APPENDIX 8.4

Subsea Noise Modelling

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Iona and Fionnphort Ferry Ports

Subsea Noise Modelling

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1 Introduction

The location of the Iona Breakwater Project is illustrated in Figure 1.1. The planned construction activities at Iona and Fionnphort involve drilled piles, dredging and rock placement.

Noise is readily transmitted underwater and there is potential for sound emissions from the survey to affect marine mammals and fish. At long ranges the introduction of additional noise could potentially cause short-term behavioural changes, for example to the ability of species to communicate and to determine the presence of predators, food, underwater features, and obstructions. At close ranges and with high noise source levels, permanent or temporary hearing damage may occur, while at very close range, gross physical trauma is possible. This report provides an overview of the potential effects due to underwater noise from the survey on the surrounding marine environment.

The primary purpose of this underwater noise study is to predict the likely range of onset for potential injury (i.e. permanent threshold shifts in hearing) and behavioural effects.

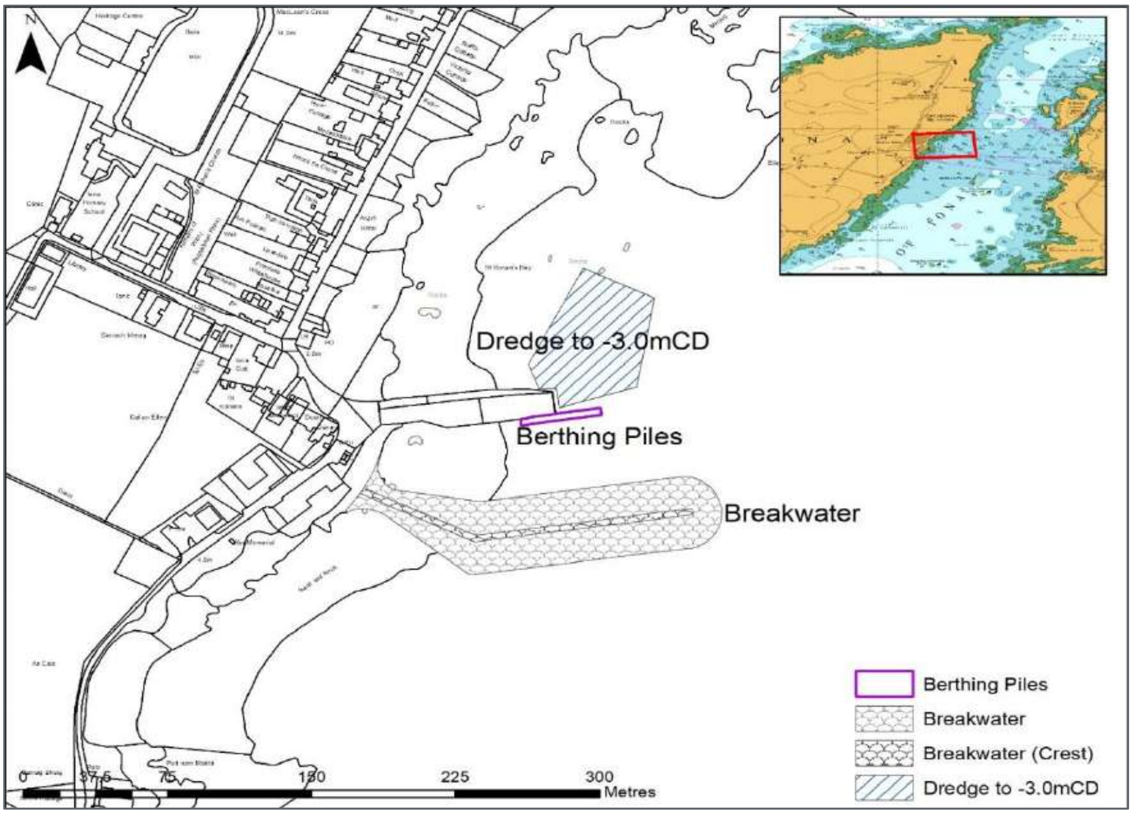

Figure 1.1: Iona Breakwater Project

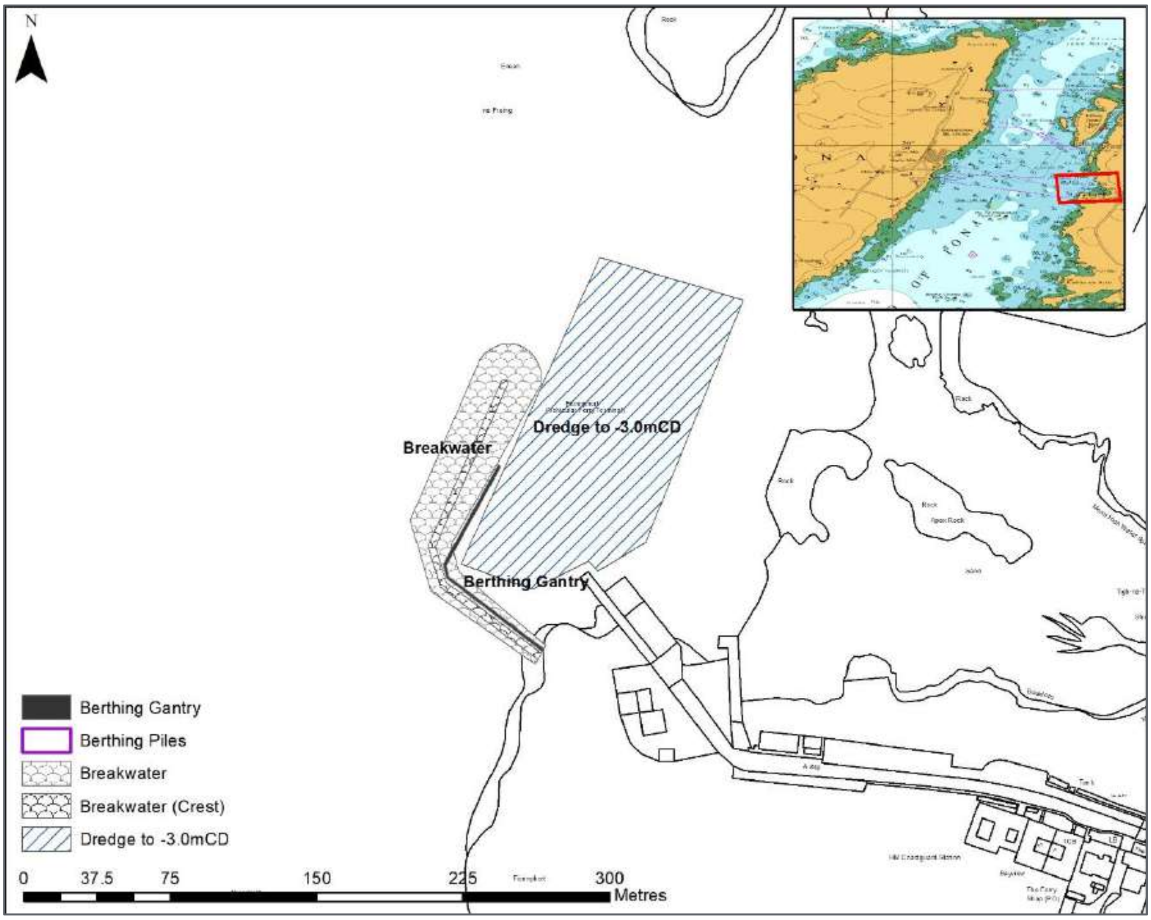

Figure 1.2 Fionnphort Breakwater and Overnight Berth Project

2 Acoustic Concepts and Terminology

Sound travels through the water as vibrations of the fluid particles in a series of pressure waves. The waves comprise a series of alternating compressions (positive pressure) and rarefactions (negative pressure). Because sound consists of variations in pressure, the unit for measuring sound is usually referenced to a unit of pressure, the Pascal (Pa). The decibel (dB) scale is used to conveniently communicate the large range of acoustic pressures encountered, with a known pressure amplitude chosen as a reference value (i.e., 0 dB). In the case of underwater sound, the reference value (P_{ref}) is taken as 1 μPa, whereas the airborne sound is usually referenced to a pressure of 20 μPa. To convert from a sound pressure level referenced to 20 μPa to one referenced to 1 μPa, a factor of 20 log (20/1) i.e., 26 dB has to be added to the former quantity. Thus 60 dB re 20 μPa is the same as 86 dB re 1 μPa, although differences in sound speeds and different densities mean that the decibel level difference in sound intensity is much more than the 26 dB when converting pressure from air to water. All underwater sound pressure levels in this report are quantified in dB re 1 μPa.

There are several descriptors used to characterise a sound wave. The difference between the lowest pressure variation (rarefaction) and the highest-pressure variation (compression) is called the peak to peak (or pk-pk) sound pressure level. The difference between the highest variation (either positive or negative) and the mean pressure is called the peak pressure level. Lastly, the root mean square (rms) sound pressure level is used as a description of the average amplitude of the variations in pressure over a specific time window. Decibel values reported should always be quoted along with the P_{ref} value employed during calculations. For example, the measured SPL_{rms} value of a pulse may be reported as 100 dB re 1 μPa. These descriptions are shown graphically in Figure 2.1.

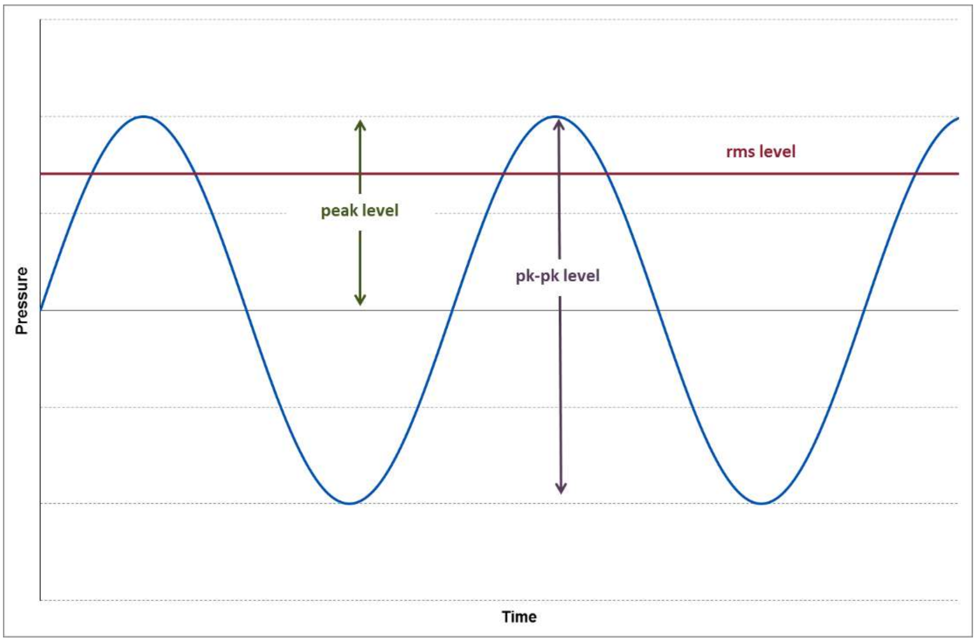

Figure 2.1: Graphical representation of acoustic wave descriptors

The rms sound pressure level (SPL) is defined as follows:

$$SPL_{rms} = 10log_{10}\left(\frac{1}{T}\int_{0}^{T}\left(\frac{p^2}{p_{ref}^2}\right)dt\right) \quad (1)$$

The magnitude of the rms sound pressure level for an impulsive sound (such as that from a seismic source array) will depend upon the integration time, T, used for the calculation (Madsen 2005). It has become customary to utilise the T90 time period for calculating and reporting rms sound pressure levels. This is the interval over which the cumulative energy curve rises from 5% to 95% of the total energy and therefore contains 90% of the sound energy.

