Partners in UK offshore wind

MONA OFFSHORE WIND PROJECT

Preliminary Environmental Information Report

Volume 7, annex 22.2: Construction noise and vibration

Image of an offshore wind farm

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Final

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Prepared by:

RPS

Prepared for:

Mona Offshore Wind Ltd.

Contents

Tables

Figures

Appendices

Glossary

Term	Meaning
A-weighting	A frequency weighting devised to attempt to account for the fact that human response to sound is not equally sensitive to all frequencies. It consists of an electronic filter in a sound level meter which attempts to build this variability into the indicative sound level reading so that it will correlate, approximately, with the human response.
Ambient sound level, $L_{Aeq,T}$	The steady sound level which, over a period of time T, contains the same amount of A-weighted sound energy as the time varying sound over the same period. Also known as the equivalent continuous sound pressure level.
Attenuation	The reduction in magnitude of sound energy.
Basic Noise Level (BNL)	A measure of traffic source noise prior to development. It is calculated from traffic flows, road speed, and HGV percentage.
Broadband	A sound with energy distributed across a wide range of frequencies. Used to describe a single-figure sound level.
Decibel (dB)	A unit used to measure or compare the intensity of a sound by comparing it with a given reference level on a logarithmic scale.
Ground factor, *G*	A dimensionless parameter which allows for the consideration of the acoustic properties of the ground surface between a sound source and the receptor.
Hemispherical radiation	The emission of sound throughout a hemisphere in the presence of a single reflective surface (e.g., the ground). Corresponds to a radiation loss of 8 dB.
Noise	An unwanted or unexpected sound.
Ordinance datum	A means for deriving altitude on maps. Usually presented as the height above sea level.
Peak Particle Velocity (PPV)	An indicator of the magnitude of ground vibration which refers to the movement of molecular particles within the ground.
Propagation	The transmission of acoustic energy through a medium via a sound wave.
Sound	Fluctuations of pressure within a medium (gas, solid or fluid) within the audible range of loudness and frequencies which excite the sensation of hearing.
Sound Power Level, *Lw*	The total sound energy emitted by a source per unit time.
Sound Pressure Level, *Lp*	The amount of force a sound wave exerts on a surface area perpendicular to the direction of travel. A measure of the variation of sound level over a distance.
Spectrum	The presentation of sound in terms of the amount of energy at different frequencies.

Acronyms

Acronym	Description
BNL	Base Noise Level
BS	British Standard
CoCP	Code of Construction Practice
CoPA	Control of Pollution Act
CRTN	Calculation of Road Traffic Noise
DMRB	Design Manual for Roads and Bridges
GIS	Geographical Information Systems
IoA	Institute of Acoustics
ISO	International Organisation for Standardisation
LOAEL	Lowest Observed Adverse Effect Level
NOEL	No Observed Effect Level
OS	Ordinance Survey
PPV	Peak Particle Velocity

Units

Unit	Description
dB	Decibel
h	hours
kJ	Kilojoules
Km	Kilometres
m	Metres
Mins	Minutes

1 CONSTRUCTION NOISE AND VIBRATION

1.1 Introduction

1.1.1.1 This Construction noise and vibration technical report provides the methodology and results of indicative calculations undertaken to assess the noise and vibration impacts on nearby receptors due to the construction of the Mona Offshore Wind Project. This report should be read in conjunction with volume 3, chapter 22: Noise and vibration of the Preliminary Environmental Information Report (PEIR).

1.1.1.2 Baseline sound measurements, which inform the derivation of construction noise impact criteria, have only be undertaken at the Mona Landfall and Onshore Substation option locations to characterise the baseline sound environment where permanent structures are proposed. Monitoring was not undertaken within other areas of the Mona Proposed Onshore Development Area as the location of the Onshore Cable Corridor and 400kV Grid Connection Corridor has not been confirmed. Further targeted baseline sound surveys may be undertaken once the Onshore Cable Corridor and 400kV Grid Connection Corridor have been refined.

1.1.1.3 No baseline vibration surveys were undertaken since vibration impacts are assessed against absolute criteria as opposed to criteria derived based on the existing environment which is the case for noise impacts.

1.1.2 Study area

1.1.2.1 The Mona Offshore Wind Project noise and vibration study area focuses on receptors (landward of Mean High Water Springs (MHWS)) where potential impacts are most likely to occur on receptors sensitive to noise and vibration.

1.1.2.2 The noise and vibration study area relevant to this technical report is defined as:

- The area of land to be temporarily or permanently occupied during the construction, operation and maintenance and decommissioning of the Mona Offshore Wind project (hereafter referred to as the Mona Proposed Onshore Development Area).
- Noise sensitive receptors located within 1km of the Mona Landfall (approximately 1648 receptors) and Onshore Substation (approximately 46 and 803 receptors for Options 2 and 7, respectively).
- Noise sensitive receptors located within 250m of the Mona Proposed Onshore Development Area (excluding the Mona Landfall and Onshore Substation options) (approximately 1,903 receptors).
- Noise sensitive receptors located within 2km of the Mona Offshore Cable Corridor (approximately 7,370 receptors)
- Noise sensitive receptors located within 50km of the Mona Array Area where construction piling is required (receptor count not available due to limited address data)
- Vibration sensitive receptors located within 100m of the construction of the Mona Landfall (approximately 47 receptors).

1.1.2.3 The above descriptors are those set out in the Mona Offshore Wind Project Environmental Impact Assessment Scoping Report (Mona Offshore Wind Ltd, 2022) and are presented graphically in Figure 1.1 to Figure 1.5 below

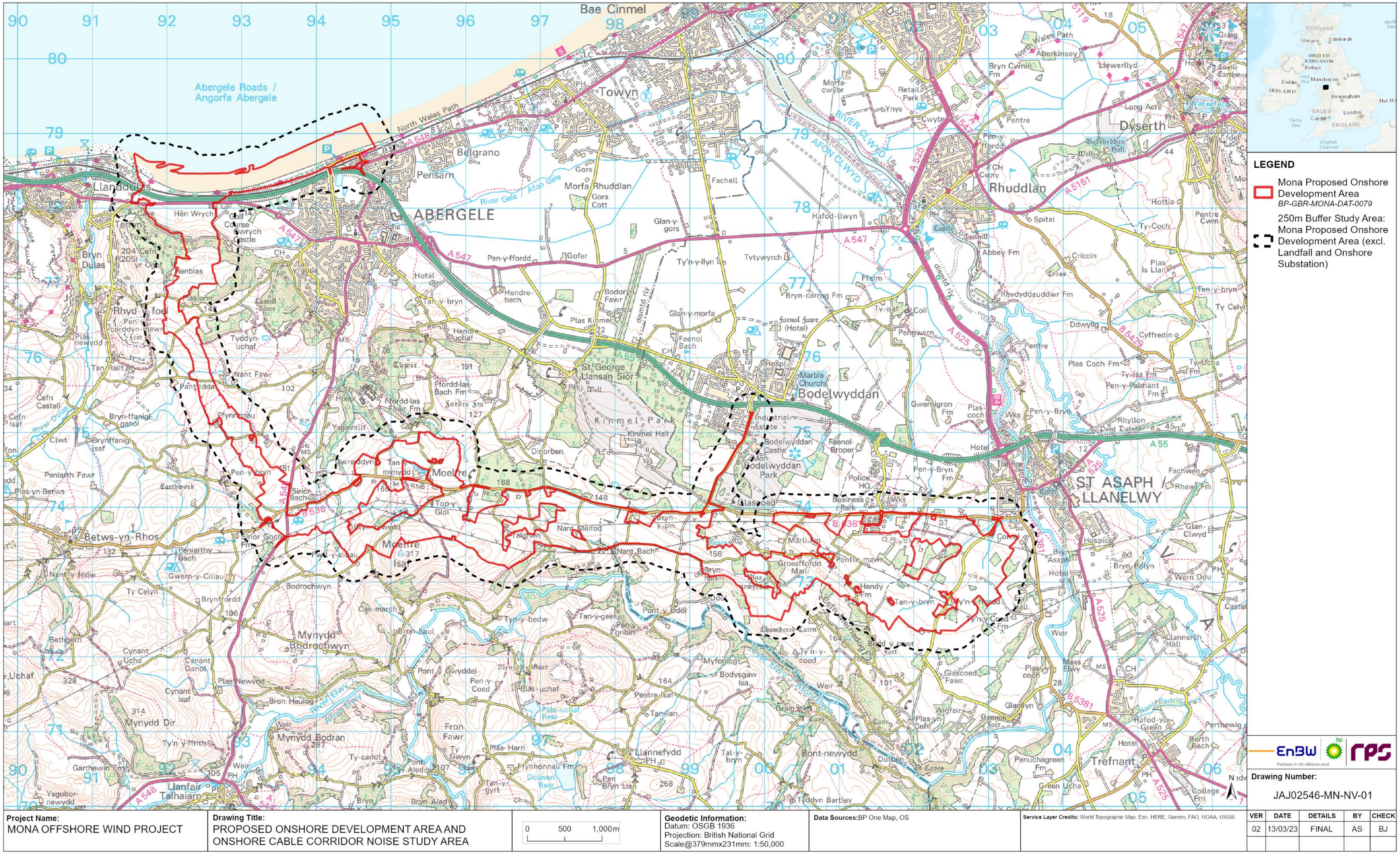


Figure 1.1: Noise study area – Proposed Onshore Development Area.

