topic is addressed under **Chapter 10 - Noise**.

10(a).2.2 Guidelines and Criteria

There is no published Irish guidance relating to vibration during construction or operational activities. Common practice in Ireland has been to use guidance from internationally recognised standards. Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. In both instances, the magnitude of vibration is expressed in terms of Peak Particle Velocity (PPV) in millimetres per second (mm/s).

In the case of nominally continuous sources of vibration such as traffic, vibration is perceptible at around 0.5mm/s and may become disturbing or annoying at higher magnitudes. However, higher levels of vibration are typically tolerated for single events or events of short duration. For example, intermittent blasting and piling, two of the primary sources of vibration during construction, are typically tolerated at vibration levels up to 12mm/s and 2.5mm/s respectively. This guidance is applicable to the day-time only; it is unreasonable to expect people to be tolerant of such activities during the night-time.

Guidance on the relationship between the magnitude of vibration and peoples' reaction to it is contained *in BSI Standards BS5228-2:2009 - Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 2: Vibration Table B1*, and reproduced in **Table 10(a).1** below.

Vibration level	*Effect*
0.14 mm/s	**Threshold of Perception:** 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 mm/s	**Barely Noticeable:** Vibration might be just perceptible in residential environments.
1.0 mm/s	**Noticeable:** 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.
10 mm/s	**Strongly Noticeable:** Vibration is likely to be intolerable for any more than a very brief exposure to this level.

Table 10(a).1: Guidance on effects of vibration levels (reproduced from Table B.1 of BS5228)

Vibration is principally a cause of perceived concern in residential environments, as the occupants may fear that property damage could result. House dwellers may complain about damage induced by traffic vibrations, such as cracks in walls and ceilings, separation of masonry blocks, and cracks in the foundation. However, vibration levels are rarely high enough to be the direct cause of this damage, though they could contribute to the process of deterioration from other causes. Limits for transient vibration, above which cosmetic damage could occur are shown in **Table 10A.2** (reproduced from Table B.2 of BS5228).

Type of building	*Peak component particle velocity in frequency range of predominant pulse*	
	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	50 mm/s at 4 Hz and above
Un-reinforced or light framed structures Residential or light commercial buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Table 10(a).2: Transient vibration guide values for cosmetic damage (reproduced from Table B.2 of BS5228)

The National Roads Authority (NRA) publication 'Guidelines for the Treatment of Badgers Prior to the Construction of National Road Schemes' (NRA, 2009) outlines mitigation for badgers during construction and mitigation therein is deemed appropriate for a development of the size of a wind farm such as the Pinewoods Wind Farm. In general, a survey of setts within 150m of where piling or blasting will be undertaken no more than 10-12 months in advance of construction (NRA, 2009).

The Northern Ireland Environment Agency (NIEA) has published an advisory document in relation to badgers, 'Badgers - Advice for planning officers and applicants seeking planning permission for developments which may impact on badgers' (NIEA, 2015). NIEA (2015) recommend that loud noises or vibrations from heavy machinery that might disturb badgers occupying a sett should be avoided or limited near a sett. An NIEA licence is required for blasting or piling within 100m of a sett.

SNH (2001) point out that there are some activities that can cause disturbance at much greater distances (e.g blasting or pile driving) and generally recommended that such activities are avoided within 100 metres of the closest sett entrance.

10(a).2 Description of the Existing Environment

It is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads. Some common sources of ground borne vibration are trains, buses or heavy goods vehicles on rough roads, and construction activities such as blasting, pile-driving and operating heavy earth-moving equipment.

The existing environment in the vicinity of the subject site does not display any significant vibration source features. All of the dwellings within the study area of the proposed development are not located along major transport routes or other vibration generating sources. There are a number of quarries approximately 2 km distant from the subject site. However, vibration resulting from normal quarry operations is not likely to be perceptible at this distance. There is a church (and adjacent dwelling) and a school located approximately 1 km north of Turbine 1. There is also a horse training facility approximately 600-800m south of Turbine 11. These locations are also considered vibration sensitive locations. **Map 10(a).1** below indicates all of the dwellings and other potentially sensitive receptors in the study area.