Another useful measure of sound used in underwater acoustics is the Sound Exposure Level, or SEL. This descriptor is used as a measure of the total sound energy of an event or a number of events (e.g., over the course of a day) and is normalised to one second. This allows the total acoustic energy contained in events lasting a different amount of time to be compared on a like for like basis[1]. The SEL is defined as follows:

$$SEL = 10log_{10}\left(\int_{0}^{T}\left(\frac{p^2(t)}{p_{ref}^2 t_{ref}}\right)dt\right) \quad (2)$$

The frequency, or pitch, of the sound is the rate at which the acoustic oscillations occur in the medium (air/water) and is measured in cycles per second, or Hertz (Hz). When sound is measured in a way which approximates to how a human would perceive it using an A-weighting filter on a sound level meter, the resulting level is described in values of dBA. However, the hearing faculty of marine mammals is not the same as humans, with marine mammals hearing over a wider range of frequencies and with a different sensitivity. It is therefore important to understand how an animal's hearing varies over its entire frequency range to assess the effects of anthropogenic sound on marine mammals. Consequently, use can be made of frequency weighting scales (m-weighting) to determine the level of the sound in comparison with the auditory response of the animal concerned. A comparison between the typical hearing response curves for fish, humans and marine mammals is shown in Figure 2.2. (It is worth noting that hearing thresholds are sometimes shown as audiograms with sound level on the y axis rather than sensitivity, resulting in the graph shape being the inverse of the graph shown.)

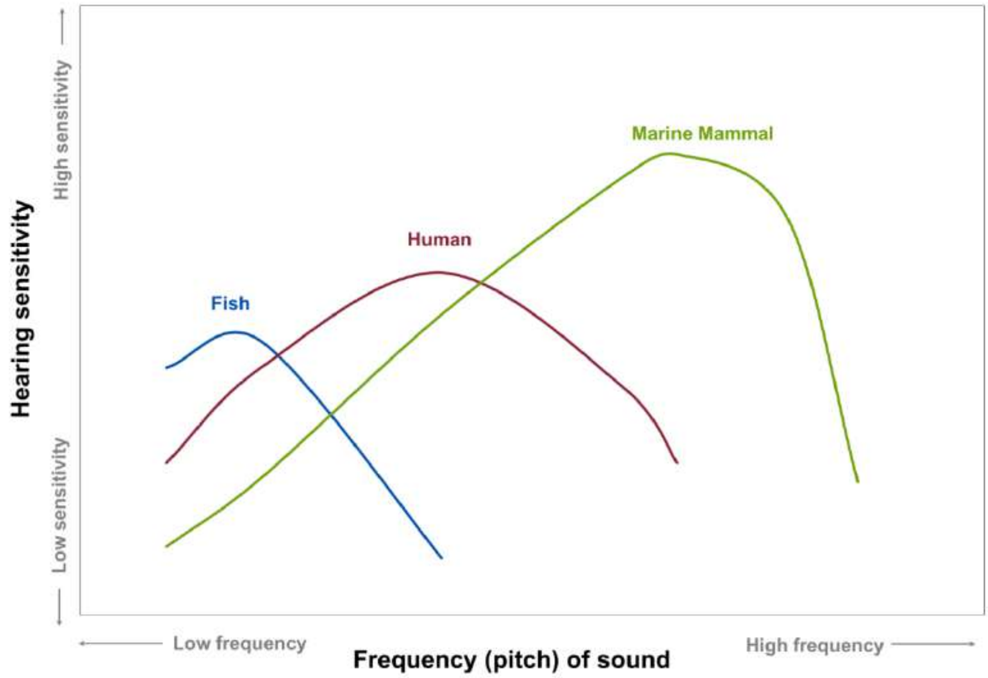

Figure 2.2: Comparison between hearing thresholds of different animals

Other relevant acoustic terminology and their definitions used in the report are detailed below.

1/3rd octave bands

The broadband acoustic power (i.e., containing all the possible frequencies) emitted by a sound source, measured/modelled at a location within the survey region is generally split into and reported in a series of frequency bands. In marine acoustics, the spectrum is generally reported in standard 1/3rd octave band frequencies, where an octave represents a doubling in sound frequency.

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1 Historically, use was primarily made of rms and peak sound pressure level metrics for assessing the potential effects of sound on marine life. However, the SEL is increasingly being used as it allows exposure duration and the effect of exposure to multiple events to be considered.

Source level (SL)

The source level is the sound pressure level of an equivalent and infinitesimally small version of the source (known as *point source*) at a hypothetical distance of 1 m from it. The source level may be combined with the transmission loss (TL) associated with the environment to obtain the received level (RL) in the *far field* of the source. The far field distance is chosen so that the behaviour of the distributed source can be approximated to that of a point source. Source levels do not indicate the real sound pressure level at 1 m.

Transmission loss (TL)

TL at a frequency of interest is defined as the loss of acoustic energy as the signal propagates from a hypothetical (point) source location to the chosen receiver location. The TL is dependent on water depth, source depth, receiver depth, frequency, geology, and environmental conditions. The TL values are generally evaluated using an acoustic propagation model (various numerical methods exist) accounting for the above dependencies.

Received level (RL)

The RL is the sound level of the acoustic signal recorded (or modelled) at a given location, that corresponds to the acoustic pressure/energy generated by a known active sound source. This considers the acoustic output of a source and is modified by propagation effects. This RL value is strongly dependant on the source, environmental properties, geological properties and measurement location/depth. The RL is reported in dB either in rms or peak-to-peak SPL, and SEL metrics, within the relevant third-octave band frequencies. The RL is related to the SL as

$$RL = SL - TL \tag{3}$$

where TL is the transmission loss of the acoustic energy within the survey region.

The directional dependence of the source signature and the variation of TL with azimuthal direction α (which is strongly dependent on bathymetry) are generally combined and interpolated to report a 2-D plot of the RL around the chosen source point up to a chosen distance.

3 Acoustic Assessment Criteria

3.1 Introduction

Underwater noise has the potential to affect marine life in different ways depending on its noise level and characteristics. Richardson et al. (1995) defined four zones of noise influence which vary with distance from the source and level. These are:

- **The zone of audibility:** this is the area within which the animal can detect the sound. Audibility itself does not implicitly mean that the sound will have an effect on the marine mammal.
- **The zone of masking:** this is defined as the area within which noise can interfere with detection of other sounds such as communication or echolocation clicks. This zone is very hard to estimate due to a paucity of data relating to how marine mammals detect sound in relation to masking levels (for example, humans can hear tones well below the numeric value of the overall noise level).
- **The zone of responsiveness:** this is defined as the area within which the animal responds either behaviourally or physiologically. The zone of responsiveness is usually smaller than the zone of audibility because, as stated previously, audibility does not necessarily evoke a reaction.
- **The zone of injury / hearing loss:** this is the area where the sound level is high enough to cause tissue damage in the ear. This can be classified as either temporary threshold shift (TTS) or permanent threshold shift (PTS). At even closer ranges, and for very high intensity sound sources (e.g., underwater explosions), physical trauma or even death are possible.

For this study, it is the zones of injury and disturbance (i.e., responsiveness) that are of concern (there is insufficient scientific evidence to properly evaluate masking). To determine the potential spatial range of injury and disturbance, a review has been undertaken of available evidence, including international guidance and scientific literature. The following sections summarise the relevant thresholds for onset of effects and describe the evidence base used to derive them.

3.2 Injury (Physiological Damage) to Mammals

Sound propagation models can be constructed to allow the received noise level at different distances from the source to be calculated. To determine the consequence of these received levels on any marine mammals which might experience such noise emissions, it is necessary to relate the levels to known or estimated impact thresholds. The injury criteria proposed by Southall et al (2019). are based on a combination of linear (i.e., un-weighted) peak pressure levels and mammal hearing weighted sound exposure levels (SEL). The hearing weighting function is designed to represent the bandwidth for each group within which acoustic exposures can have auditory effects. The categories include:

- **low-frequency (LF) cetaceans** (i.e., marine mammal species such as baleen whales);
- **high-frequency (HF) cetaceans** (i.e., marine mammal species such as dolphins, toothed whales, beaked whales and bottlenose whales);
- **very high-frequency (VHF) cetaceans** (i.e., marine mammal species such as true porpoises, river dolphins and pygmy/dwarf sperm whales and some oceanic dolphins, generally with auditory centre frequencies above 100 kHz);
- **phocid pinnipeds (PCW)** (i.e., true seals; hearing in air is considered separately in the group PCA); and
- **other marine carnivores (OCW)** (including otariid pinnipeds (e.g., sea lions and fur seals), sea otters and polar bears; air hearing considered separately in the group OCA).

These weightings have therefore been used in this study and are shown in Figure 3.1.

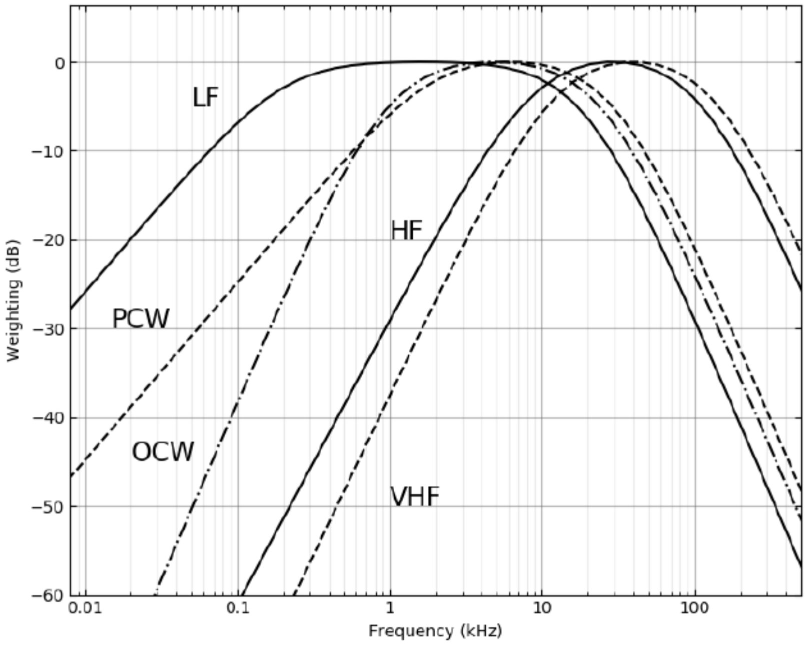

Figure 3.1: Hearing weighting functions for pinnipeds and cetaceans (Southall et al. 2019)

Injury criteria are proposed in Southall et al (2019) are for two different types of sound as follows:

- **Impulsive sounds** which are typically transient, brief (less than 1 second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay (ANSI 1986; NIOSH 1998; ANSI 2005). This category includes sound sources such as seismic surveys, impact piling and underwater explosions; and
- **Non-impulsive sounds** which can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent and typically do not have a high peak sound pressure with rapid rise/decay time that impulsive sounds do (ANSI 1995; NIOSH 1998). This category includes sound sources such as continuous running machinery, sonar and vessels.

The criteria for non-impulsive sound have been adopted for this study given the nature of the sound source used during port construction activities.

The relevant criteria proposed by Southall et al. (2019) are as summarised in Table 3.1.