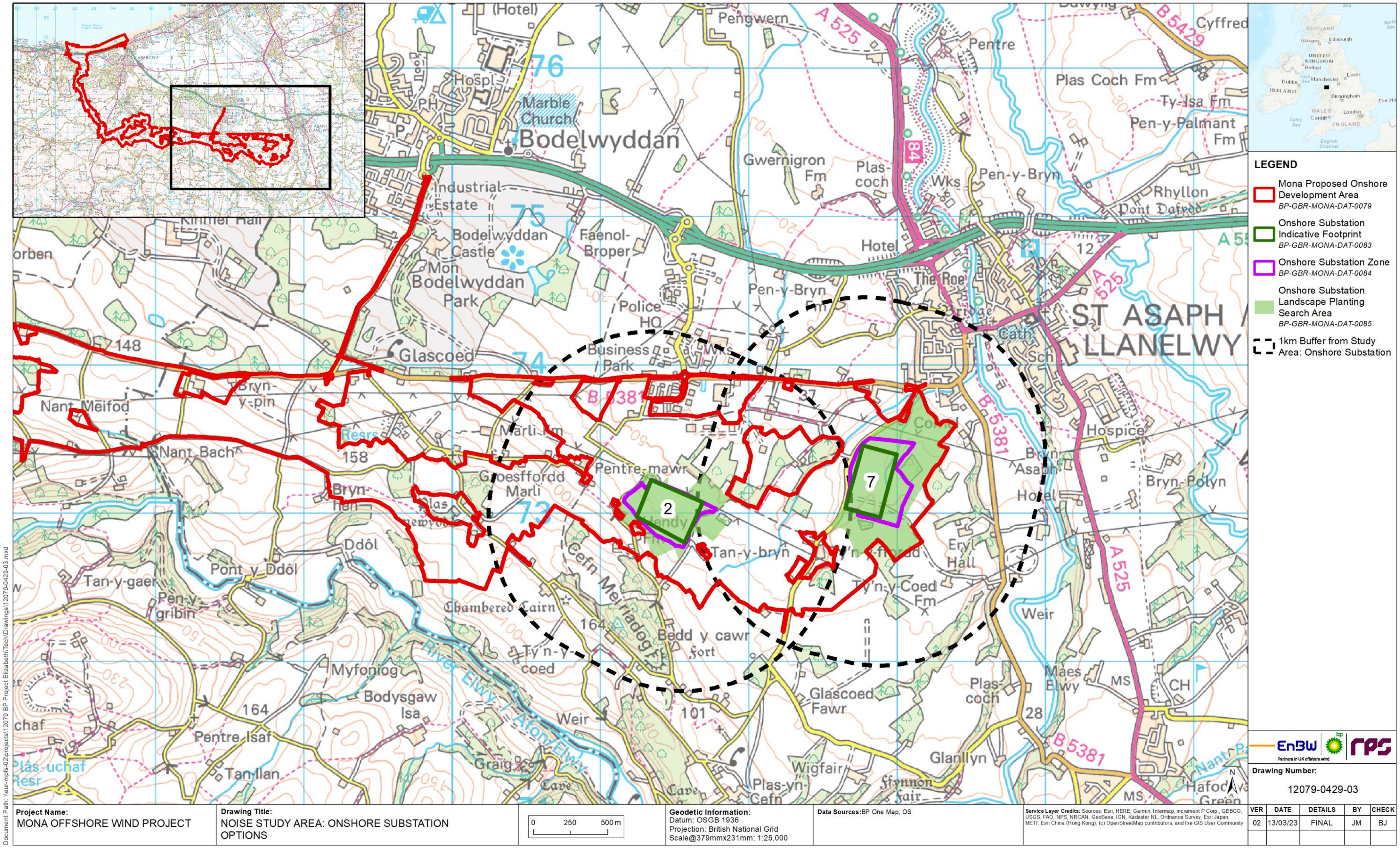


Figure 1.2: Noise study area – Proposed Onshore Substation footprints.

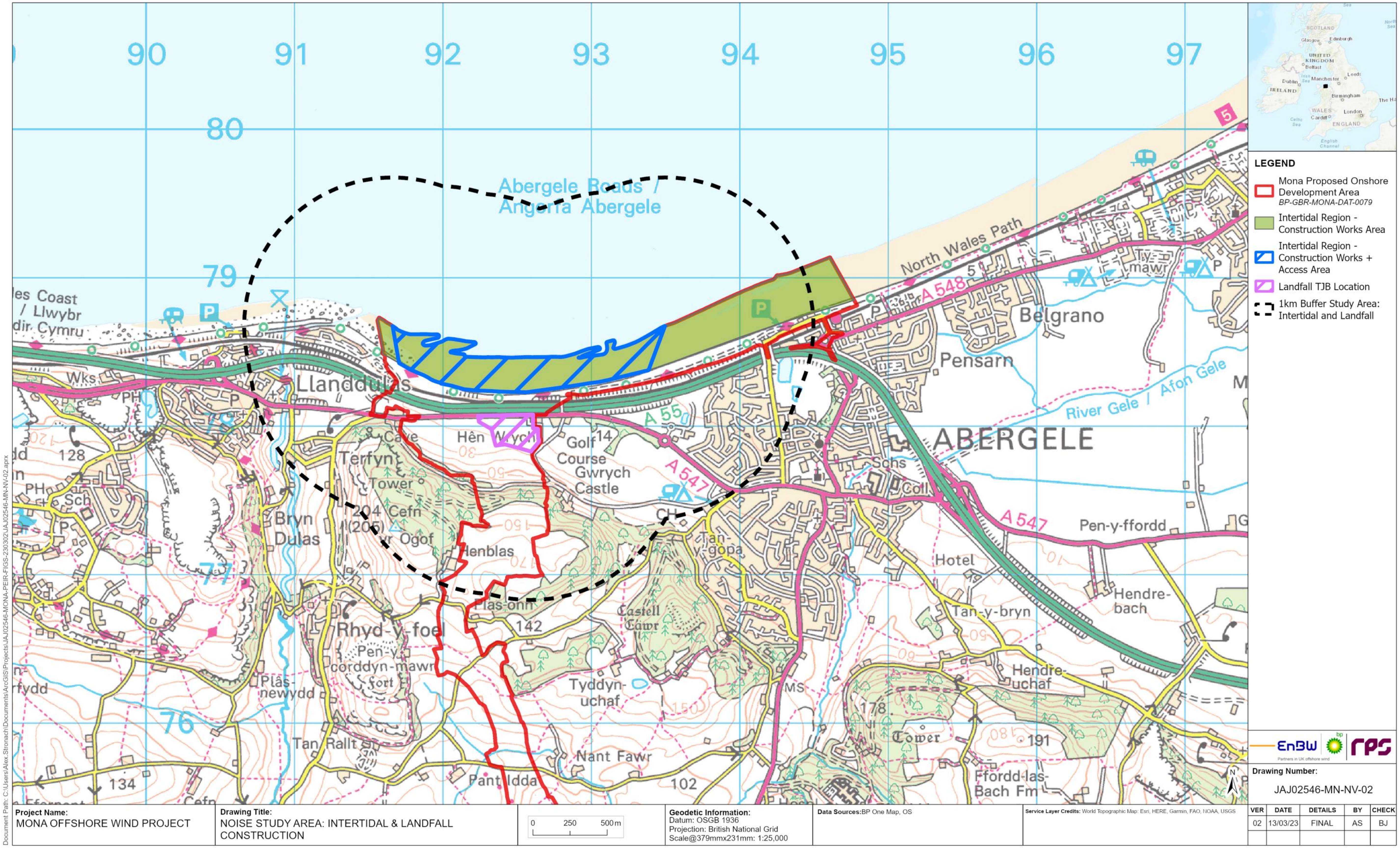
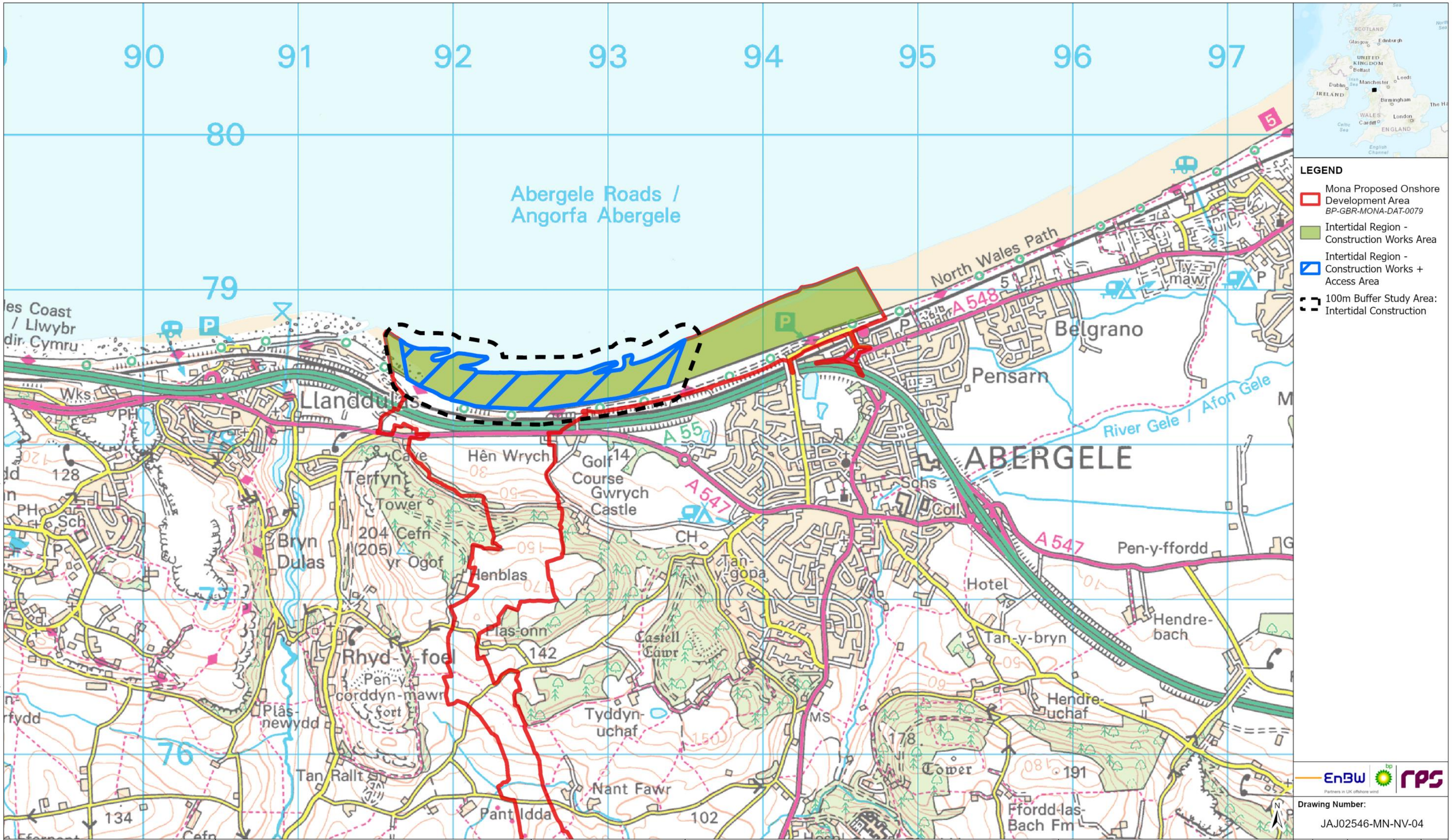