Taking the above into account, and the fact that the site and its environs contain no significant vibration features, it was not considered necessary to undertake baseline vibration surveys. No buildings or structures were identified which may be particularly susceptible to vibration damage such as premises with machinery that is highly sensitive to vibration or historic buildings that may be in poor repair, including residential properties. House 02 (H02) and St. Lazerian's Church (and adjacent dwelling) are located immediately adjacent to the construction access route along the L7800 and considered potentially sensitive to vibration from traffic movements.

Ecology

There are two inactive badger setts within the land boundary of the proposed development site but both are outside of the application boundary (areas directly affected by the proposed development). Both of these setts are in the townland of Boleybawn at the south western extent of the proposed development. Proposed Turbine 7 is located approximately 200m east-north-east of one of these inactive setts. Turbine 11 and is approximately 360m to the east of the other sett. Neither of these inactive setts would be directly impacted by the proposed development due to geographical separation. No other vibration sensitive fauna were identified within the study area.

10(a).3 Description of Likely Impacts

10(a).3.1 Construction Phase

Construction Traffic

As a vehicle travels along a road, vibration can be generated in the road and subsequently propagate towards nearby buildings. Such vibration is generated by the interaction of a vehicle's wheels and the road surface and by direct transmission through the air or ground of low frequency energy waves. Some of these waves arise as a function of the size, shape and speed of the vehicle, and others from pressure fluctuations due to engine, exhaust and other noises generated by the vehicle.

Ground borne vibration from traffic on arterial roads is not normally of a level that affects residents or buildings and is commonly confused with high levels of low frequency airborne noise. **Chapter 13** of the EIS and the Traffic Impact Assessment submitted presents the expected number and type of vehicle movements during the construction phase. All construction traffic will enter and exit the subject site along the designated L7800/R430 route. Although the construction activity will generate additional traffic for a temporary period, it is not considered a significant source of vibration. LGVs and HGVs, including aggregate and cement lorries, are not expected to give rise to perceptible ground borne vibration in houses along the designated construction traffic route or in the vicinity of the proposed development site. A HGV over normal (smooth) or irregular road surfaces would result in 0.01 to 0.2 mm/s at the footings of buildings located 10 to 20 m from a roadway. As indicated in **Table 10(a).1**, this is below the threshold of barely perceptible.

Abnormal loads to be transported to the subject site are of unusual size but are not considered to be of unusual weight. They will also travel at slow speeds. Vibration levels decrease with distance from the road as a result of geometrical spreading of the vibration energy and its dissipation by soil viscosity and/or friction. As part of the proposed development the developer proposes to strengthen the L7800 and the L78001 along the length of the haul route to the junction with the R430, which will include a new pavement surface. The R430 is also of generally good pavement condition. There are significant forestry activities on the subject site such that HGV movements along these routes are not unusual. Dwellings and St. Lazerian's Church (a protected structure) along the haul route are generally set back in excess of 20m from the L7800 and R430. The Knock Community School is also sufficiently setback from the road and there is unlikely to be any significant impact in terms of vibration. It is noted that H02 is located immediately adjacent to the L7800 (within 5m) and vibration levels could theoretically rise to a noticeable levels at this distance. The small dwelling adjacent to St. Lazerian's Church is also close to the L7800. Vibration would have to rise above 15 mm/s or above to cause any structural damage, which is not possible from transient passing vehicle movements of the scale proposed. Given the nature and alignment of the access road, together with the proposed road strengthening and pavement works, construction vehicles will be moving at low speed along smooth road conditions and with a generally low frequency for a temporary period. Moreover, specific speed limits will be put in place to ensure no impact in terms of vibration. Once the construction traffic travels at appropriate modest speeds, and given the proposed strengthening of the haul road pavements, vehicle movements will not likely be a significant sources of vibration and is unlikely to be perceptible or cause a nuisance or damage.

Construction Works

Sources of ground vibration during construction include pile drivers, bulldozers (ripping), hydraulic rock breakers and vibratory rollers etc. Vibration generated from construction activities is characteristically an order of magnitude greater than that generated from operational activities. The following list provides an indication of the approximate vibration levels that may be expected for various common construction vibration sources:

- Vibratory rollers: Up to 1.5 mm/s at distances of 25m
- Hydraulic rock breakers: 4.5 mm/s at 5m; 1.3 mm/s at 10m; 0.4 mm/s at 20 m; 0.1 mm/s at 50m
- Compactor: 20 mm/s at 5m; 1 mm/s at 15m; 0.3 mm/s at 30m
- Piling: 1-3 mm/s at distances of 25m – 50m depending on soil conditions
- Bulldozer: 1-2 mm/s at 5m. At distances greater than 20m, vibration is below 0.2 mm/s
- Air track drill: 4-5 mm/s at 5m; 1.5 mm/s at 10m; 0.6 mm/s at 25m; 0.1 mm/s at 50m