Table 3.1: Summary of PTS onset acoustic thresholds (Southall et al. 2019 Tables 6 and 7)

Hearing Group	Parameter	Impulsive	Non impulsive
Low-frequency (LF) cetaceans	Peak, unweighted	219	-
	SEL, LF weighted	183	199
High-frequency (HF) cetaceans	Peak, unweighted	230	-
	SEL, MF weighted	185	198
Very High-frequency (VHF) cetaceans	Peak, unweighted	202	-
	SEL, HF weighted	155	173
Phocid Carnivores in Water (PCW)	Peak, unweighted	218	-
	SEL, PW weighted	185	201
Other Marine Carnivores in Water (OCW)	Peak, unweighted	232	-
	SEL, OW weighted	203	219

These updated marine mammal injury criteria were published in March 2019 (Southall et al. 2019). The paper utilised the same hearing weighting curves and thresholds as presented in the preceding regulations document NMFS (2018) with the main difference being the naming of the hearing groups and introduction of additional thresholds for animals not covered by NMFS (2018). A comparison between the two naming conventions is shown in Table 3.2.

For avoidance of doubt, the naming convention used in this report is based upon those set out in Southall et al (2019). Consequently, this assessment utilises criteria which are applicable to both NMFS (2018) and Southall et al. (2019).

Table 3.2: Comparison of hearing group names between NMFS 2018 and Southall 2019

NMFS (2018) hearing group name	Southall et al. (2019) hearing group name
Low frequency cetaceans (LF)	Low-frequency cetaceans (LF)
Mid frequency cetaceans (MF)	High-frequency cetaceans (HF)
High frequency cetaceans (HF)	Very high-frequency cetaceans (VHF)
Phocid pinnipeds in water (PW)	Phocid carnivores in water (PCW)

3.3 Disturbance to Marine Mammals

Beyond the area in which injury may occur, the effect on marine mammal behaviour is the most important measure of impact. Significant (i.e., non-trivial) disturbance may occur when there is a risk of animals incurring sustained or chronic disruption of behaviour or when animals are displaced from an area, with subsequent redistribution being significantly different from that occurring due to natural variation.

To consider the possibility of significant disturbance resulting from the project, it is therefore necessary to consider the likelihood that the sound could cause non-trivial disturbance, the likelihood that the sensitive receptors will be exposed to that sound and whether the number of animals exposed are likely to be significant at the population level. Assessing this is however a challenging task due to the complex and variable nature of sound propagation, the variability of documented animal responses to similar levels of sound, and the availability of population estimates, and regional density estimates for all marine mammal species.

Southall et al. (2007) recommended that the only currently feasible way to assess whether a specific non-impulsive sound could cause disturbance is to compare the circumstances of the situation with empirical studies. The more severe the response on the scale, the lower the amount of time that the animals will tolerate it before there could be significant negative effects on life functions, which would constitute a disturbance under the relevant regulations. The Southall scale is shown in Table 3.3.

Table 3.3: Southall et al. (2007) behavioural disturbance scale.

Response Score	Corresponding Behaviours in free ranging subjects
0	• No observable response
1	• Brief orientation response (investigation / visual orientation)
2	• Moderate or multiple orientation behaviours • Brief or minor cessation/modification of vocal behaviour • Brief or minor change in respiration rates
3	• Prolonged orientation behaviour • Individual alert behaviour • Minor changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source • Moderate change in respiration rate • Minor cessation or modification of vocal behaviour (duration < duration of source operation)
4	• Moderate changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source • Brief, minor shift in group distribution • Moderate cessation or modification of vocal behaviour (duration more or less equal to the duration of source operation)
5	• Extensive or prolonged changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source • Moderate shift in group distribution • Change in inter-animal distance and/or group size (aggregation or separation) • Prolonged cessation or modification of vocal behaviour (duration > duration of source operation)
6	• Minor or moderate individual and/or group avoidance of sound source • Brief or minor separation of females and dependent offspring • Aggressive behaviour related to noise exposure (e.g. tail/flipper slapping, fluke display, jaw clapping/gnashing teeth, abrupt directed movement, bubble clouds) • Extended cessation or modification of vocal behaviour • Visible startle response • Brief cessation of reproductive behaviour
7	• Extensive or prolonged aggressive behaviour • Moderate separation of females and dependent offspring • Clear anti-predator response • Sever and/or sustained avoidance of sound source • Moderate cessation of reproductive behaviour
8	• Obvious aversion and/or progressive sensitization • Prolonged or significant separation of females and dependent offspring with disruption of acoustic reunion mechanisms • Long-term avoidance of area (> source operation) • Prolonged cessation of reproductive behaviour
9	• Outright panic, flight, stampede, attack of conspecifics, or stranding events • Avoidance behaviour related to predator detection.

For non-pulsed sound, the lowest sound pressure level at which a score of 5 or more occurs for low-frequency cetaceans is 90 - 100 dB re 1 μPa (rms). However, this relates to a study involving migrating grey whales. A study for minke whales showed a response score of 3 at a received level of 100 – 110 dB re 1 µPa (rms), with no higher severity score encountered for this species. For high-frequency cetaceans, a response score of 8 was encountered at a received level of 90 - 100 dB re 1 µPa (rms), but this was for one mammal (a sperm whale) and might not be applicable for the species likely to be encountered near the project. For very high-frequency cetaceans, several individual responses with a response score of 6 are noted ranging from 80 dB re 1 µPa (rms) and upwards. There is a significant increase in the number of mammals responding at a response score of 6 once the received sound pressure level is greater than 140 dB re 1 µPa (rms).

Clearly, there is much intra-category and perhaps intra-species variability in behavioural response. As such, a conservative approach should be taken to ensure that the most sensitive marine mammals remain protected.

This assessment therefore adopts a conservative approach and uses the US National Marine Fisheries Service (NMFS, 2005) Level B harassment thresholds for non-impulsive sounds. Level B Harassment is defined as having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild. This description of non-trivial disturbance has therefore been used as the basis for onset of behavioural change in this assessment.

The (NMFS, 2005) guidance sets the marine mammal level B harassment threshold for continuous noise at 120 dB re 1 µPa (rms). This value sits approximately mid-way between the range of values identified in Southall et al. (2007) for continuous sound but is lower than the value at which the majority of mammals responded at a response score of 6 (i.e., once the received rms sound pressure level is greater than 140 dB re 1 µPa). Considering the paucity and high-level variation of data relating to onset of behavioural effects due to continuous sound, it is recommended that any ranges predicted using this number are viewed as probabilistic and potentially over-precautionary.

The relevant criteria for marine mammals are summarised in Table 3.4. This includes the thresholds for non-impulsive sound based on the relevant guidelines (NMFS 2018, NMFS 2005). In Table 3.4 SELs are expressed as dB re 1 µPa^{2}s (cumulative over a 24-hour period) and RMS sound pressure levels are in dB re 1 µPa (rms).

Table 3.4: Summary of acoustic thresholds for marine mammals for non-impulsive sound.

Hearing group	Parameter	PTS	TTS	Disturbance
Low-frequency (LF) cetaceans	SEL, LF weighted dB re 1 µPa^{2}s	199	179	-
	RMST90 dB re 1 µPa (rms)	-	-	120
High-frequency (HF) cetaceans	SEL, MF weighted dB re 1 µPa^{2}s	198	178	-
	RMST90 dB re 1 µPa (rms)	-	-	120
Very High-frequency (VHF) cetaceans	SEL, HF weighted dB re 1 µPa^{2}s	173	153	-
	RMST90 dB re 1 µPa (rms)	-	-	120
Phocid carnivores (PCW)	SEL, PW weighted dB re 1 µPa^{2}s	201	181	-
	RMST90 dB re 1 µPa (rms)	-	-	120
Other marine carnivores (OCW)	SEL, OW weighted dB re 1 µPa^{2}s	219	199	-
	RMST90 dB re 1 µPa (rms)	-	-	120

3.4 Fish

Adult fish not in the immediate vicinity of the noise generating activity are generally able to vacate the area and avoid physical injury. However, larvae and spawn are not highly mobile and are therefore more likely to incur injuries from the sound energy, including damage to their hearing, kidneys, hearts, and swim bladders. Such effects are unlikely to happen outside of the immediate vicinity of even the highest energy sound sources.

For fish, the most relevant criteria for injury are considered to be those contained in ASA S3/SC1.4 TR-2014, Sound Exposure Guidelines for Fishes and Sea Turtles (Popper et al. 2014) (Table 3.5). The guidelines set out criteria for injury due to different sources of noise. Those relevant to this project are for injury due to continuous noise (which are applicable for vessel operation, drilled pin piling activities, and operational noise). The criteria include a mixture of indices including SEL, rms and peak sound pressure levels. Where insufficient data exists to determine a quantitative guideline value the risk is categorised in relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (i.e. in the tens of metres), “intermediate” (i.e. in the hundreds of metres) or “far” (i.e. in the thousands of metres). It should be noted that these qualitative criteria cannot differentiate between exposures to different noise levels and therefore all sources of noise, no matter how noisy, would theoretically elicit the same assessment result. However, because the qualitative risks are generally qualified as “low”, with the exception of a moderate risk at “near” range (i.e. within tens of meters) for some types of animal and impairment effects, this is not considered to be a significant issue with respect to determining the potential effect of noise on fish.

Table 3.5: ASA guideline criteria for injury in fish due to non-impulsive sound.

Type of animal	Mortality and potential mortal injury	Impairment	
		Recoverable injury	TTS
Fish: no swim bladder (particle motion detection)	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
Fish: where swim bladder is not involved in hearing (particle motion detection)	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
Fish: where swim bladder is involved in hearing (primarily pressure detection)	(Near) Low (Intermediate) Low (Far) Low	170 dB re 1 µPa (rms) for 48 hours	158 dB re 1 µPa (rms) for 12 hours
Eggs and larvae	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low
Notes: *Range of effect classified as Near = tens of meters / Intermediate= hundreds of meters / Far = thousands of meters* *Relative risk classified as high, moderate or low*			

Behavioural reactions of fish to sound have been found to vary between species based on their hearing sensitivity. Typically, fish sense sound via particle motion in the inner ear which is detected from sound-induced motions in the fish’s body. The detection of sound pressure is restricted to those fish which have air filled swim bladders; however, particle motion (induced by sound) can be detected by fish without swim bladders.

Highly sensitive species such as herring have elaborate specialisations of their auditory apparatus, known as an otic bulla - a gas-filled sphere connected to the swim bladder which enhances hearing ability. The gas filled swim bladder in species such as cod and salmon may be involved in their hearing capabilities, so although there is no direct link to the inner ear, these species are able to detect lower sound frequencies and as such are considered to be of medium sensitivity to noise. Flat fish and elasmobranchs have no swim bladders and as such are considered to be relatively less sensitive to sound pressure.

The most recent criteria for disturbance are considered to be those contained in ASA S3/SC1.4 TR-2014, Sound Exposure Guidelines for Fishes and Sea Turtles (Popper et al., 2014) which set out criteria for disturbance due to different sources of noise (Table 3.6). The risk of behavioural effects is categorised in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. in the tens of metres), "intermediate" (i.e. in the hundreds of metres) or "far" (i.e. in the thousands of metres).

Table 3.6: ASA guideline criteria for onset of behavioural effects in fish due to non-impulsive sound.