Figure 1.3: Noise study area – Landfall



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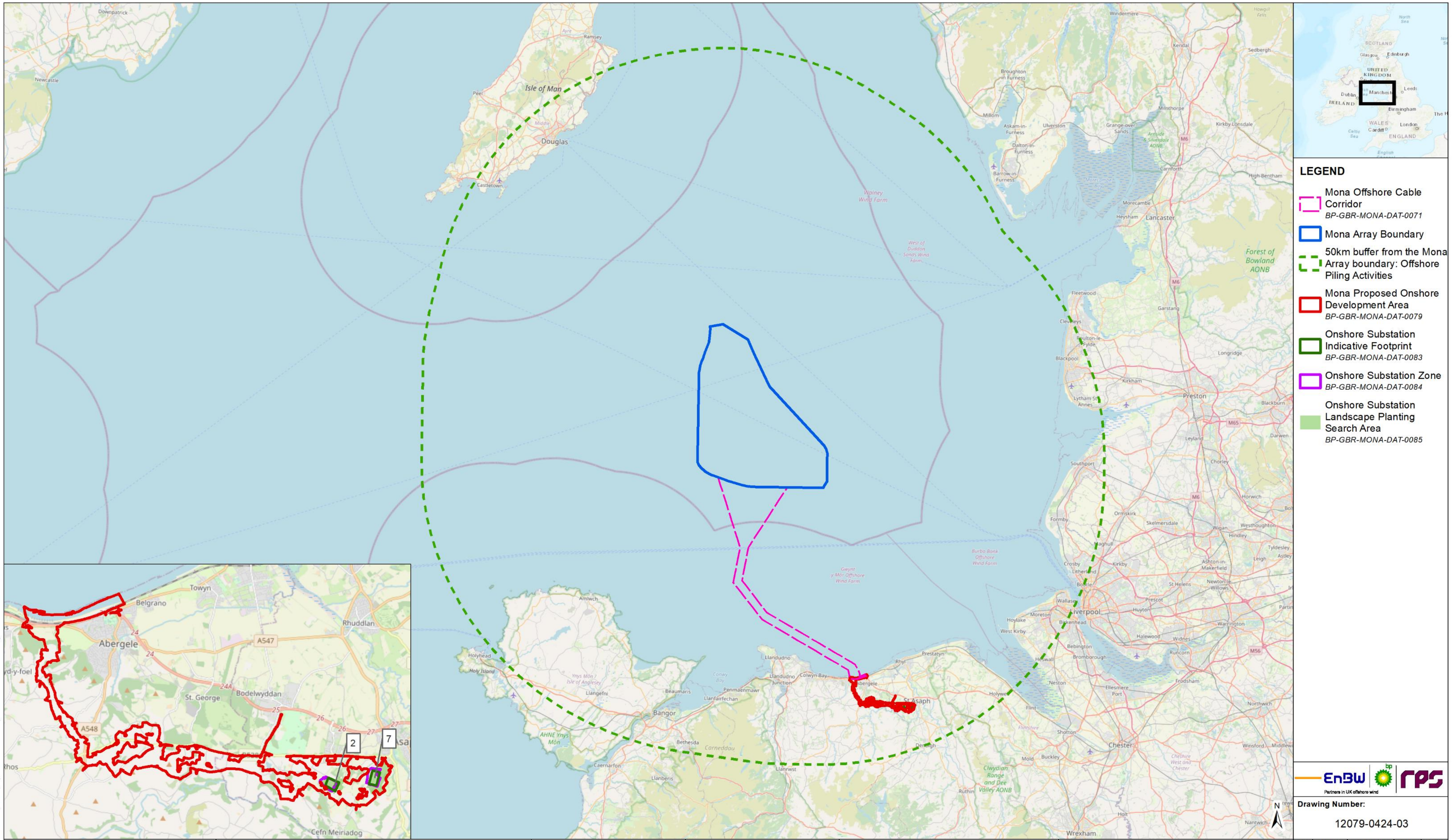
Project Name:	Drawing Title:	Scale	Geodetic Information:	Data Sources:	Service Layer Credits:	VER	DATE	DETAILS	BY	CHECK
MONA OFFSHORE WIND PROJECT	VIBRATION STUDY AREA: INTERTIDAL CONSTRUCTION	0 250 500m	Datum: OSGB 1936 Projection: British National Grid Scale@379mmx231mm: 1:25,000	BP One Map, OS	World Topographic Map: Esri, HERE, Garmin, FAO, NOAA, USGS	02	13/03/23	FINAL	AS	BJ

Figure 1.4: Vibration study area – piling at landfall



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Project Name:	Drawing Title:	Scale	Geodetic Information:	Data Sources:	Service Layer Credits:	VER	DATE	DETAILS	BY	CHECK
MONA OFFSHORE WIND PROJECT	NOISE STUDY AREA: OFFSHORE PILING	0 2.5 5 10 nm; 0 2.5 5 10 15 20 km	Datum: OSGB 1936; Projection: British National Grid; Scale@379mmx231mm: 1:700,000	BP One Map, OS	© OpenStreetMap (and) contributors, CC-BY-SA. Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community	02	13/03/23	FINAL	JM	BJ

Figure 1.5: Noise study area – Offshore piling

1.2 Legislation and guidance

1.2.1.1 This section contains a summary of the relevant guidance and legislation for construction noise and vibration control.

1.2.2 Control of Pollution Act (CoPA) 1974

1.2.2.1 Section 60, Part III of the CoPA refers to the control of noise on construction sites. It outlines legislation by which Local Authorities can control noise from construction sites and prevent noise disturbance.

1.2.2.2 British Standards (BS) 5228-1:2009+A1:2014 and BS 5228 2:2009+A1:2014 were approved within The Control of Noise (Code of Practice for Construction and Open Sites) Order 2015 as suitable guidance on appropriate methods for the control of noise from construction and open sites in exercise of the powers conferred on the Secretary of State by sections 71(1)(b), (2) and (3) of the CoPA.

1.2.2.3 The CoPA provides a Local Authority the power to serve a notice imposing requirements for the way in which construction works are to be carried out in their jurisdiction. This notice can specify the following:

- The plant or machinery permitted for use
- The hours during which construction work may be undertaken
- Limits for the emission levels of noise and vibration due to the works at any time or spatial position on site
- Any other change in circumstance.

1.2.2.4 Section 61, Part III of the CoPA refers to prior consent for work on construction sites. It provides a method by which a contractor can apply for consent to undertake construction works in advance. Providing consent is granted, and compliance is maintained with the stated method and hours of work, no action may be taken by the Local Authority under Section 60.

1.2.2.5 Section 71, Part III of the CoPA refers to the preparation and approval of codes of practice for minimising noise.

1.2.2.6 Section 72, Part III of the CoPA refers to BPM, which is defined as:

'In that expression, 'practicable' means reasonably practicable, having regards among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications'. Whilst 'Means' includes 'the design, installation, maintenance and manner and periods of operation of plant and machinery, and the design, construction and maintenance of buildings and acoustic structures.'

1.2.3 Environmental Protection Act (EPA) 1990

1.2.3.1 Section 79, Part III of the EPA contains a list of matters that amount to statutory nuisances and places a duty on Local Authorities to regularly inspect areas in their jurisdiction to determine where statutory nuisances may exist.

1.2.3.2 This section also considers and defines the concept of 'Best Practicable Means' (BPM) which originates from Section 72, Part III of the Control of Pollution Act (CoPA).

1.2.3.3 The Local Authority must serve an abatement notice where it is satisfied that a statutory nuisance does not exist, or likely to occur/recur. Section 80, Part III of the EPA provides Local Authorities with the power to serve an abatement to prohibit or restrict its occurrence or recurrence; and to carry out works or other action necessary to abate the nuisance.

1.2.3.4 Section 82, Part III of the EPA allows a Magistrates' court to act on a complaint made by any person on the grounds that they are aggrieved by a statutory nuisance, such as noise.

1.2.3.5 The procedures for appeals against abatement notices are detailed in the Statutory Nuisance (Appeals) Regulations 1995.

1.2.4 British Standard 5228

1.2.4.1 British Standard (BS) comprises two parts:

- BS 5228-1:2009+A1:2014 – '*Code of practice for noise and vibration control on construction and open sites'* – Part 1: Noise
- BS 5228-2:2009+A1:2014 – '*Code of practice for noise and vibration control on construction and open sites'* – Part 2: Vibration

1.2.4.2 The Standard provides guidance, information, and procedures for the control of noise and vibration from demolition and construction sites. BS 5228-1:2009+A1:2014 and BS 5228-2:2009+A1:2014 gained approval as guidance on appropriate methods for minimising noise from construction and open sites under the relevant sections of the CoPA 1974.

1.2.4.3 There are no set standards for the definition of the significance of construction noise effects. However, noise example criteria are provided in BS 5228-1:2009+A1:2014 Annex E and vibration example criteria are provided in BS 5228-2:2009+A1:2014 Annex B.

1.2.4.4 BS 5228-1:2009+A1:2014 provides basic information and recommendations for methods of noise control relating to construction and open sites where work activities/operations generate significant noise levels. It includes sections on:

- Community relations
- Noise and persons on site
- Neighbourhood nuisance
- Project supervision
- The control of noise.

1.2.4.5 The annexes include information on legislative background, noise sources, remedies and their effectiveness (mitigation options); current and historic sound level data for on-site equipment and site activities; significance of noise effects; calculation procedures estimating sound emissions from sites and sound level monitoring; types of piling; and air overpressure.

1.2.4.6 BS 5228-2:2009+A1:2014 contains information and recommendations for basic methods of vibration control arising from construction and open sites where work activities/operations generate significant levels of vibration. It includes sections on community relations; vibration and persons on site; neighbourhood nuisance; project supervision; control of vibration and measurement. BS 5228-2:2009+A1:2014 refers to BS ISO 4866:2010; BS 7385-2:1993; BS 6472-1:2008, and BS 6472-2:2008 for further advice on the significance of vibration.

1.2.5 Design Manual for Roads and Bridges (DMRB) – LA111 – Noise and vibration

1.2.5.1 The DMRB LA111 (Highways England, Transport Scotland, Llwyodraeth Cymru, Department for Infrastructure, 2020), provides on guidance on methods for assessing noise and vibration from construction traffic.

1.2.5.2 The magnitude of noise impacts is assessed using the predicted change in the Basic Noise Level (BNL) on the closest public roads to a receptor following the introduction of construction traffic.

1.2.5.3 The noise change is calculated using the methods outlined in the Calculation of Road Traffic Noise (CRTN) (Department for Transport, 1988) which considers the following:

- The change in traffic flow due to construction traffic
- Vehicle speed
- The percentage of Heavy Goods Vehicles (HGVs)

1.2.5.4 Paragraph 3.19 of DMRB LA111 states the following:

- '*Construction noise and construction traffic noise shall constitute a significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:*
  - *10 or more days or nights in any 15 consecutive days or nights;*
  - *A total number of days exceeding 40 in any 6 consecutive months*.'

1.2.5.5 Additional guidance is provided for the determination of construction noise impact criteria in terms of the Lowest Observed Adverse Effect Level (LOAEL) and the Significant Observed Adverse Effect Level (SOAEL).

1.2.5.6 Whilst not applicable in Wales, the Planning Practice Guidance – Noise (PPG-N) provides a useful definition of these terms. For reference, a summary is provided in Table 1.1 below.

Table 1.1: Description of LOAEL and SOAEL from PPG-N

Perception	Examples of outcomes	Increasing effect level	Action
No Observed Effect Level (NOEL)			
Not noticeable	No effect	No Observed Effect	No specific measures required
Noticeable and not intrusive	Noise can be heard but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life.	No Observed Adverse Effect	No specific measures required
Lowest Observed Adverse Effect Level (LOAEL)			
Noticeable and intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
Significant Observed Adverse Effect Level (SOAEL)			
Noticeable and disruptive	The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Noticeable and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory	Unacceptable Adverse Effect	Prevent

1.2.5.7 Criteria for the impacts of construction noise have been derived based on the guidance detailed in DMRB LA111 in conjunction with BS 5228-1:2009+A1:2014. Full details are provided in section 1.2.6.

1.2.6 Institute of Acoustics (IoA) – A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise – Supplementary Guidance Note 6: Noise Propagation Over Water for On-Shore Wind Turbines

1.2.6.1 ETSU-R-97 (1996) is the UK government's preferred method of assessing the impacts of noise from wind farms for planning purposes. The IoA produced a Good Practice Guide (2013) to supplement the ETSU-R-97 guidance.

1.2.6.2 The assessment procedure in the IoA guidance relates primarily to operational noise from wind turbines and thus isn't directly applicable to this assessment.

1.2.6.3 However, Supplementary Guidance Note 6 (2014) highlights the lack of published research or guidance on wind turbine noise propagation over water.

1.2.6.4 Guidance is presented in the form of a summary of the available published research to aid practitioners in the assessment of noise propagation over water, particularly long distances. The important variables to consider include:

- The distance between source and receiver

- The losses due to geometric divergence of the sound waves including a correction for the tendency of the sound waves to deviate from spherical spreading (a decay in the amplitude with the inverse of the square of the source-receiver separation) to cylindrical spreading (a decay in the amplitude with the inverse of the source-receiver separation) at distances greater than 700m
- The ground reflections from the water surface
- Atmospheric absorption

1.2.6.5 The relevant equations and how they've been applied is discussed in more detail in section 1.4.1 below.

1.3 Assessment criteria

1.3.1.1 Based on the guidance above, the following impact criteria have been adopted.

1.3.2 Construction noise

1.3.2.1 Impact criteria for construction noise have been determined in accordance with DMRB LA111 and Annex E of BS 5228-1:2009+A1:2014. Table 3.12 of DMRB LA111 provides the following guidance (as summarised in

1.3.2.2 Table 1.2 below) for determining the LOAEL and SOAEL for construction noise and in Table 1.3 for determining the magnitude of impacts.