Depending on the geotechnical make-up of the ground at the proposed turbine locations, rock breaking and piling may be necessary during the construction of the foundations. Trial pitting was undertaken at various locations throughout the proposed development site, with the results demonstrating that bedrock can be found between 0.3m and 2m below the surface. Further detailed geotechnical investigations shall also be carried out prior to the commencement of construction. If rock breaking or piling is required at the proposed development site, such activity would only be required to facilitate the provision of turbine foundations and not for the construction of site access tracks. Rock blasting shall not be necessary. Given that all proposed turbines are set back in excess of 500m from any sensitive receptors, vibration from construction activities is not likely to be perceptible.

The nearest badger sett to the proposed development was found to be 200m away from a turbine, and as no component of the works are envisaged within 150m of a badger sett there is unlikely to be any impact. No other vibration sensitive fauna were identified within the study area.

10(a).3.2 Operational Phase

The operation of the proposed development will not give rise to any ground borne vibration source.

10(a).3.3 Decommissioning Phase

The decommissioning phase will involve similar operations to those outlined for the construction phase, but the requirements for ground breaking will be clearly be less intensive than for construction. The decommissioning of the project will also involve a fewer number of vehicle movements than the constructions stage, the impacts of which have been discussed above.

10(a).4 Mitigation Measures

10(a).4.1 Construction Phase

As part of the Construction Environment Management Plan (CEMP), the developer will monitor pavement conditions along the construction access route. If any irregularities, cracks or potholes are identified, they will be immediately brought to the attention of the local authority and repaired in conjunction with the Local Authority at the developer's expense.

The Traffic Management Plan will apply strict speed limits for construction traffic along the construction access route including signage.

All construction activities will be undertaken in accordance with *BSI Standards BS5228-2:2009 - Code of Practice for Noise and Vibration Control on Construction and Open Sites* and the *National Roads Authority Guidelines for the Treatment of Noise and Vibration in National Road Schemes 2004* (as applicable).

The hours of construction activity should be generally limited to between 08.00 hours and 20.00 hours Monday to Friday and 08.00 hours and 18.00 hours on Saturdays, except for emergency works.

As all sensitive locations are in excess of 500m from a proposed turbine, there will be no impact in terms of vibration arising from construction activities, even in the 'worst-case' scenario that all vibration control measures fail. However, a liaison officer will be appointed as part of the CEMP to which residents can address any vibration related complaints arising from the construction phase. If any rock breaking or piling activity is required which may, even in an unlikely event, give rise to perceptible vibration, then the residents will be regularly updated and informed in advance of the timing and duration of such works. The contact details of the liaison officer will be distributed to the residents within 1,030m of a proposed turbine as part of ongoing project updates.

In the event of piling, minimisation of piling energy (i.e. reduced hammer drop distance), as necessary, will be applied.

The nearest badger sett to the proposed development was found to be 200m away from a turbine and no component of the works are envisaged within 150m of a badger sett. From an examination of the literature, there is no requirement for additional mitigation with reference to that contained in the EIS for the proposal.

10(a).4.2 Operational Phase

Operation of the proposed development itself is not a source of ground borne vibration. Mitigation measures are therefore not required.

10(a).4.3 Decommissioning Phase

The mitigation measures outlined above for the construction phase are also applicable to the decommissioning phase.