Type of Animal	Relative Risk of Behavioural Effects
Fish: no swim bladder (particle motion detection)	(Near) Moderate (Intermediate) Moderate (Far) Low
Fish: where swim bladder is not involved in hearing (particle motion detection)	(Near) Moderate (Intermediate) Moderate (Far) Low
Fish: where swim bladder is involved in hearing (primarily pressure detection)	(Near) High (Intermediate) Moderate (Far) Low
Eggs and larvae	(Near) Moderate (Intermediate) Moderate (Far) Low

It is important to note that the ASA criteria for disturbance due to sound are qualitative rather than quantitative criteria. Consequently, a source of noise of a particular type (e.g. drilled pin piling or sound from vessels etc.) would result in the same predicted impact, no matter the level of noise produced or the propagation characteristics.

4 Baseline noise

Background or “ambient” underwater noise is generated by a number of natural sources, such as rain, breaking waves, wind at the surface, seismic noise, biological noise and thermal noise. Biological sources include marine mammals (which use sound to communicate, build up an image of their environment and detect prey and predators) as well as certain fish and shrimp also contribute to this spectrum. Anthropogenic sources add to the existing background noise, including from sources such as fishing boats, ships, industrial noise, seismic surveys, and leisure activities. Generalised ambient noise spectra trends (Wenz, 1962) attributable to various noise sources including both natural and anthropogenic sources are shown in Figure 4.1.

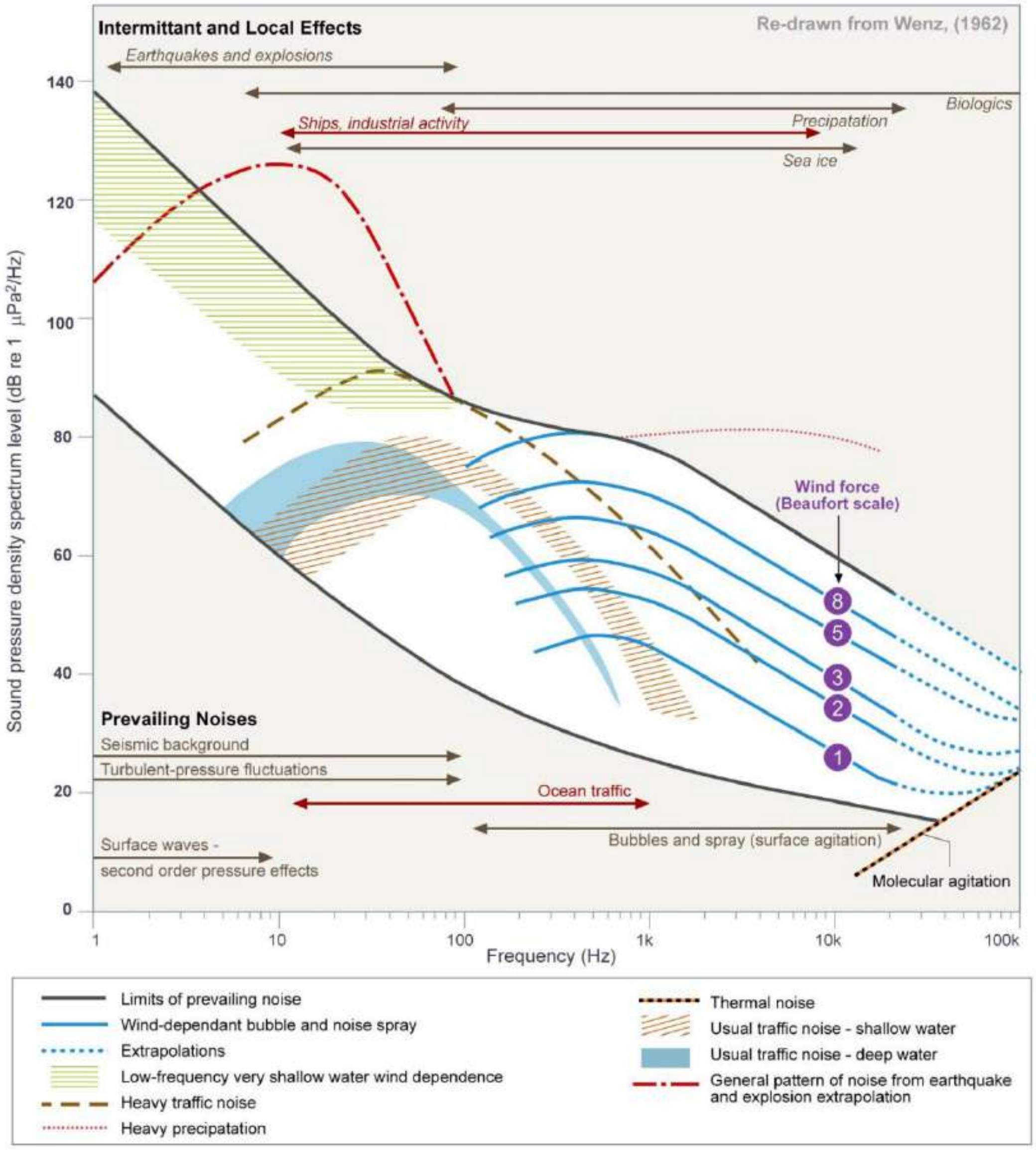

Figure 4.1: Generalised ambient noise spectra attributable to various noise sources (Wenz 1962).

The vast majority of research relating to both physiological effects and behavioural disturbance due to noise on marine species is based on determining the absolute noise level for the onset of that particular effect. As a result, criteria for assessing the effects of noise on marine mammals and fish tend to be based on the absolute noise criteria, as opposed to the difference between the baseline noise level and the specific noise being assessed (e.g. Southall et al., 2007). Given the lack of evidence-based studies investigating the effects of noise relative to background on marine wildlife, the value of establishing the precise baseline noise level is somewhat diminished. It is important to understand that baseline noise levels will vary significantly depending on, amongst other factors, seasonal variations and different sea states, meaning that the usefulness of establishing such a value would be very limited. Nevertheless, it can be useful (though not essential) when undertaking an assessment of underwater noise, to have an understanding of the range of noise levels likely to be prevailing in the area, so that any noise predictions can be placed in the context of the baseline. It is important to note however, that even if an accurate baseline noise level could be determined, there is a paucity of scientific understanding regarding how various species distinguish anthropogenic sound relative to masking noise.

An animal's perception of sound is likely to depend on numerous factors including the hearing integration time, the character of the sound, and hearing sensitivity. It is not known for example, to what extent marine mammals and fish can detect tones of lower magnitude than the background masking noise, or how they distinguish time varying sound. Therefore, it is necessary to exercise considerable caution if attempting any comparison between noise from the proposed development and the baseline noise level. For example, it does not follow that because the broadband sound pressure level due to the source being considered is below the numeric value of the baseline level, that this means that marine mammals or fish cannot detect that sound. This is particularly true where the background noise is dominated by low frequency sound which is outside the animal's range of best hearing acuity. Until such a time as further research is conducted to determine a dose response relationship between the "signal-to-noise" level and behavioural response, a precautionary approach should be adopted.

For the reasons given above, and due to the relatively low risk of non-impulsive marine sound, Seiche has reviewed baseline noise studies carried out in UK waters for other projects in order to determine the likely magnitude of noise encountered in such waters.

A review of noise data relating to other sites in UK waters was undertaken for the Beatrice Wind Farm including a review of baseline underwater noise measurements in UK coastal waters (Brooker et al., 2012). These noise data are summarised in Table 4.1 and power spectral density levels are shown graphically in Figure 4.2 (Sea State 1) and Figure 4.3 (Sea State 3).

Table 4.1: Summary of average background levels of noise around the UK coast (Brooker et al., 2012).

	Overall (Un Weighted) Average Background Noise Levels, dB re 1 µPa (rms)	
	Sea State 1	**Sea State 3**
Minimum	92	94
Maximum	126	132
Mean	111	112

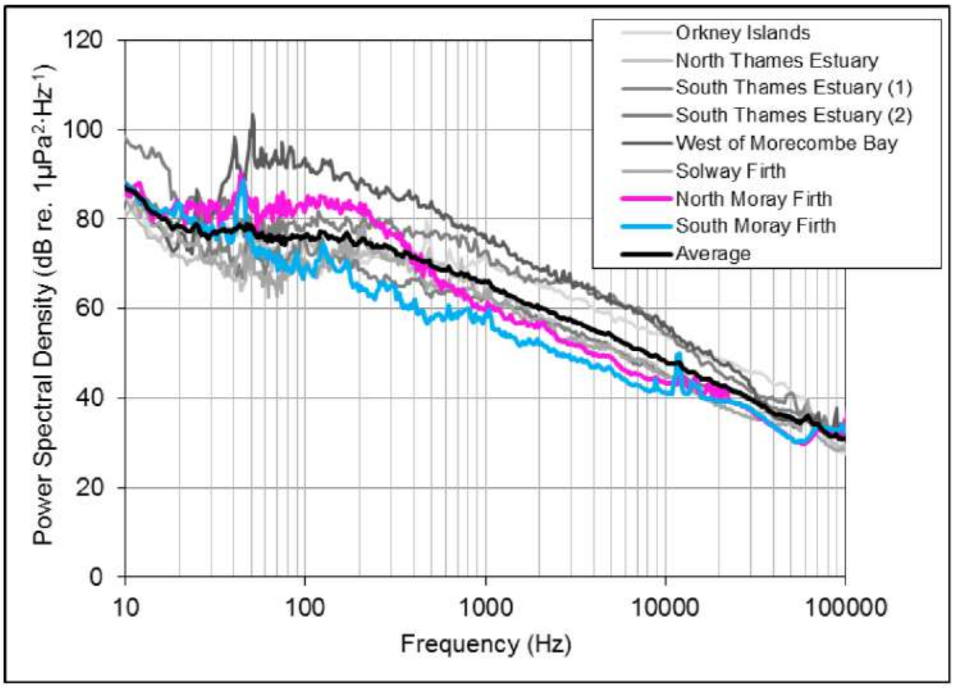

Figure 4.2: Summary of Power Spectral Density levels of background underwater noise at Sea State 1 at sites around the UK coast (Brooker, Barham, and Mason 2012).

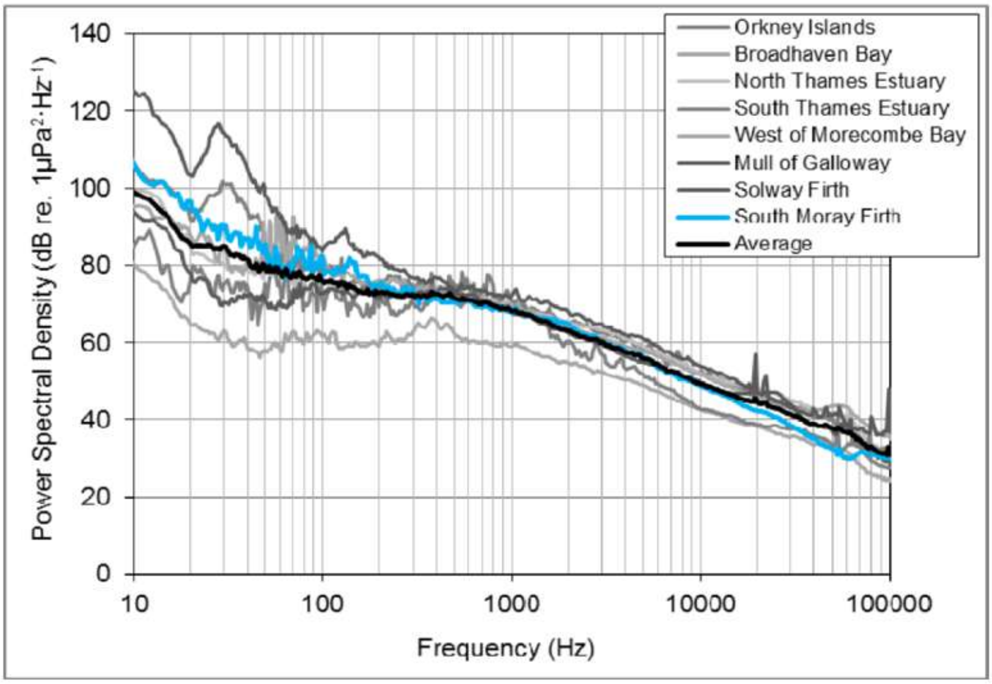

Figure 4.3: Summary of Power Spectral Density levels of background underwater noise at Sea State 3 at sites around the UK coast (Brooker et al., 2012).