Table 1.2: Construction time period – LOAEL and SOAEL.

Time Period	LOAEL	SOAEL
Weekdays (0700-1900 hours) and Saturdays (0700-1300 hours)	Baseline noise levels, $L_{Aeq,T}$	Threshold level determined as per BS 5228-1:2009+A1:2014.
Evening (1900-2300 hours) and Weekends (13:00-2300 hours on Saturdays and 0700-2300 hours on Sundays)		
Night (2300-0700 hours)		

Table 1.3: Magnitude of impact and construction noise descriptions.

Magnitude of Impact	Construction Noise Level
High	$L_{Aeq,T} \geq$ SOAEL + 5 dB
Medium	SOAEL $\leq L_{Aeq,T} <$ SOAEL +5 dB
Low	LOAEL $\leq L_{Aeq,T} <$ SOAEL
Negligible	$L_{Aeq,T} <$ LOAEL

1.3.2.3 The threshold levels which quantify the LOAEL and SOAEL have been derived from Example Method 2 in Annex E 3.3 of BS 5228-1:2009+A1:2014 which states the following:

- '*Noise levels generated by site activities are deemed to be potentially significant if the total noise (pre-construction ambient plus site noise) exceeds the pre-construction ambient noise by 5 dB or more, subject to lower cut-off values of 65 dB, 55 dB and 45 dB L_{Aeq}, from site noise alone, for the daytime, evening and night-time periods, respectively; and a duration of one month or more, unless works of a shorter duration are likely to result in significant effect*.'

1.3.2.4 Given the low ambient sound climate in the area surrounding the Mona Proposed Onshore Development Area, the lower cut-off values above provide the SOAEL against which construction noise impacts will be assessed.

1.3.2.5 The measured ambient sound levels vary significantly at receptors between the Mona Landfall and the Onshore Substation option locations (see annex 22.1: Baseline sound survey of the PEIR). Since the exact locations of construction works is not yet known, a typical ambient sound level for receptors near the Mona Landfall and the Onshore Substation option locations has been selected for the relevant time period based on the sound survey data. A detailed assessment of the predicted construction noise levels at various receptors will be undertaken once information on construction plant and locations becomes available.

1.3.2.6 The impact criteria for receptors near the Mona Landfall and the Onshore Substation locations are presented in Table 1.4 below.

Table 1.4: Construction noise criteria.

(1) Typical ambient sound level derived from baseline sound survey data near the Mona Landfall.

(2) Typical ambient sound level derived from baseline sound survey data near the Mona Onshore Substation option locations.

Magnitude of impact and threshold value period ($L_{Aeq,T}$)	Threshold value (dB)		
	Weekdays (0700-1900 hours) & Saturdays (0700-1300 hours)	Evening (1900-2300 hours) & Weekends (13:00-2300 hours on Saturdays and 0700-2300 hours on Sundays)	Night (2300-0700 hours)
Receptors near the Mona Landfall			
High	$L_{Aeq,T} > 70$	$L_{Aeq,T} > 60$	$L_{Aeq,T} > 50$
Medium	$65 \leq L_{Aeq,T} < 70$	$55 \leq L_{Aeq,T} < 60$	$45 \leq L_{Aeq,T} < 50$
Low	$52^{(1)} \leq L_{Aeq,T} < 65$	$46^{(1)} \leq L_{Aeq,T} < 55$	$42^{(1)} \leq L_{Aeq,T} < 45$
Negligible	$L_{Aeq,T} < 52^{(1)}$	$L_{Aeq,T} < 46^{(1)}$	$L_{Aeq,T} < 42^{(1)}$
Receptors near the Mona Onshore Substation option locations			
High	$L_{Aeq,T} > 70$	$L_{Aeq,T} > 60$	$L_{Aeq,T} > 50$
Medium	$65 \leq L_{Aeq,T} < 70$	$55 \leq L_{Aeq,T} < 60$	$45 \leq L_{Aeq,T} < 50$
Low	$45^{(2)} \leq L_{Aeq,T} < 65$	$41^{(2)} \leq L_{Aeq,T} < 55$	$38^{(2)} \leq L_{Aeq,T} < 45$

Magnitude of impact and threshold value period ($L_{Aeq,T}$)	Threshold value (dB)		
	Weekdays (0700-1900 hours) & Saturdays (0700-1300 hours)	Evening (1900-2300 hours) & Weekends (13:00-2300 hours on Saturdays and 0700-2300 hours on Sundays)	Night (2300-0700 hours)
Negligible	$L_{Aeq,T} < 45^{(2)}$	$L_{Aeq,T} < 41^{(2)}$	$L_{Aeq,T} < 38^{(2)}$

1.3.3 Construction vibration

1.3.3.1 Impact criteria for vibration from construction have been identified based on guidance provided in DMRB LA111. The following outline criteria in terms of peak particle velocity (PPV) can be used to identify potential significant impacts on nearby receptors.

Table 1.5: Construction vibration criteria.

(3) Vibration at these levels is unlikely to be tolerable for more than a very brief period and major effects could occur below these levels, particularly where impacts occur for longer periods.

Magnitude of impact	Vibration level, Peak Particle Velocity (PPV), mm/s
High	PPV ≥ 10(3)
Medium	PPV ≥ 1
Low	PPV ≥ 0.3
Negligible	PPV < 0.3

1.3.3.2 The magnitude of impact will also depend on the frequency and duration for which people are likely to be exposed to vibration. As an example, a single vibration event of 1mm/s PPV is unlikely to be considered significant in isolation. Conversely, a very high level of vibration (i.e. over 3 mm/s) for a short duration may not result in a major impact.

1.3.4 Construction traffic noise

1.3.4.1 Impact criteria for these changes have been obtained from the guidance in DMRB LA 111 and are presented in Table 1.6 below.

Table 1.6 Construction traffic criteria.

Magnitude of Impact	Increase in Basic Noise Level (BNL) of closest public road used for construction traffic (dB)
High	BNL ≥ 5
Medium	3 ≤ BNL < 5
Low	1 ≤ BNL < 3
Negligible	BNL < 1
No change	-

1.4 Offshore airborne noise assessment

1.4.1 Methodology

1.4.1.1 The maximum design scenario is represented by monopiling for the foundations of the Mona Offshore Wind Turbines and Offshore Substation Platform since:

- Higher hammer energies are required to install the larger monopile foundations, compared pin piles, suction bucket jacket foundations, or a gravity base
- The duration for which the pile is exposed above the water surface is longer than other methods where the piles are fully submerged
- The maximum piling duration is longest for monopiles
- Contact between the hammer and larger piles has a larger low frequency component to the noise level emitted. Lower frequencies are attenuated less by atmospheric absorption and thus can have a greater impact over long source-receiver distances.

1.4.1.2 The parameters forming the basis of the maximum design scenario are presented in Table 1.7 below.

Table 1.7: Maximum design scenario for monopiling.

Parameter	Maximum design scenario
Pile diameter (m)	16
Penetration depth (m)	60
Hammer energy (kJ)	5500
Number of strikes	21307
Total duration (mins) / (hours)	570 / 9.5
Number of concurrent events	2
Minimum spacing between turbines/concurrent events (m)	980

1.4.1.3 The piling process involves the following:

- **Initiation:** The initial strikes of the pile starting at as low a strike-rate as possible
- **Soft start:** Increasing the strike rate to approximately 10% of the maximum hammer energy

- **Standard operation:** The strike rate is increased to the standard operational value.

1.4.1.4 The maximum design scenario for the impact piling schedule is presented in Table 1.8 below.

Table 1.8: Maximum design scenario for impact piling schedule.

Stage	Duration (mins)	Hammer energy (kJ)	Strike rate (per minute)	Number of strikes	Description
Initiation	10	550	0.67	7	Preparing the piles (alignment etc.) with 1 strike every 90 seconds.
Soft start	20	550	10	200	Soft start at low hammer energy
Ramp up	20	550-5000	15	300	Increase in hammer energy after soft start
Maximum power	331	5500	40	13240	Driving piles at maximum hammer energy

1.4.1.5 The exact equipment to be used has not yet been confirmed and no sound source data is available for the proposed hammer. Volume 5, annex 3.1: Underwater sound technical report of the PEIR highlights the risks associated with estimating source levels based on existing measurements of offshore piling noise, or the extrapolation and scaling of existing data as a ratio of known hammer energies. This is due to the level of uncertainty which arises for large pile diameters and high hammer energies.

1.4.1.6 Volume 5, annex 3.1: Underwater sound technical report of the PEIR contains details numerical modelling undertaken to estimate the excitation force of the hammer and sound propagation in the water column.

1.4.1.7 Due to the differences in the ways in which sound propagates in water compared to air, there is no direct relationship between the source noise levels determined for underwater sound propagation and the airborne source noise levels due to the impact hammer.

1.4.1.8 An estimation of the sound source levels has been undertaken in liaison with Seiche Ltd. using the radial velocity impulse response output by the numerical modelling.

1.4.1.9 Based on the maximum design scenario parameters in Table 1.7 above, an initial indicative estimate of the sound power level yields L_W = 143 dB(A).

1.4.1.10 Consideration must be given to the low frequency components of the spectrum of the impact hammer and thus a spectral shaper has been applied to the broadband sound power level above obtained from historic data obtained from offshore piling activities. The spectrum used in this assessment is presented in Table 1.9 below.

Table 1.9: Estimate of sound power spectrum for impact piling hammer.

Source	Sound power level (dB) at Octave band centre frequency (Hz)								dB(A)
	63	125	250	500	1k	2k	4k	8k	
Impact Piling Hammer	145	150	139	141	139	125	125	143	**143**

1.4.1.11 The levels above are an estimation only and the actual levels may differ. A more detailed analysis will be undertaken once more information on the equipment becomes available and will be reported in the Environmental Statement.

1.4.1.12 Indicative calculations of the noise impacts have been undertaken in line with the guidance in the IoA's Supplementary Guidance Note 6, as discussed in section 1.2.6 above.

1.4.1.13 The guidance provides the following equation to calculate the variation in noise level L_s from wind turbines with distance r from the source, also accounting for the frequency dependent absorption coefficient ΔL_a as defined in ISO 9613-2:1996.

$$L = L_s - 20\log_{10}(r) - 11 + 3 - \Delta L_a + 10\log_{10}\left(\frac{r}{700}\right) \quad (1)$$

1.4.1.14 Indicative calculations of the noise impacts have been undertaken in line with the guidance in ISO 9613-2:1996 in downwind conditions at various distances to assess where the impacts change. A temperature of 15°C and relative humidity of 15% have been assumed to calculate the atmospheric attenuation coefficients. The -11 dB term in equation 1 above relates to the losses associated with a wave spreading spherically away from the source with no influence from any reflecting surfaces. The +3 dB term in equation 1 accounts for the increase in sound level due to constructive interference between the direct and reflected waves off a totally reflecting surface.

1.4.2 Results

1.4.2.1 The results are presented graphically in Figure 1.6 below. Initial indicative calculations show that no high noise impacts are predicted beyond 6km from the boundary of the Mona Array Area, with no medium impacts beyond 9km.

1.4.2.2 The assumptions forming the maximum design scenario are highly conservative and thus the noise impacts have the potential to be even lower than those shown below. The construction noise assessment will be refined to include a more detailed assessment once specific methods and locations have been confirmed.