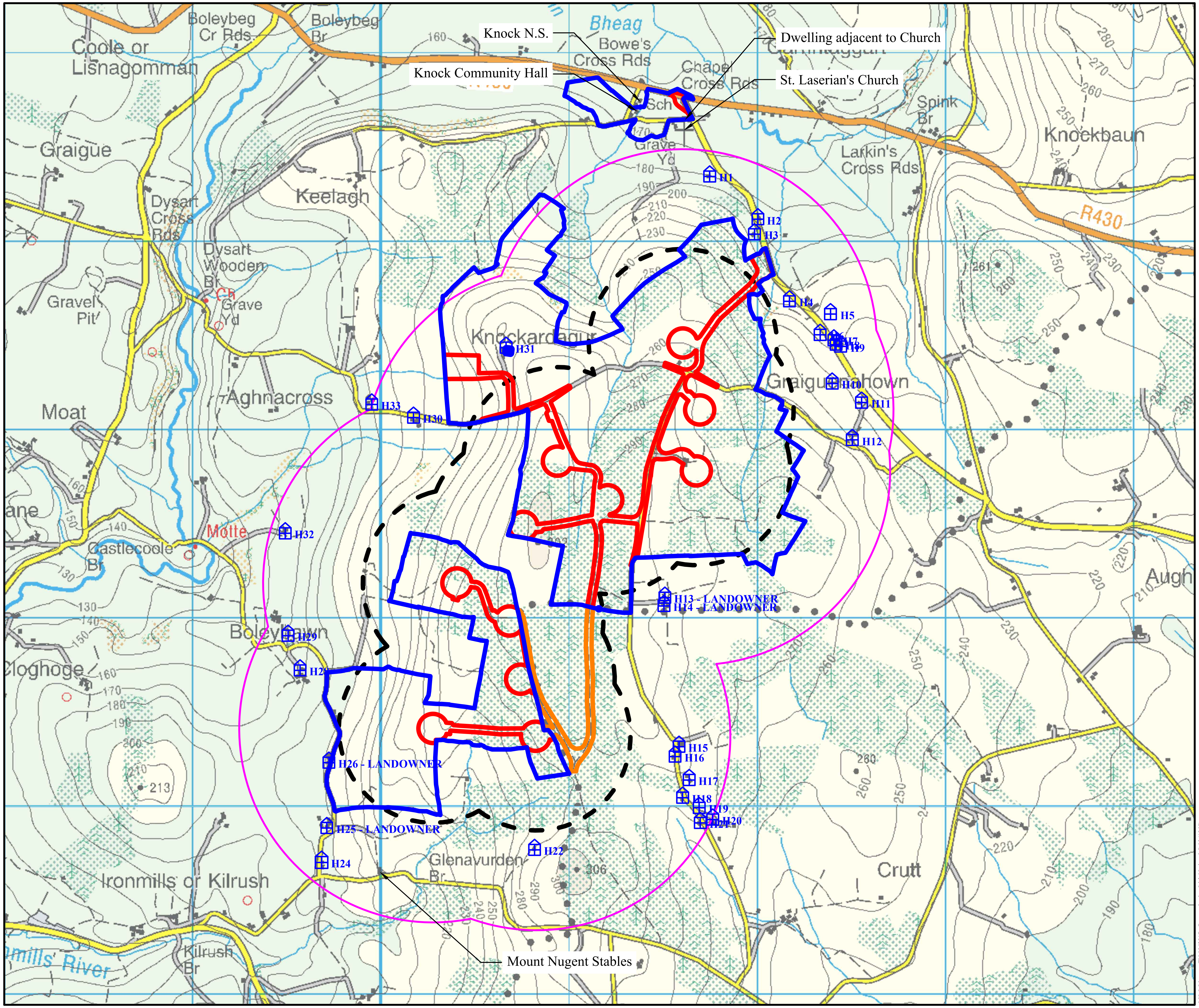
References:

NRA (2006) Guidelines for the Treatment of Badgers Prior to the Construction of National Road Schemes. National Roads Authority, Dublin, Ireland.

NIEA (2015) Badgers - Advice for planning officers and applicants seeking planning permission for developments which may impact on badgers. NIEA Planning Response Team, Klondyke Building, Cromac Avenue, Malone Lower, Belfast, BT7 2JA.

SNH (2001) Scotland's Wildlife: Badgers and Development. ISBN 1 85397 1375 NP4K0601. Scottish Natural Heritage, Battleby, Redgorton, Perth, PH1 3EW.

Appendix 10(a).1: Map indicating vibration sensitive receptors



Legend:

Ownership Boundary	
Application Boundary (Co. Laois)	
Application Boundary for concurrent application made in Co. Kilkenny	
Dwellings within 1030m	
1030m Boundary	
500m Boundary	

Date:	Rev:	Description:	Drawn By:

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Client:

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Drawing Title:

Noise and Vibration

Regarding Item 11d(iii) of Further Information Request

Drawing No.: 5220-1/JB/PD/008	Revision No.: 00	
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