The measured power spectral density levels (maximum values in red, mean values in black and minimum values in green, in dB re 1 μPa^{2}Hz^{-1}) and third octave band sound pressure levels (light blue, in dB re 1 μPa) are shown in Figure 4.4 taken from Kongsberg (2012).

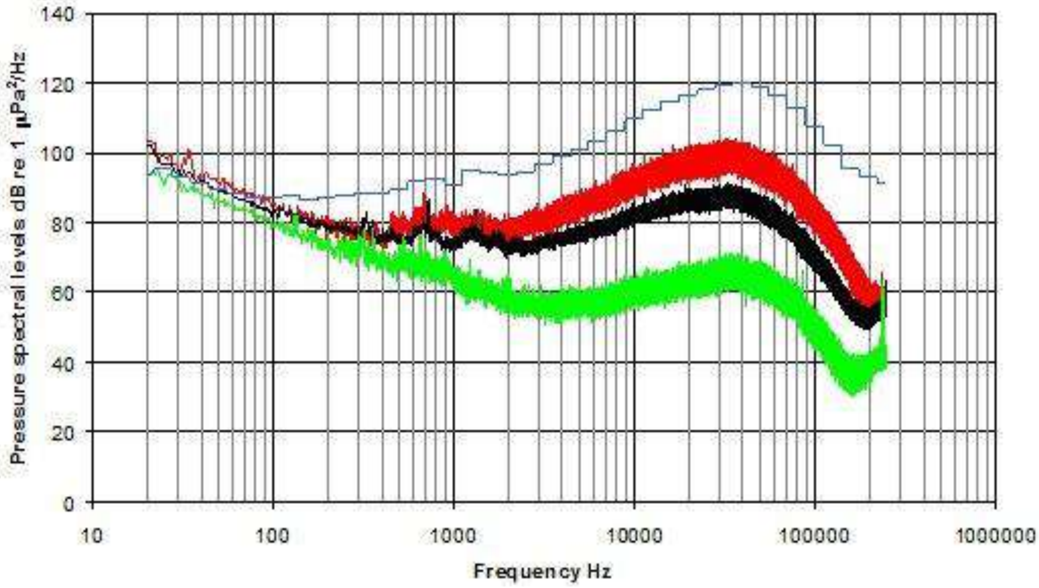

Figure 4.4: Summary of power spectral density levels and third octave band sound pressure levels of background underwater noise measured in the Inner Sound (Meygen), August 2011 (Kongsberg, 2012).

A "drifting-buoy" style assessment of background noise was undertaken by the Low Carbon Research Institute (LCRI) marine division in July 2014. Over an eleven-hour period, noise levels at the Inner Sound site were seen to vary from 91 dB re 1µPa during periods of low tidal flow speed to 121 dB re 1 µPa at high tidal flow speeds.

Based on the review, it is concluded that baseline underwater noise levels in high-tidal, coastal areas are likely to be in the range 91 to 121 dB re 1 µPa (rms).

5 Assessment Methodology

5.1 Source Levels

Underwater noise sources are usually quantified in dB re 1 µPa, as if measured at a hypothetical distance of 1 m from the source (the Source Level). In practice, it is not usually possible to measure at 1 m from a source, but this metric allows comparison and reporting of different source levels on a like-for-like basis. In reality, for a large sound source this imagined point at 1 m from the acoustic centre does not exist. Furthermore, the energy is distributed across the source and does not all emanate from this imagined acoustic centre point. Therefore, the stated sound pressure level at 1 m does not actually occur for large sources. In the acoustic near-field (i.e. close to the source), the sound pressure level will be significantly lower than the value predicted by the SL.

A wealth of experimental data is available which allows us to predict with a good degree of accuracy the sound generated by a drilling pile at discrete frequencies.

For this project, the assessment has been carried out using a scenario of installation of piles on the Fionnphort and Iona docks using drilling. In addition to the pile drilling operation, impact assessment was evaluated for dredging and vessel noise operations on both sides of the Sound of Iona.

Due to the continuous nature of these three noise sources under consideration in the Southall (2019) metrics for non-impulsive noise sources were considered for impact assessment. This assessment is prominently based on the SEL metric. The Root mean square (rms) sound pressure levels for 1-second time window (which is numerically equal to SEL metric) were extracted from the literature and were employed for Source Level data.

Noise source data on continuous construction and operational vessel have been extracted from literature and are set out in *Table 5.1*. Frequencies of modelling were chosen to coincide with the maximum energy bands emitted by the sources and cut-off frequency limitations for propagation of acoustic energy in some of the shallower regions of the Sound of Iona.

Table 5.1: Source level values used for modelling.

	Third octave centre frequency bands (Hz)	63	80	100	125	160	200	250	315	400	500	630	800	1000
RMS Source level dB re 1 µPa	Shipping/tugboat	149	158	158	159	158	159	160	160	161	161	161	156	158
	Drill piling	141	145	148	143	145	148	154	152	152	147	147	149	145
	Dredging	154	155	156	159	153	152	152	155	158	156	155	155	155

5.2 Propagation Model

As distance from the sound source increases the level of sound recorded reduces, primarily due to the spreading of the sound energy with distance, in combination with attenuation due to absorption of sound energy by molecules in the water. This latter mechanism is more important for higher frequency sound than for lower frequencies.

The way that the sound spreads (geometrical divergence) will depend upon several factors such as water column depth, pressure, temperature gradients, salinity as well as water surface and bottom (i.e. seabed) conditions. Thus, even for a given locality, there are temporal variations to the way that sound will propagate. However, in simple terms, the sound energy may spread out in a spherical pattern (close to the source) or a cylindrical pattern (much further from the source), although other factors mean that decay in sound energy may be somewhere between these two simplistic cases.

In acoustically shallow waters[2] in particular, the propagation mechanism is coloured by multiple interactions with the seabed and the water surface (Lurton 2002; Etter 2013; Urick 1983; Brekhovskikh and Lysanov 2014; Kinsler et al., 1999). Whereas in deeper waters, the sound will propagate further without encountering the surface or bottom of the sea, in shallower waters the sound may be reflected from either or both boundaries (potentially more than once).

At the sea surface, the majority of sound is reflected back into the water due to the difference in acoustic impedance (i.e. sound speed and density) between air and water. However, scattering of sound at the surface of the sea can be an important factor with respect to the propagation of sound. In an ideal case (i.e. for a perfectly smooth sea surface), the majority of sound energy will be reflected back into the sea. However, for rough seas, much of the sound energy is scattered (e.g. Eckart 1953; Fortuin 1970; Marsh, Schulkin, and Kneale 1961; Urick and Hoover 1956). Scattering can also occur due to bubbles near the surface such as those generated by wind or fish or due to suspended solids in the water such as particulates and marine life. Scattering is more pronounced for higher frequencies than for low frequencies and is dependent on the sea state (i.e. wave height). However, the various factors affecting this mechanism are complex.

Because surface scattering results in differences in reflected sound, its effect will be more important at longer ranges from the sound source and in acoustically shallow water (i.e. where there are multiple reflections between the source and receiver). The degree of scattering will depend upon the sea state/wind speed, water depth, frequency of the sound, temperature gradient, grazing angle and range from source. It should be noted that variations in propagation due to scattering will vary temporally within an area primarily due to different sea-states / wind speeds at different times. However, over shorter ranges (e.g. several hundred meters or less) the sound will experience fewer reflections and so the effect of scattering should not be significant.

When sound waves encounter the bottom, the amount of sound reflected will depend on the geoacoustic properties of the bottom (e.g. grain size, porosity, density, sound speed, absorption coefficient and roughness) as well as the grazing angle and frequency of the sound (Cole 1965; Hamilton 1970; Mackenzie 1960; McKinney and Anderson 1964; Etter 2013; Lurton 2002; Urick 1983). Thus, bottoms comprising primarily mud or other acoustically soft sediment will reflect less sound than acoustically harder bottoms such as rock or sand. This will also depend on the profile of the bottom (e.g. the depth of the sediment layer and how the geoacoustic properties vary with depth below the sea floor). The effect is less pronounced at low frequencies (a few kHz and below). A scattering effect (similar to that which occurs at the surface) also occurs at the bottom (Essen 1994; Greaves and Stephen 2003; McKinney and Anderson 1964; Kuo 1992), particularly on rough substrates (e.g. pebbles).

Waveguide effect should also be considered, which defines the shallow water columns do not allow the propagation of low frequency sound (Urick 1983; Etter 2013). The cut-off frequency of the lowest mode in a channel can be calculated based on the water depth and knowledge of the sediment geoacoustic properties. Any sound below this frequency will not propagate far due to energy losses through multiple reflections.

Sound speed gradient is the final piece of the puzzle. Changes in the water temperature and the hydrostatic pressure with depth imply that the speed of sound varies throughout the water column. This can lead to significant variations in sound propagation and can also lead to sound channels, particularly for high frequency sound. Sound can propagate in a duct-like manner within these channels, effectively focussing the sound, and conversely they can also lead to shadow zones. The frequency at which this occurs depends on the characteristics of the sound channel but, for example, a 25 m thick layer would not act as

2 Acoustically, shallow water conditions exist whenever the propagation is characterised by multiple reflections with both the sea surface and bottom (Etter 2013). Consequently, the depth at which water can be classified as acoustically deep or shallow depends upon numerous factors including the sound speed gradient, water depth, frequency of the sound and distance between the source and receiver.

a duct for frequencies below 1.5 kHz. The temperature gradient can vary throughout the year and thus there will be potential variation in sound propagation depending on the season.

Sound energy is also absorbed due to interactions at the molecular level converting the acoustic energy into heat. This is another frequency dependent effect with higher frequencies experiencing much higher losses than lower frequencies.

5.2.1 Modelling approach

There are several methods available for modelling the propagation of sound between a source and receiver ranging from very simple models which simply assume spreading according to a 10 log (R) or 20 log (R) relationship (as discussed above, and where R is the range from source to receiver) to full acoustic models (e.g. ray tracing, normal mode, parabolic equation, wavenumber integration and energy flux models). In addition, semi-empirical models are available, whose complexity and accuracy is somewhere in between these two extremes.

In choosing the correct propagation model to employ, it is important to ensure that it is fit for purpose and produces results with a suitable degree of accuracy for the application in question, taking into account the context (as detailed in Monitoring Guidance for Underwater Noise in European Seas Part III, NPL Guidance Wang et al 2014, and Farcas et al., 2016). Thus, in some situations (e.g. low risk due to underwater noise, range dependent bathymetry is not an issue, non-impulsive sound) a simple (N log R) model will be sufficient, particularly where other uncertainties outweigh the uncertainties due to modelling. On the other hand, some situations (e.g. very high source levels, impulsive sound, complex source and propagation path characteristics, highly sensitive receivers and low uncertainties in assessment criteria) warrant a more complex modelling methodology.