1.5 Onshore construction noise and vibration assessment

1.5.1 Methodology

Construction noise

1.5.1.1 The specific construction plant, locations, and methods of construction have not yet been confirmed. As such, an initial assessment of the potential noise and vibration impacts has been undertaken based on an indicative list of construction plant proposed for each relevant section of the Mona Proposed Onshore Development Area. As described in Table 1.19 of volume 3, chapter 22: Noise and vibration of the PEIR, the maximum design scenario is represented by all construction works being undertaken at the boundary of the temporary construction compounds.

1.5.1.2 Typical noise levels for the types of plant proposed have been obtained from Annex C of BS 5228-1:2009+A1:2014 which contains current and historic noise data for various on-site construction activities. The data used is presented in Appendix A.

1.5.1.3 It has been assumed that any generators proposed to power elements of the construction works and compounds are operational 24-hours a day and all other plant items will be operational 50% of the time.

1.5.1.4 Mitigation measures, such as low-noise equipment, barriers, and acoustic enclosures will be adopted via the implementation of an Outline Code of Construction Practice (CoCP). The measures have been accounted for in this assessment by reducing the input construction noise levels in Appendix A by -5 dB. This represents a conservative loss typically associated with that achieved by a barrier which only marginally intersects the direct path (line of sight) between a source and receiver.

1.5.1.5 The magnitude of construction noise impacts has been calculated at various distances to determine where the impact magnitudes change within the proposed noise and vibration study areas. Subsequent analysis of the number of residential receptors where a significant impact is predicted has been undertaken using Ordinance Survey (OS) AddressBase Plus data and Geographic Information System (GIS) software.

Construction vibration

1.5.1.6 The levels of vibration generated by the installation of the cofferdam via vibratory piling at landfall have been calculated using library data from a historic project where similar techniques were adopted. A summary of the specification is provided in Table 1.10 below. It is unlikely that the vibratory energy per cycle will be of the magnitude assessed and it is likely to be much lower.

Table 1.10: Vibro-hammer specification.

(4) The ground conditions are defined by the dimensionless soil/hammer parameter C which for vibratory piling has a value of 0.7 for all soil types

Hammer model	Hammer type	Maximum power energy, *E* (J/cycle)	Soil/hammer parameter(4), *C*
SPI MRZV 30VV (TM20)	Vibro	13154	0.7

1.5.1.7 Indicative calculations of the impact magnitudes at various distances have been undertaken using a technique by Heckman & Hagerty (1978) which defines the inversely proportional relationship between the peak particle velocity *v* of a vibratory source and distance to the receptor *r*, dependent upon the hammer energy *E* and soil/hammer parameter *C*. The relationship is defined by equation 1 below.

$$v = \frac{C\sqrt{E}}{r} \quad (1)$$

Construction traffic

1.5.1.8 Indicative baseline traffic flows on key highway links within the traffic and transport study area are presented in volume 3, chapter 21: Traffic and transport of the PEIR.

1.5.1.9 These initial figures have been predicted using a mixture of site-specific surveys, comprising traffic counts over a 2-week period, and detailed desktop reviews of existing studies and datasets.

1.5.1.10 The change in the BNL due to the introduction of addition vehicles onto local highways as part of the construction of the Mona Offshore Wind Project has been calculated using the method outlined in CRTN, as detailed in paragraph 1.2.5.3.

1.5.1.11 The 18-hour BNL $L_{10.18h}$ is calculated using the linear equation for Chart 3 of CRTN reproduced in equation 2 below. This equation is empirically and depends upon the traffic flow Q at a mean speed of V = 75 km/h assuming no HGVs.

$$L_{10,18hr} = 29.1 + 10\log_{10} Q \quad (2)$$

1.5.1.12 This BNL is corrected adjusted by a correction C to account for variations in mean traffic speed V and the percentage of HGVs p using the empirically derived equation in Chart 4 of CRTN, as given by equation 3 below.

$$C = 33\log_{10}\left(V + 40 + \frac{500}{V}\right) + 10\log_{10}\left(1 + \frac{5p}{V}\right) - 68.8 \quad (3)$$

1.5.1.13 The baseline traffic and predicted construction traffic flows are presented in Table 1.11 below. Emphasis should be placed on the fact that only key highway links have been considered at this stage. Detailed calculations of the baseline and future traffic flows will be undertaken for the Environmental Statement once proposed construction access routes have been defined.

Table 1.11: Baseline traffic flows, corrected BNL, and predicted construction traffic flows.

Link	Baseline Traffic Flows				Construction Traffic Flows	
	Total Vehicles	HGVs	p (%)	BNL + C, (dB)	Total Vehicles	HGVs
Link 1: A55 between Junctions 27 and 27A	41471	3170	8%	79	272	140
Link 2: A55 between Junctions 27 and 26	46215	2938	6%	79	272	140
Link 3: A55 between Junctions 26 and 25	46215	2938	6%	79	190	110
Link 4: A55 between Junctions 25 and 24A	46215	2938	6%	79	165	96

Link	Baseline Traffic Flows				Construction Traffic Flows	
	Total Vehicles	HGVs	p (%)	BNL + C, (dB)	Total Vehicles	HGVs
Link 5: A55 between Junctions 24A and 24	46215	2938	6%	79	165	96
Link 6: A55 between Junctions 24 and 23A	43715	2280	5%	79	109	89
Link 7: A55 between Junctions 23A and 23	50827	2968	6%	80	109	89
Link 8: A547 through Llanddulas	8408	755	9%	65	166	128
Link 9: A547 between Llanddulas and Parc Busnes Gogledd Cymru	6847	812	12%	70	214	128
Link 10: A547 between Parc Busnes Gogledd Cymru and A548 Chapel Street	9256	839	9%	66	99	29
Link 11: A547 between A548 Chapel Street and A55	5955	657	11%	64	99	29
Link 12: A548 Chapel Street between A547 and Lon Dirion	9042	974	11%	66	102	57
Link 13: A548 Chapel Street between Lon Dirion and Abergele Hospital	4000	824	21%	64	102	57
Link 14: A548 Chapel Street between Abergele Hospital and B5381 Roman Road	2919	460	16%	63	102	57
Link 15: B5381 Roman Road between A548 and Moelfre	1972	368	19%	61	93	56
Link 16: B5381 Roman Road between Moelfre and Capel Carmel	1554	223	14%	63	169	117
Link 17: B5381 Roman Road between Capel Carmel and Roberts D a O	1586	298	19%	63	162	117
Link 18: B5381 Roman Road between Roberts D a O and Engine Hill	1736	284	16%	64	162	117
Link 19: B5381 Glascoed Road between Engine Hill and Ffordd William Morgan	1745	234	13%	59	84	61
Link 20: B5381 Glascoed Road between Ffordd William Morgan and Cwttir Lane	4046	493	12%	62	111	29
Link 21: Ffordd William Morgan between A55 and Carlton Court	3481	398	11%	62	195	90
Link 22: Ffordd William Morgan between Carlton Court and B5381 Glascoed Road	5991	505	8%	64	195	90
Link 23: Engine Hill between A55 and B5381 Glascoed Road	3492	565	16%	62	78	56

1.5.2 Results

Construction noise and vibration

1.5.2.1 The results of the initial construction noise and vibration assessment for the period where impacts are highest are presented graphically in Figure 1.6 below. The number of receptors within each impact magnitude band are presented in Table 1.12 below.

Table 1.12: Number of receptors per construction noise impact magnitude band.

Scenario	Number of receptors per impact magnitude band		
	High	Medium	Low
Noise impacts due to the Mona Proposed Onshore Development Area at the Landfall (HDD Only)	75	560	1016
Noise impacts due to the Mona Proposed Onshore Development Area at the Landfall (Cofferdam Construction)	733	628	6229
Vibration impacts due to the Mona Proposed Onshore Development Area at the Landfall (Cofferdam Construction)	0	1	247
Noise impacts due to the Mona Proposed Onshore Development Area landward of MHWS (Open Trench)	178	133	982
Noise impacts due to the Onshore Substation (Option 7)	1	147	938
Noise impacts due to the Onshore Substation (Option 2)	3	10	42

1.5.2.2 A draft CoCP will be submitted as part of the PEIR for the Mona Offshore Wind Project. The CoCP will outline general construction principles and commitments to implement the best practicable means for the control of construction noise. A noise management plan will include measures such as barriers, set working hours, quieter equipment, and acoustic enclosures for continuously operating plant such as generators; and/or construction noise monitoring, where necessary.

Construction traffic

1.5.2.3 The predicted changes in BNL on the key highway links are presented in Table 1.13 below.

Table 1.13 Increase in BNL of closest public road used for construction traffic

Link	Increase in Basic Noise Level (BNL) of closest public road used for construction traffic (dB)				
	Total Vehicles	HGVs	p (%)	BNL + C, (dB)	Impact
Link 1: A55 between Junctions 27 and 27A	41743	3310	8%	79	**Negligible**
Link 2: A55 between Junctions 27 and 26	46487	3078	7%	80	**Low**
Link 3: A55 between Junctions 26 and 25	46405	3048	7%	80	**Low**
Link 4: A55 between Junctions 25 and 24A	46380	3034	7%	80	**Low**
Link 5: A55 between Junctions 24A and 24	46380	3034	7%	80	**Low**
Link 6: A55 between Junctions 24 and 23A	43824	2369	5%	79	**Negligible**
Link 7: A55 between Junctions 23A and 23	50936	3057	6%	80	**Negligible**
Link 8: A547 through Llanddulas	8574	883	10%	65	**Negligible**
Link 9: A547 between Llanddulas and Parc Busnes Gogledd Cymru	7061	940	13%	70	**Negligible**
Link 10: A547 between Parc Busnes Gogledd Cymru and A548 Chapel Street	9355	868	9%	66	**Negligible**
Link 11: A547 between A548 Chapel Street and A55	6054	686	11%	64	**Negligible**
Link 12: A548 Chapel Street between A547 and Lon Dirion	9144	1031	11%	66	**Negligible**
Link 13: A548 Chapel Street between Lon Dirion and Abergele Hospital	4102	881	21%	64	**Negligible**
Link 14: A548 Chapel Street between Abergele Hospital and B5381 Roman Road	3021	517	17%	63	**Negligible**
Link 15: B5381 Roman Road between A548 and Moelfre	2065	424	21%	61	**Negligible**
Link 16: B5381 Roman Road between Moelfre and Capel Carmel	1723	340	20%	64	**Low**
Link 17: B5381 Roman Road between Capel Carmel and Roberts D a O	1748	415	24%	64	**Low**
Link 18: B5381 Roman Road between Roberts D a O and Engine Hill	1898	401	21%	64	**Negligible**
Link 19: B5381 Glascoed Road between Engine Hill and Ffordd William Morgan	1829	295	16%	59	**Negligible**
Link 20: B5381 Glascoed Road between Ffordd William Morgan and Cwttir Lane	4157	522	13%	62	**Negligible**
Link 21: Ffordd William Morgan between A55 and Carlton Court	3676	488	13%	62	**Negligible**
Link 22: Ffordd William Morgan between Carlton Court and B5381 Glascoed Road	6186	595	10%	64	**Negligible**
Link 23: Engine Hill between A55 and B5381 Glascoed Road	3570	621	17%	62	**Negligible**

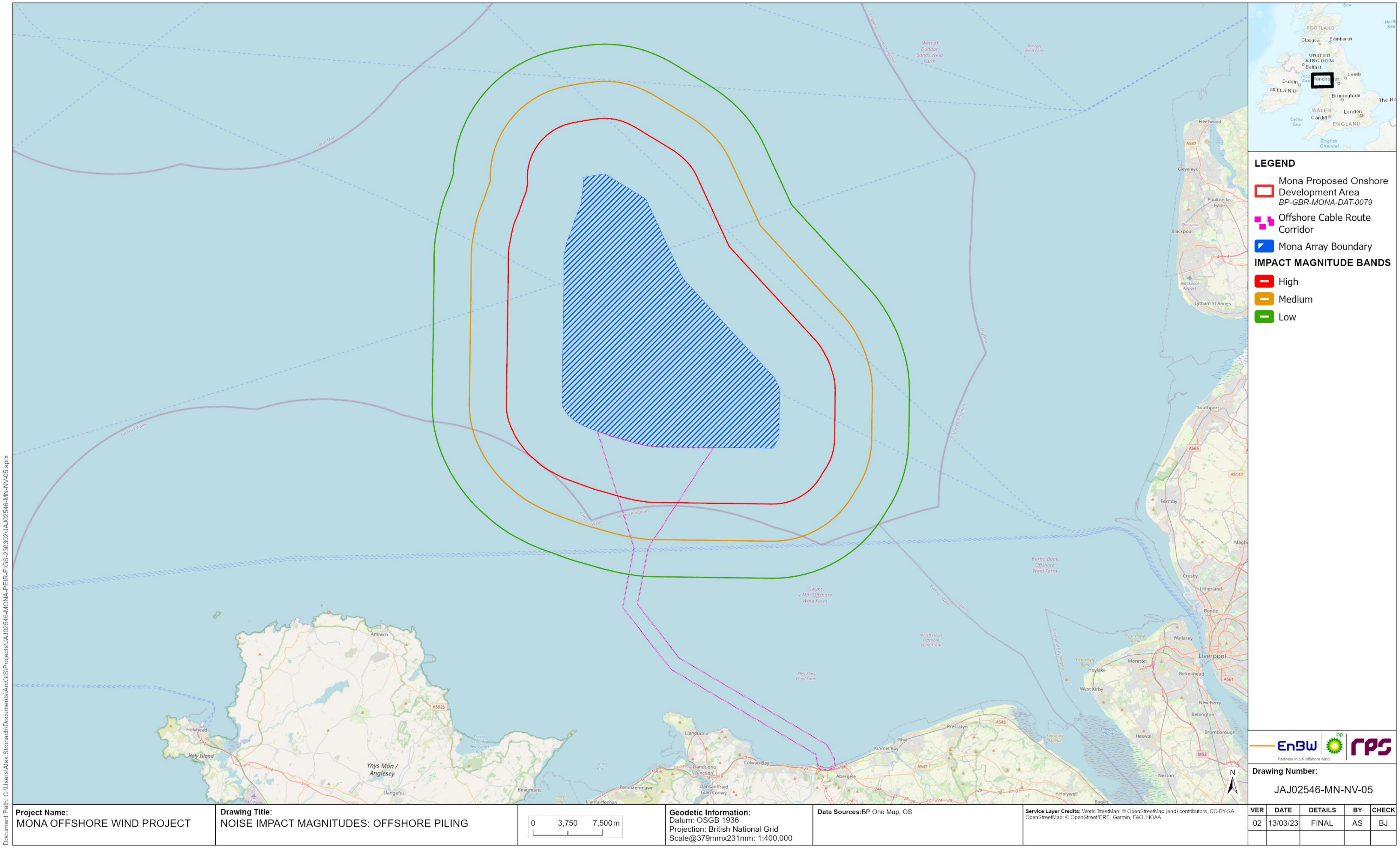

Figure 1.6: Noise impact magnitudes – Monopiling of offshore foundations

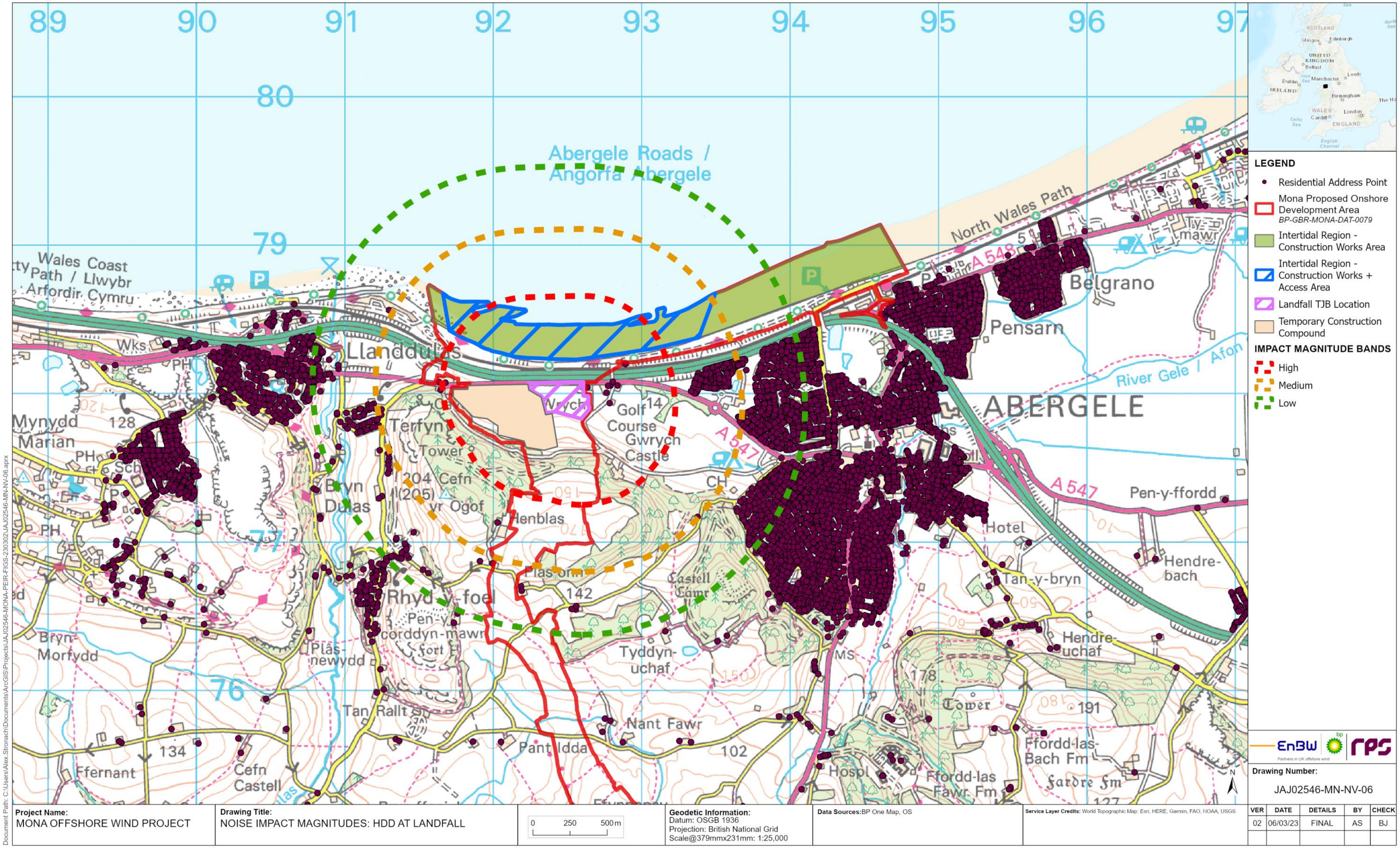

Figure 1.7: Noise impact magnitudes – Night-time HDD at landfall

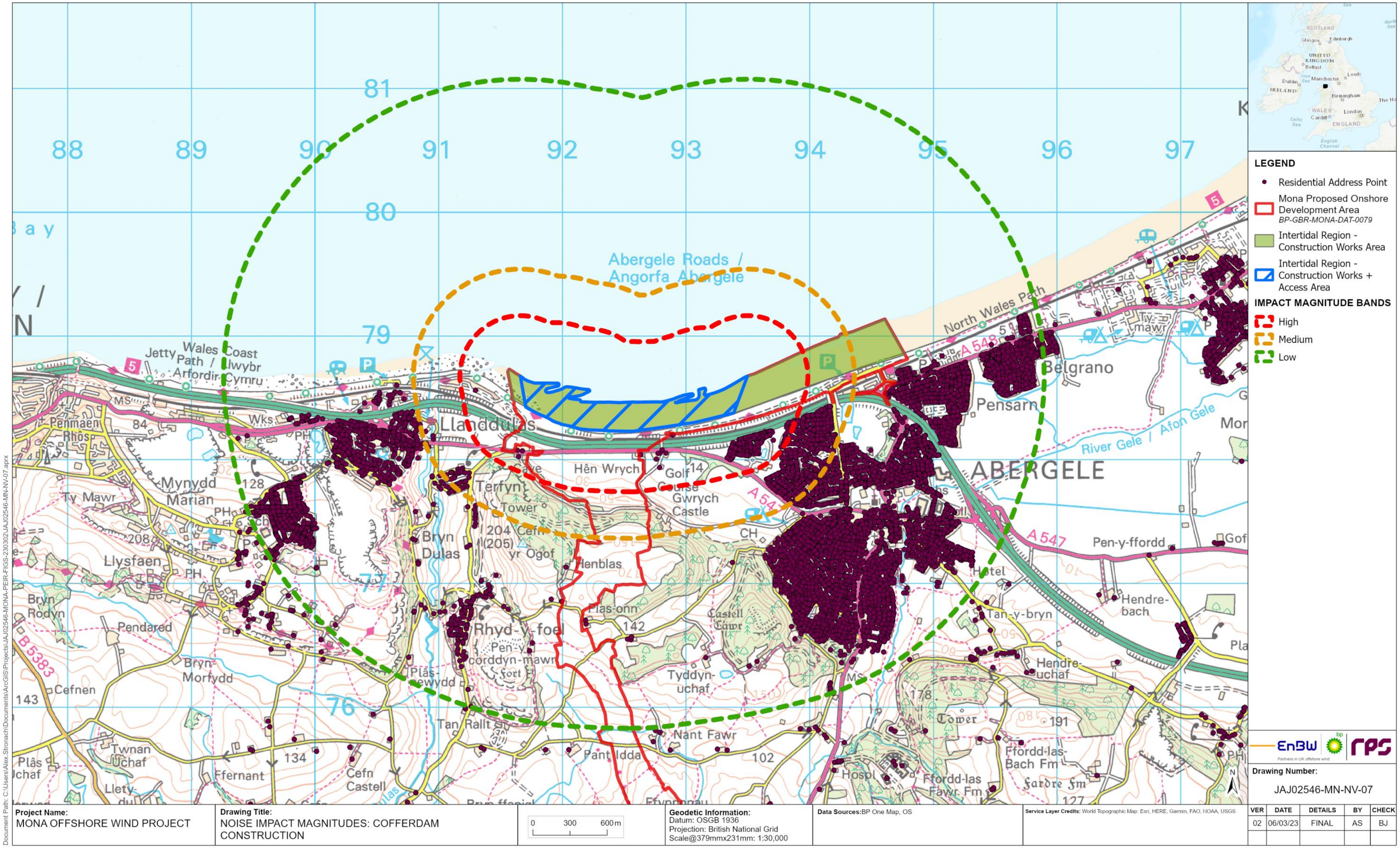

Figure 1.8: Noise impact magnitudes – Piling for cofferdam construction

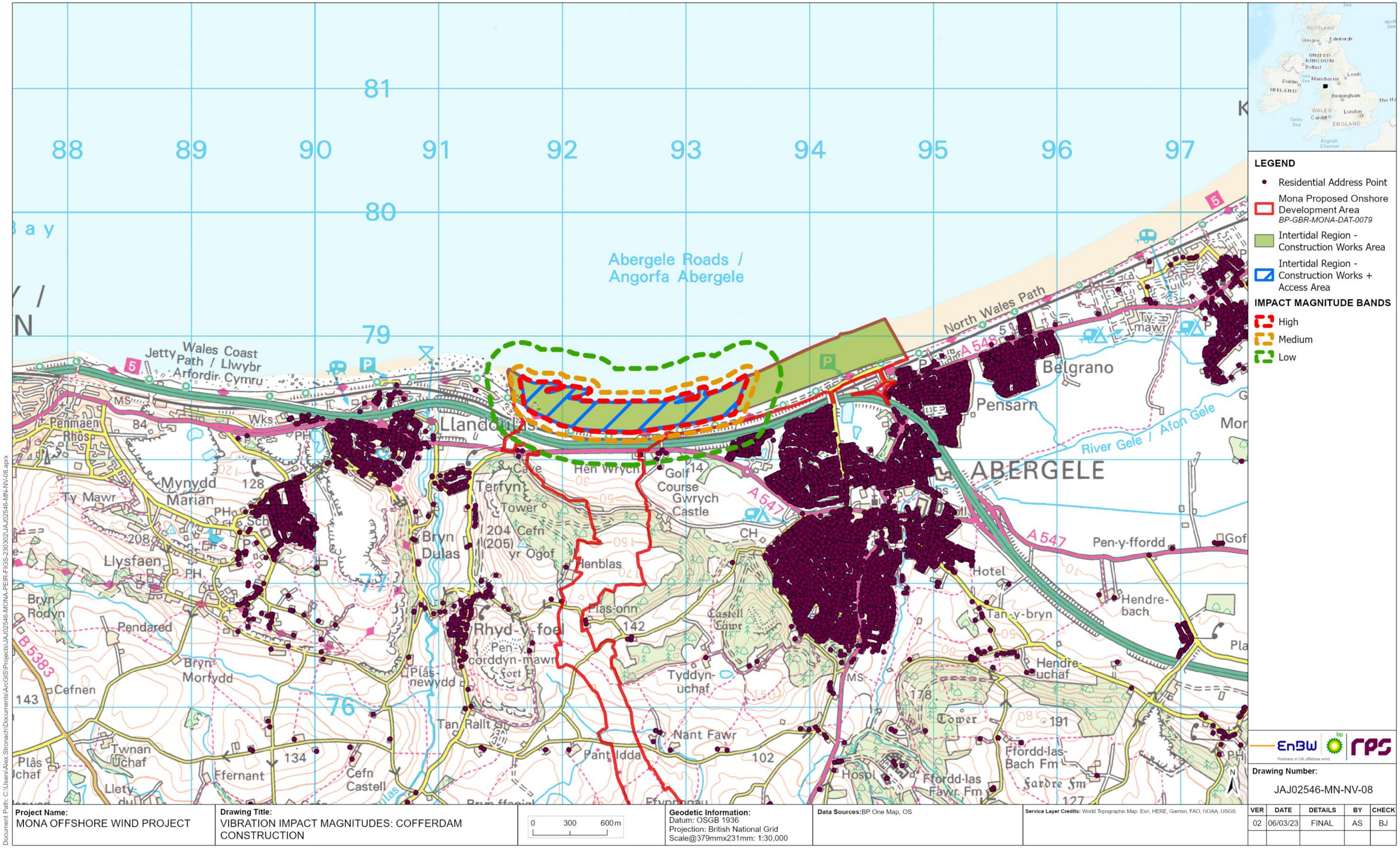