The first step in choosing a propagation model is therefore to examine these various factors, such as set out below:

- Balancing of errors / uncertainties;
- Range dependant bathymetry;
- Frequency dependence;
- Source characteristics.

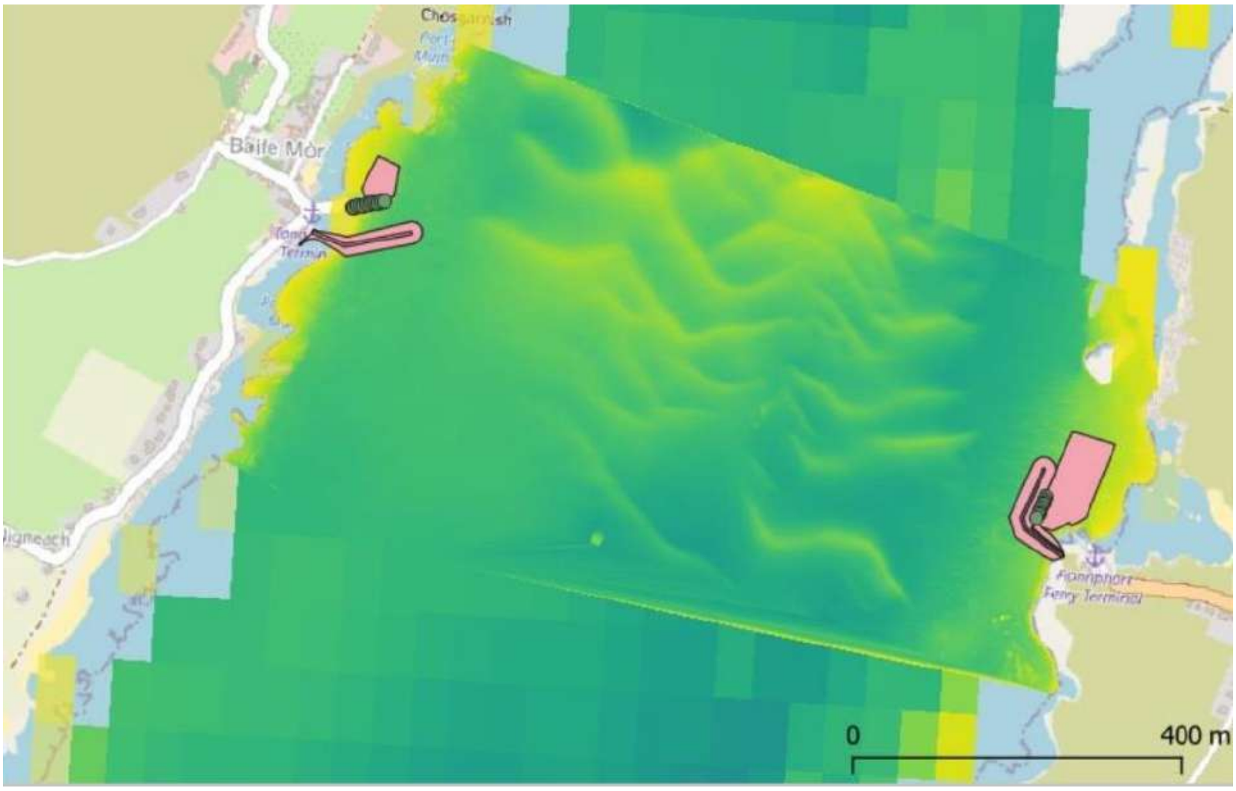

Figure 5.1: High-resolution (1-m) bathymetry in the survey area, island of Iona on the left (west).

For the sound field model, and relevant survey parameters based on a combination of data provided by the client combined with that gathered from publicly available literature. These parameters were fed into an appropriate propagation model routine suited to the region and the frequencies of interest. The frequency-dependent loss of acoustic energy with distance (transmission loss, TL) values were then evaluated along different transects around the chosen source points. The frequencies of interest in the present study are up to 1 kHz since these dominate the acoustic energy for the sources of concern. These frequencies overlap with the hearing sensitivities of some of the marine mammals that are likely to be present in the survey area.

For the calculation of the transmission loss, a range-dependent sound propagation model based on RAMGeo was used to cover the full range of frequencies of interest, which is suitable for frequencies below 1 kHz. RAMGeo is a range-dependent, parabolic equation solver for *elastic* seabed. The code derives from the RAM modelling routine (Collins, 1993) for *fluid* seabed. RAMSGeo receives an environmental input file, which includes the bathymetry (see Figure 5.1), the environmental characteristics, the simulation frequency, and spatial discretisation parameters, and returns the complex transmission loss at each point within the grid of receivers (at different ranges and depths).

RAMSGeo is available as part of the Acoustic Toolbox[3], a free-access compilation of routines and executables for underwater sound propagation modelling. The modelling routines were run through AcTUP (Duncan and Maggi, 2006), an open-source graphic user interface based on the Acoustic Toolbox. By using an in-house developed wrapper for AcTUP to access the RAMSGeo codes directly, we were able to execute the propagation modelling routines for each azimuthal transect around each source point with improved efficiency and control over the processing steps.

[3] http://oalib.hlsresearch.com/AcousticsToolbox/

The propagation and sound exposure calculations were conducted over a range of water column depths in order to determine the likely range for injury and disturbance.

It should be borne in mind that noise levels (and associated range of effects) will vary depending on actual conditions at the time (day-to-day and season-to-season) and that the model predicts a typical worst-case scenario. Considering factors such as animal behaviour and habituation, any injury and disturbance ranges should be viewed as indicative and probabilistic ranges to assist in understanding potential impacts on marine life rather than lines either side of which an impact will or will not occur. (This is a similar approach to that adopted for airborne noise where a typical worst case is taken, though it is known that day to day levels may vary to those calculated by 5 - 10 dB depending on wind direction etc.).

The acoustical properties of different layers employed in the propagation modelling are presented in Table **5.2**. This data is evaluated using recommendations by Hamilton (1980) based on the geological layers present in the survey region and the acoustic properties of the water column. Due to the shallow nature of the Sound of Iona, only a single speed of sound in the water column was considered.

Table 5.2: Acoustical properties of the water layer and sediment used for propagation modelling.

	Max depth (m)	Speed of sound (m/s)		Density	Attenuation (dB/λ)	
		Compressional	Shear	kg/m^3	Shear	Compressional
Water column	100	1500	0	1024	0	0.1
Geological layer	500	1700	250	200	10	0.5

5.2.2 Batch Processing

To improve the performance and reduce the time taken to process and evaluate multiple TL calculations required for this study, Seiche's proprietary software was employed. This software iteratively evaluates the propagation modelling routine for the specified number of azimuthal bearings radiating from a source point, providing a fan of range-dependent TL curves departing from the noise source for each given frequency and receiver depth. We then employ in-house MATLAB routines to interpolate the TL values across transects, to give an estimate of the sound field for the whole area around the source point.

5.3 Received Levels

Once the TL values were evaluated at the source points in all azimuthal directions and at all frequencies of interest for all the sources, the results were coupled with the corresponding SL values in third-octave frequency bands. The combination of SL with TL data provided us with the third-octave band received levels (RL) at each point in the receiver grid (i.e. at each modelled range, depth and azimuth of the receiver).

The received levels were evaluated for the SPL_{rms} or equivalent SEL metric, for each source type, source location, and azimuthal transect to produce the associated 2-D maps. The broadband RL were then calculated for these metrics and from the third-octave band results. The set of simulated RL transects were circularly interpolated to generate the broadband 2-D RL maps centred around each source point.

5.4 Exposure Calculations

As well as calculating the un-weighted rms sound pressure levels at various distances from the source, it is also necessary to calculate the acoustic signal in the SEL metric for a mammal using the relevant hearing weightings to which it is exposed. For operation of the different sources, the SEL sound data was numerically equal to the SPL rms value integrated over 1-second window as the sources are continuous and non-impulsive. These SEL values are employed for calculation of cSEL (cumulative SEL) metric for different marine mammal groups to assess impact ranges.

Exposure modelling could assume that the mammal either being static and at a fixed distance away from the noise source or the mammal is swimming at a constant speed in a perpendicular direction away from a noise source. For fixed receiver calculations, it has been assumed that a mammal will stay at a known distance from the noise source for a period of 24-hours. As the animal does not move, the noise will be constant over the integration period of 24-hours (assuming the source does not change its operational characteristics over this time). Hence the cSEL value calculate would imply the cumulative SEL over the time accumulate by the marine mammal. Although this is a worst case compared to a swimming animal model, this presents a comparative and quicker estimate of impact ranges and can be considered as a worst case.

It should be noted that the sound exposure calculations are based on the simplistic assumption that the noise source is active continuously over a 24-hour period. The real-world situation is more complex. The SEL calculations presented in this study do not take any breaks in activity into account.

Furthermore, the continuous sound criteria described in the Southall et al (2019) guidelines assume that the animal does not recover hearing between periods of activity. It is likely that both the intervals between operations could allow some recovery from temporary hearing threshold shifts for animals exposed to the sound and, therefore, the assessment of sound exposure level is conservative.

In this report, the static mammal 24-hour cSEL calculation was employed using the Southall (2019) metric for non-impulsive noise sources.

6 Sound Modelling Results

TTS impact ranges on most frequently occurring marine mammal groups for the survey region for the sources studied in the current survey are summarised in Table 6.1, Table 6.2, and Table 6.3. The distances presented in the table reflect the start point of the mammal relative to the source when the source first starts up, rounded to the nearest 10 m. The mammal is assumed to stay at the start-up distance, so the distance between the mammal and the source does not increase over time. It should be noted that the rms values in the table use the estimated 1-second time window at various distances from the source.

Table 6.1: Summary of potential TTS zones for marine mammals (N/E – not exceeded)

Source type	Source Location	Group	TTS range (m)	PTS range (m)
Vessel / tug	Centre of the channel	Low frequency cetacean (HF)	250	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	20	N/E
		Phocid carnivores (in water; PCW)	30	N/E
		Other carnivores (in water; OCW)	N/E	N/E
	Iona	Low frequency cetacean (LF)	270	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	20	N/E
		Phocid carnivores (in water; PCW)	20	N/E
		Other carnivores (in water; OCW)	N/E	N/E
	Fionnphort	Low frequency cetacean (LF)	270	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	20	N/E
		Phocid carnivores (in water; PCW)	30	N/E
		Other carnivores (in water; OCW)	N/E	N/E

Table 6.2: Summary of potential TTS zones for marine mammals (N/E – not exceeded)

Source type	Source Location	Group	TTS range (m)	PTS range (m)
Pile drilling	Centre of the channel	Low frequency cetacean (LF)	30	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	N/E	N/E
		Phocid carnivores (in water; PCW)	10	N/E
		Other carnivores (in water; OCW)	N/E	N/E
	Iona	Low frequency cetacean (HF)	30	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	N/E	N/E
		Phocid carnivores (in water; PCW)	10	N/E
		Other carnivores (in water; OCW)	N/E	N/E
	Fionnphort	Low frequency cetacean (LF)	40	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	N/E	N/E
		Phocid carnivores (in water; PCW)	10	N/E
		Other carnivores (in water; OCW)	N/E	N/E

Table 6.3: Summary of potential TTS zones for marine mammals (N/E – not exceeded)

Source type	Source Location	Group	TTS range (m)	PTS range (m)
Dredging	Centre of the channel	Low frequency cetacean (LF)	180	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	10	N/E
		Phocid carnivores (in water; PCW)	20	N/E
		Phocid carnivores (in water; OCW)	N/E	N/E
	Iona	Low frequency cetacean (LF)	180	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	10	N/E
		Phocid carnivores (in water; PCW)	20	N/E
		Other carnivores (in water; OCW)	N/E	N/E
	Fionnphort	Low frequency cetacean (LF)	190	N/E
		High frequency cetacean (HF)	N/E	N/E
		Very High frequency cetacean (VHF)	10	N/E
		Phocid carnivores (in water; PCW)	20	N/E
		Other carnivores (in water; OCW)	N/E	N/E

The largest impact ranges are for low-frequency cetaceans which would not be expected to traverse the channel.