Figure 1.9: Vibration impact magnitudes – Piling for cofferdam construction

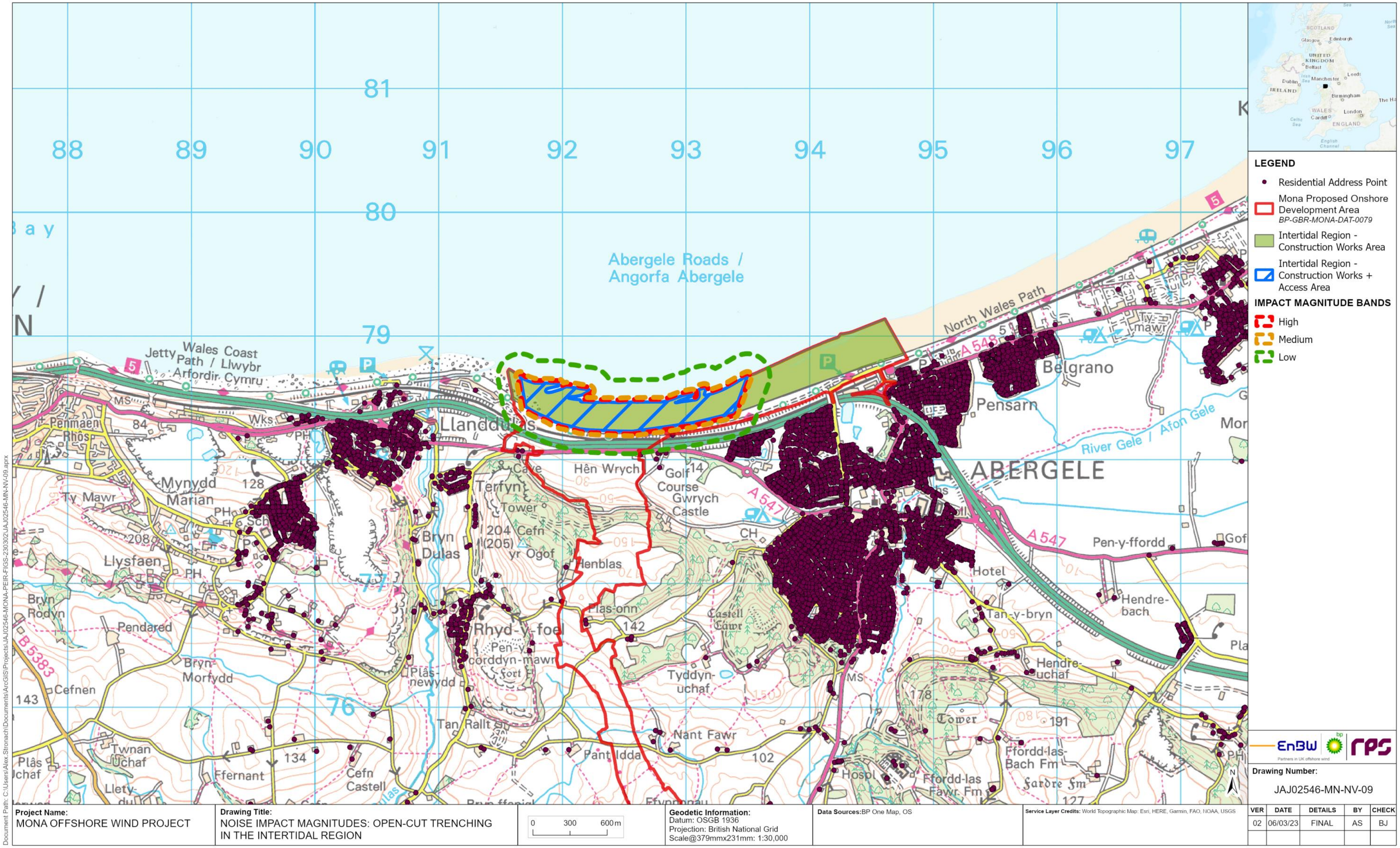

Figure 1.10: Noise impact magnitudes – Open trenching in the intertidal region

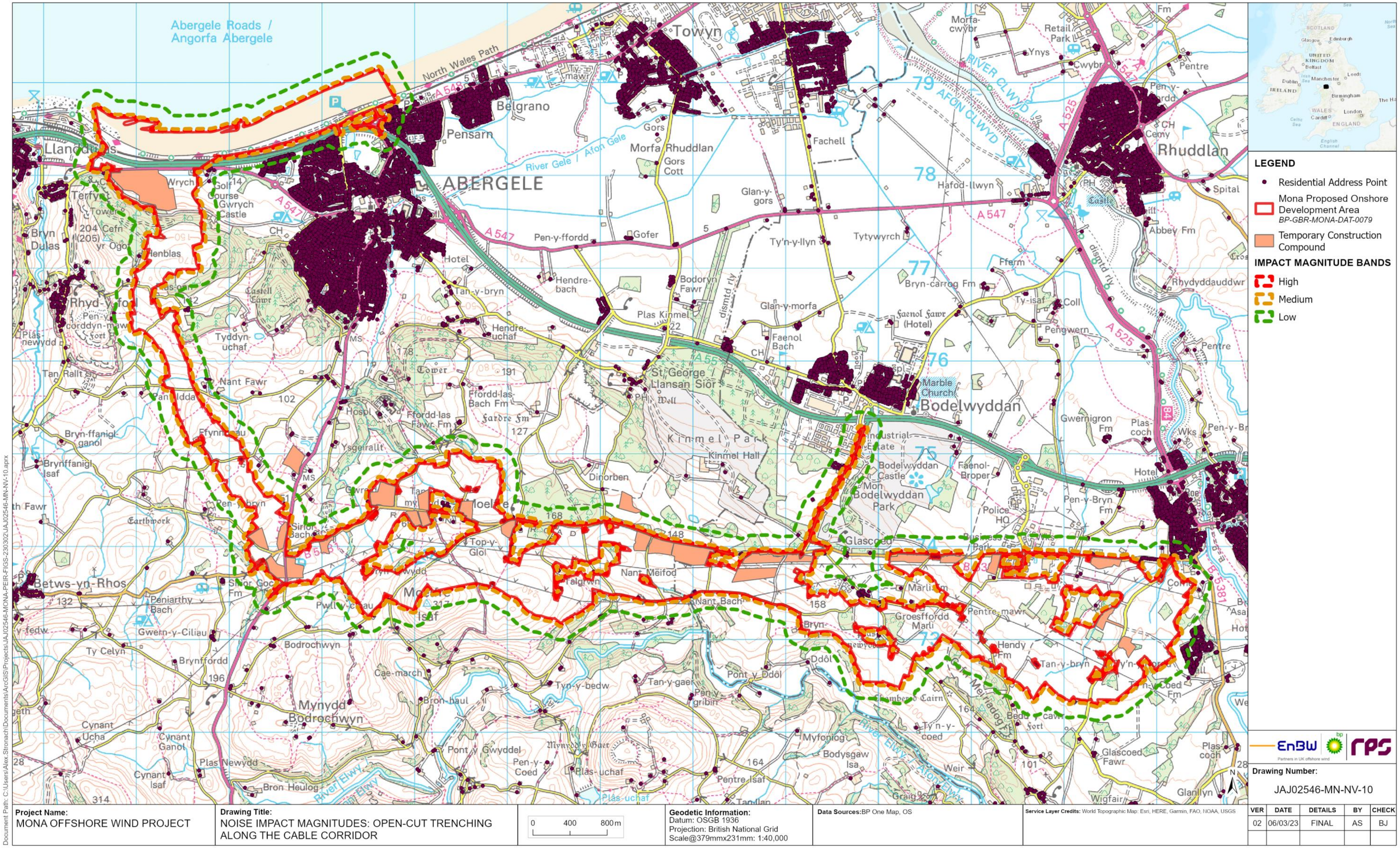

Figure 1.11: Noise impact magnitudes – Construction compound search areas Mona Proposed Onshore Development Area

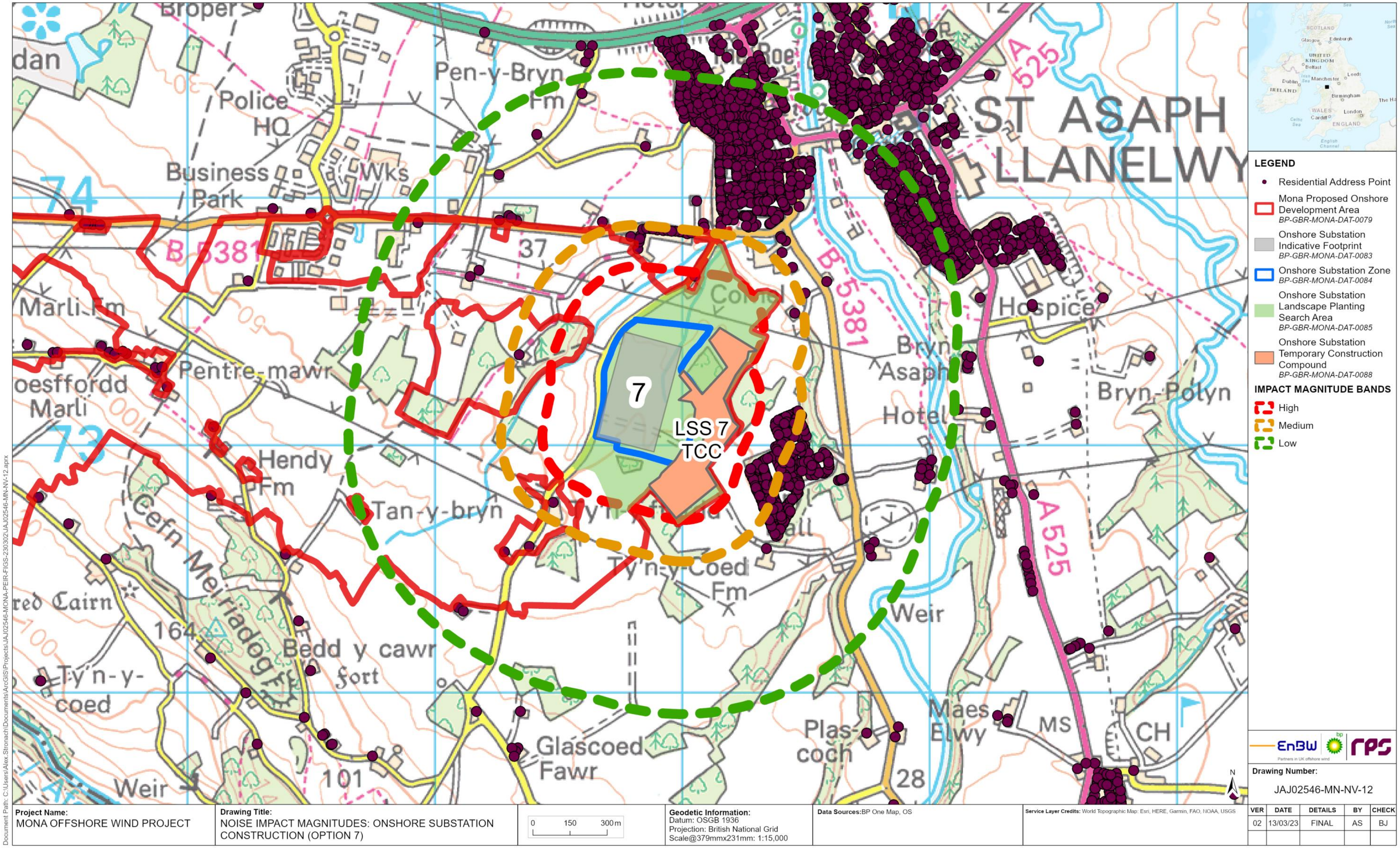

Figure 1.12: Noise impact magnitudes – Mona Onshore Substation option location 7

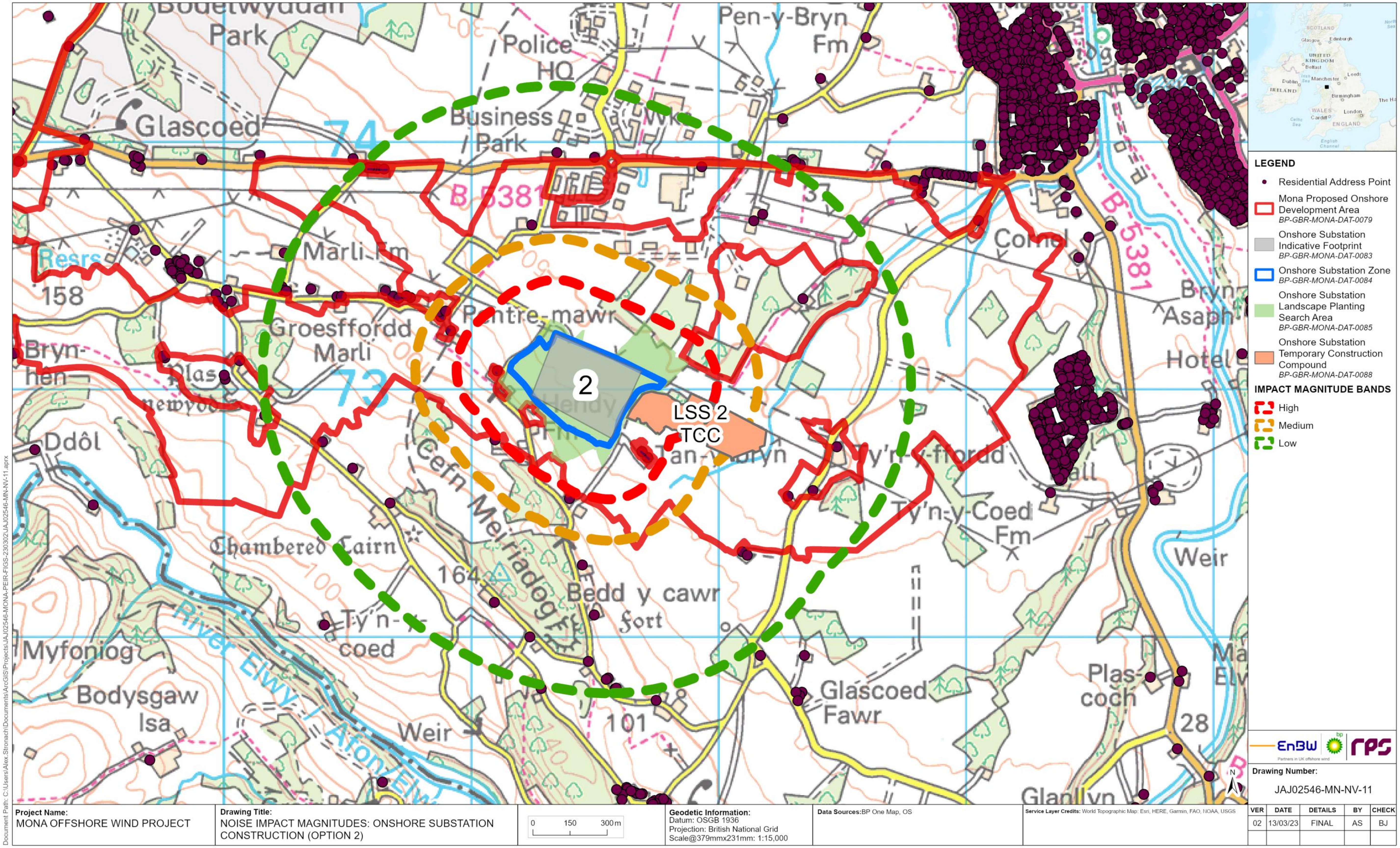

Figure 1.13: Noise impact magnitudes – Mona Onshore Substation option location 2

1.6 Next steps

1.6.1.1 An additional baseline sound survey will be undertaken once the Onshore Cable Corridor and 400kV Grid Connection Corridor have been refined with consideration also given to ecological receptors.

1.6.1.2 The assessment of construction noise and vibration impacts will also be refined once more detail on construction activities, such as equipment and locations, is available.

1.7 References

British Standards Institution (2014a) '*British Standard 5228-1:2009+A1:2014 (2014) Code of practice for noise and vibration control on construction and open sites - Part 1: Noise'*

British Standards Institution (2014b) '*British Standard 5228-2:2009+A1:2014 (2014) Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration'*

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Institute of Acoustics (2014). '*A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise: Supplementary Guidance Note 6: Noise Propagatation Over Water for On-Shore Wind Turbines''*

International Organisation for Standards (1996),'*ISO 9613-2:1996 – Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation'*

Mona Offshore Wind Ltd (2022) Mona Offshore Wind Farm Environmental Impact Assessment Scoping Report

Appendix A: Construction Noise Source Spectra

Plant Item	Sound Pressure Level at 10 m (dB) at Octave Band Centre Frequency (Hz)								dB(A)
	63	125	250	500	1k	2k	4k	8k	
LANDFALL									
Mobile Crane	80	79	73	74	73	73	64	55	**78**
Flat bed articulated truck	85	87	77	75	76	73	69	62	**81**
Rock breakers/Concrete munchers	79	82	81	82	86	86	86	85	**93**
CAT 320 Excavators	89	78	73	67	64	62	58	51	**71**
Compressors (Diesel) (Atlas Copco)	58	58	58	61	64	64	64	59	**70**
Piling rigs	83	82	79	82	82	84	82	77	**89**
Lighting towers (Diesel)	80	74	57	54	53	48	45	37	**61**
Concrete pumps	83	77	75	75	74	75	67	63	**80**
Temporary welfare facilities (incl. diesel genies)	80	74	57	54	53	48	45	37	**61**
HDD (LANDFALL and CROSSINGS)									
Rig Generator	67	80	74	72	72	72	68	61	**78**
Drilling rig	75	79	76	73	74	79	74	69	**83**
Mud Pump	87	82	76	76	75	70	67	55	**79**
Pump House	78	73	67	67	66	61	58	46	**70**
Mixing System	73	74	80	73	70	68	64	61	**77**
Re-cycling system	74	75	81	74	71	69	65	62	**78**
MONA PROPOSED ONSHORE DEVELOPMENT AREA (OPEN TRENCH)									

Plant Item	Sound Pressure Level at 10 m (dB) at Octave Band Centre Frequency (Hz)								dB(A)
	63	125	250	500	1k	2k	4k	8k	
CAT 320 Excavators	89	78	73	67	64	62	58	51	**71**
ONSHORE SUBSTATION									
Mobile Crane	80	79	73	74	73	73	64	55	**78**
Flat bed articulated truck	85	87	77	75	76	73	69	62	**81**
Rock Breakers/Concrete Munchers	79	82	81	82	86	86	86	85	**93**
CAT 320 Excavators	89	78	73	67	64	62	58	51	**71**
Compressors (Diesel) (Atlas Copco)	58	58	58	61	64	64	64	59	**70**
Piling Rigs	83	82	79	82	82	84	82	77	**89**
Lighting Towers (Diesel)	80	74	57	54	53	48	45	37	**61**
Concrete Pumps	83	77	75	75	74	75	67	63	**80**
Temporary Welfare Facilities (incl. diesel genies)	80	74	57	54	53	48	45	37	**61**