For all marine mammal groups, the largest range for impact to behaviour is 8,170 km. This is the maximum distance where sound levels exceed 120 dB re 1 μPa (rms).

The potential ranges presented for injury and disturbance are not a hard and fast 'line' where an impact will occur on one side and not on the other. Potential impact is more probabilistic than that; dose dependency in PTS onset, individual variations and uncertainties regarding behavioural response and swim speed/direction all mean that it is much more complex than drawing a contour around a location. These ranges are designed to provide an understandable way in which a wider audience can appreciate the potential spatial extent of the impact.

A 2D contour map representation of the sound levels radiated into the Sound of Iona by the source model Tugboat is shown in Figure 6.1. In this plot the source was placed at centre of the model is 129272, 723741 (OSBG 1936) and the RL results are calculating up to either 10 km distance from the sources or when we encounter land. Two additional contour map plots for the Iona port side and Fionnphort port side are presented in Figure 6.2 and Figure 6.3 respectively. These plots show the RMS unweighted broadband received levels in dB re 1 μPa for Tugboat source radiating noise at each of these ports (source locations are given in figure labels).

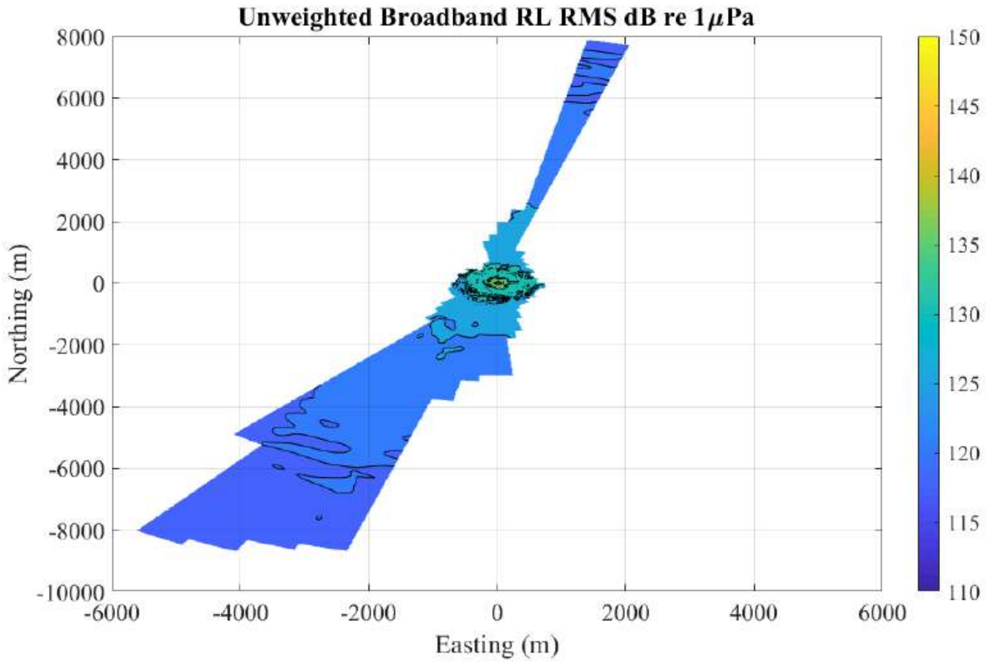

Figure 6.1: A 2D contour map of modelled unweighted SPL rms from the Tugboat source model. Centre of the model in the plot above is 129272, 723741 (OSBG 1936) in the Sound of Iona.

The calculations that are based on an individual mammal being exposed to sound resulting from continuous source activation which, as noted previously, could be a simplification. Care should be taken in interpreting any results within tens of meters of the source due to near-field effects potentially overestimating exposure.

The SPL rms levels within 10 m of the source location are less than 154 dB re 1 µPa for all sources, which is below the TTS exposure level for fish with swim bladders (158 dB re 1 µPa from Table 3.5).

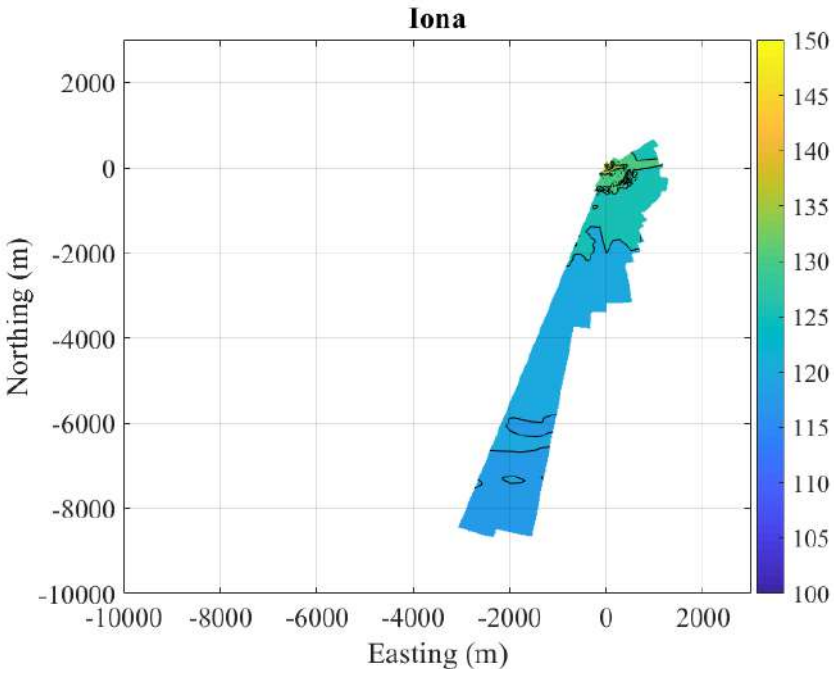

Figure 6.2: A 2D contour map of modelled unweighted SPL rms from the Tugboat source model. Centre of the model in the plot above is 128692, 724001 (OSBG 1936) in the port of Iona.

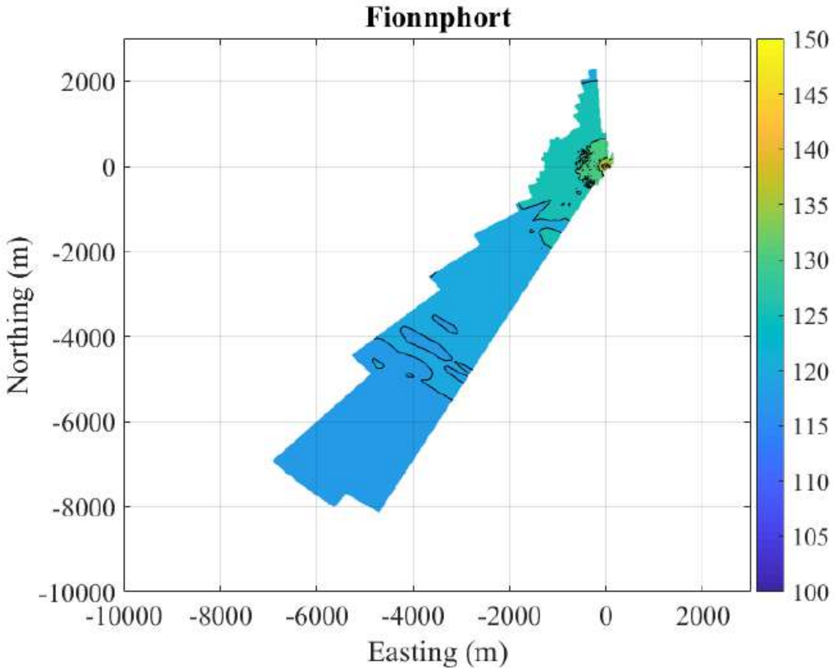

Figure 6.3: A 2D contour map of modelled unweighted SPL rms from the Tugboat source model. Centre of the model in the plot above is 129849, 723482 (OSBG 1936) on the port of Fionnphort.

7 Mitigation

Without any mitigation measures in place, the noise causing activities were identified as having the potential to cause temporary threshold shift at a range of up to 30 m from the source (for vessel or Tugboat) for phocid marine mammal ground underwater, 20 m for very high frequency cetaceans, and 0 m for high frequency cetaceans and other marine mammal carnivores. The impact ranges for dredging and pile drilling are much smaller than those generated by shipping noise.

The impact ranges are higher for low frequency marine mammal group at 270 m for vessel type noise source (and much lower for other noise sources). However, it is very rare to find LF marine mammals in this region (particularly due to very shallow water depths in some places of the survey).

Given the low potential for injury from the construction activities, it is unlikely that mitigation measures will be required.

8 Conclusions

Based on the modelling conducted here, there is little potential for TTS/PTS to be experienced by marine mammals or fish due to the construction activities. Impact only occurs for a stational seal being with 30 m of the construction work for 24 hours. This represents a worst-case scenario, and it is considered highly unlikely that a marine mammal would remain within this range for a period of 24 hours. Consequently, it is considered highly unlikely that any PTS or TTS will occur as a result of the activities. For fish with swim bladders, the maximum impact range is 10 m for a prolonged period of 12 hours. In conclusion, there is minimal concert for disturbance to either marine mammals or fish.

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APPENDIX 9.1

Ornithology

9 ORNITHOLOGY

9.1 Introduction

9.1.1 Purpose and Scope of the Report

This report details the results of ornithology surveys undertaken for the proposed Iona Breakwater Project ('the Proposed Development') (Figure 9-1). These surveys were designed to assess the baseline conditions within the Site boundary and surrounding area. The findings of these surveys will be used to inform the Iona Breakwater Project Ecological Impact Assessment.

9.1.2 Report Objectives

The main objectives of these surveys were to identify any areas:

- Which may support significant numbers of relevant qualifying ornithology features of nearby designated sites that may have connectivity to the habitats present within the Proposed Development;
- Which may be of importance for large assemblages of wetland birds;
- Which may support important numbers of notable or legally protected wetland bird species; and
- Seasonal periods of sensitivity for wetland birds (e.g., traditional feeding and roosting grounds).

9.2 Relevant Legislation

A summary of the legislation relevant to ornithology, or those which may pose a potential constraint to the scheme as identified in this report include:

- Environmental Impact Assessment Directive 2014/52/EU (the EIA Directive);
- Directive 2009/147/EC on the Conservation of Wild Birds (the Birds Directive);
- Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats Directive);
- The Conservation (Natural Habitats &c.) Amendment (Scotland) Regulations 2012, relating to reserved matters in Scotland;
- Wildlife and Countryside Act 1981 (as amended);
- The Nature Conservation Act (Scotland) Act 2004;
- The Wildlife and Natural Environment (Scotland) Act (2011);
- Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017, which transpose the EIA Directive into the Scottish planning system;
- Planning Circular 1/2017 – Environmental Impact Assessment regulations (Scottish Government 2017);
- PAN 51: Planning Environmental Protection and Regulation (revised 2006);
- PAN 60: Planning for Natural Heritage (Scottish Government 2000);

- Nature Conservation: Implementation in Scotland of the Habitats and Birds Directives: Scottish Executive Circular 6/1995 as amended (June 2000);
- Scottish Planning Policy (2020).

9.3 Methodology

9.3.1 Desk Study

A desk study was undertaken to gather information on the potential value of the site and wider area for ornithological species through the following:

- A request was made to Argyll Biological Record Centre (ABReC) for records from the last 10 years relating to:
  - Ornithological species - 2km buffer; and
  - Non-statutory designated sites (e.g., Scottish Wildlife Nature Reserves, Local Nature Conservation Sites (LNCS) - 2km buffer.

The desk study also sought to collate relevant information on all sites with designated ornithological features including: Ramsar sites and Special Protected Areas (SPAs) (within 30km); and Sites of Special Scientific Interest (SSSIs) and Sites of Importance for Nature Conservation (SINCs) (within 5km) where there may be existing ecological connectivity between the Proposed Development and qualifying bird populations. This included a review of international sites with qualifying mobile species whose range (e.g., foraging, migratory, overwintering, breeding or natural habitat range) overlapped with the Proposed Development. For example, during the breeding season, the mean-maximum foraging range of gannet is 315.2km (Woodward *et al.,* 2019) therefore there is potential for gannets observed within the Proposed Development to originate from SPA colonies located within that distance. However, it should be noted that most seabirds feed offshore in summer, with the exception of terns which may feed close to the colonies.

A search for relevant designated sites was made using online sources, allowing the identification of all designated sites with qualifying ornithological interests. The search radius of 30km for internationally designated sites is consistent with published connectivity distances, across which any bird populations may have interaction with the Site. The online sources used to obtain this information were

- NatureScot Sitelink[6];
- Scotland's environment web[7];
- JNCC website[8];
- Argyll and Bute Council open data website[9]; and

[6] https://sitelink.nature.scot/home

[7] Map | Scotland's environment web

[8] https://jncc.gov.uk/our-work/list-of-spas/

[9] https://data-argyll-bute.opendata.arcgis.com/datasets/open-data-local-nature-conservation-site

- Aerial imagery which was studied prior to the survey to inform any areas of high sensitivity which might require additional survey effort during the site visit.

In addition, information from both confidential and public domain survey data, scientific publications, grey literature (i.e., information not produced or controlled by commercial publishers, e.g., policy documents, web content, conference proceedings, etc.) and ES/EIA/Consultations for nearby developments was searched to build understanding of ornithological interests in and around the Proposed Development.

The British Trust for Ornithology (BTO) Wetland Bird Survey (WeBS) website was also consulted to identify if count data was held for the site and immediate environs. No relevant data was held pertaining to the Proposed Development.

9.3.2 Ornithology

The intertidal and nearshore surveys comprised a programme of monthly surveys carried out over a period of five months between April and August 2021 inclusive.

The survey area comprised a 500m buffer area around the Proposed Development area in the intertidal and nearshore habitats. During each survey the number of birds present along the foreshore and near shore coastal waters was counted. Observations of bird species (including the numbers of each species in a given location and behaviour – see below) were plotted onto a field map using standard BTO species codes and notation.

Surveys were scheduled to cover a range of different tidal conditions (high, low and mid-tide; spring and neap tides) throughout the survey programme. Survey methods were based on the high tide (core count) methodology of the BTO/ Joint Nature Conservancy Committee (JNCC)/ Royal Society for the Protection of Birds (RSPB)/ Wildfowl and Wetlands Trust (WWT) WeBS scheme (Musgrove *et al.* 2003 and Holt *et al.* 2011). This involved the surveyor counting birds from vantage points along the coast using binoculars and a telescope. In addition to the location and number of birds, notes were also made as to whether they were foraging, roosting or loafing. Flying birds were also recorded although for the purposes of this report only those birds which were obviously using the habitats of the survey area (e.g., terns or gannets, as opposed to birds simply flying over/through the sectors) have been included here.

Field records were transferred to a Geographic Information System (GIS). This produced accurate information on the distribution of birds within the study area and enabled maps to be produced so that areas of ornithological importance could be identified.

Weather conditions including wind speed (using the Beaufort Scale), cloud cover (estimated as eighths or octas of the sky), visibility and temperature were also recorded as well as sources of disturbance to birds encountered during surveys.

Full survey details are presented in Table 9-1 below.

Table 9-1 Intertidal and nearshore survey effort

Date	Start time	End time	Tidal cycle	Wind speed (direction)	Precipitation	Cloud cover	Visibility	Snow / frost
26/04/21	10:18	14:18	M-L	2-3 (NE)	1-2	8	3	0
			L-M	3 (NE)	0-4	8	2-3	0
26/04/21	16:20	20:20	M-H	4 (NE)	1	8	3	0

Date	Start time	End time	Tidal cycle	Wind speed (direction)	Precipitation	Cloud cover	Visibility	Snow / frost
			H-M	4 (NE)	0	8	3	0
27/04/21	10:50	14:50	M-L	2-3 (SW)	0	5	4	0
			L-M	3 (SW)	0	4	4	0
27/04/21	16:50	20:50	M-H	3 (SW)	0	5	4	0
			H-M	4 (SW)	0	4	4	0
26/05/21	10:29	14:29	M-L	2 (SE)	0	2	4	0
			L-M	2 (SE)	0	3	4	0
26/05/21	16:29	20:29	M-H	2 (SE)	0	3	4	0
			H-M	1-2 (SE)	0	1	4	0
27/05/21	11:07	15:07	M-L	3 (SW)	0	2-3	4	0
			L-M	3 (NW)	0	1-2	4	0
27/05/21	17:17	21:17	M-H	2 (NW)	0	8	4	0
			H-M	2 (NW)	0	8	4	0
15/06/21	07:30	11:30	M-H	4 (NW)	0	8	3	0
			H-M	4-5 (NW)	0	8	3	0
15/06/21	13:38	17:38	M-L	4 (NW)	1-2	8	2-3	0
			L-M	4 (NW)	3	8	3	0
16/06/21	08:15	12:15	M-H	2-3 (NW)	0	5-6	3-4	0
			H-M	3 (NW)	0-1	5-6	3	0
16/06/21	14:27	18:27	M-L	2 (NW)	0	4-5	4	0
			L-M	2-3 (NW)	0	5	4	0
07/07/21	09:08	13:08	M-L	3 (E)	0	6	3	0
			L-M	2 (E)	0	5	4	0
07/07/21	15:02	19:02	M-H	2 (SE)	0	7-8	4	0
			H-M	2 (SE)	0	7-8	4	0
08/07/21	09:44	13:44	M-L	3-4 (SE)	0-1	7-8	2-3	0
			L-M	2-3 (SE)	0-1	7-8	4	0
08/07/21	15:44	18:44	M-H	1 (SE)	0	6-7	4	0
			H-M	1 (SE)	0	6	4	0
03/08/21	12:49	16:49	M-H	2-3 (NW)	0	5-8	3-4	0
			H-M	2 (NW)	0	3	4	0
03/08/21	19:09	23:09	M-L	2 (NW)	0	6	4	0
			L-M	1-2 (NW)	0	7	3-4	0
04/08/21	07:53	11:53	M-L	3-4 (NW)	0	6	4	0
			L-M	3-4 (NW)	0	5-6	4	0
04/08/21	13:59	17:59	M-H	4 (NW)	0-2	8	3	0
			H-M	3 (NW)	0-1	8	3	0

Wind speed (Beaufort) 0-5; Wind direction: NE = North east, NW = North west, SE: South east, SW = South west, E = East; Precipitation: 0 = none, 1 = drizzle, 2 = Light showers, 3 = heavy showers, 4 = heavy rain; Cloud cover (octas); Visibility: 0 = very poor (<500m), 1 = Poor (<1km), 2 = Moderate (1-3km), 3 = Good (3-5km), 4 = Excellent (>5km); Tidal cycle: H-M (high to mid), M-L (mid to low), L-M (low to mid), M-H (mid to high).

9.4 Results

9.4.1 Desk Study

The desk study identified four international sites with seabirds or migratory waterbirds as qualifying interest features within 30km of the Proposed Development, as shown in Table 9-2. The sites are listed together with the mean-maximum foraging range of qualifying interest features (where available, from Woodward *et al*., 2019) and the distance of the site to the Proposed Development.

Table 9-2 International Sites designated for ornithological features (including mean-maximum foraging range) within 30km of the Proposed Development. For mean-maximum the error is presented as ± Standard Deviation (SD) and the sample sizes are shown in parentheses (i.e. the number of sites from which maximum or mean foraging ranges were available)

Site	Site Code	Relevant qualifying ornithology interest features	Mean-maximum foraging range (km)	Distance to the Proposed Development (km)
Treshnish Isles SPA	UK9003041	European storm petrel *Hydrobates pelagicus*	339* (1)	14.3
		Greenland barnacle goose *Branta leucopsis*	N/A	
Coll and Tiree SPA	UK9020310	Great northern diver *Gavia immer*	N/A	25.0
		Common eider *Somateria mollissima*	N/A	
North Colonsay and Western Cliffs SPA	UK9003171	Chough *Pyrrhocorax pyrrhocorax*	N/A	25.1
		Black-legged kittiwake *Rissa tridactyla*	156.1±144.5 (37)	
		Common guillemot *Uria aalge*	73.2±80.5 (16)	
		Breeding seabird assemblage	N/A	

**The foraging distance presented for storm petrel and common gull is the maximum from a single colony, therefore no mean nor SD*

A fourth SPA, Cnuic agus Cladach Mhuile, was located within the 30km search radius, to the east of the Proposed Development. Cnuic agus Cladach Mhuile SPA is a large, predominantly upland site on the island of Mull in the Inner Hebrides, designated for its breeding population of golden eagles.

The Proposed Development lies within the mean-maximum foraging range of a number of qualifying features/interests of SPAs outwith the 30km search radius, for example gannet (mean-maximum foraging range of 315.2km) which is a qualifying feature of Aisla Craig SPA and St Kilda SPA, located 174km and 234km from the Proposed Development respectively. Given the very low number of individual birds recorded during the survey effort and the nature of the Proposed Development (i.e., the works are of a small-scale and local spatial extent), the impact on qualifying features of these SPAs is considered *de minimis* and therefore not considered further in the assessment.

No other statutory designated sites (e.g., SSSIs) were located within a 5km search radius of the Proposed Development.

9.4.2 Survey Results

A total of 16 bird species were recorded during the surveys undertaken between April and August 2021, of which two were qualifying species for SPAs within foraging range distance: black-legged kittiwake and great northern diver.

Figures 9-1 to 9-15, show the distribution and activity of these birds across the survey area, and monthly peak counts of all 16 species recorded are presented in Table 9-3 below.

The most commonly observed species recorded were greylag goose (peak count 130 individuals in July 2021) and shag (peak count 114 individuals in August 2021). Other species were generally observed in numbers between 1 and 20 individuals.

Black-legged kittiwake were only recorded within the survey area on one occasion, with a count of one individual (August) which represented significantly less than 1% (1/9,024 i.e., 0.0001) of the latest SPA population estimate for North Colonsay and Western Cliffs SPA, which is in foraging range of black-legged kittiwake. The extremely limited presence and low number of kittiwake in the survey area suggests that it is not of significant importance to this species.

Great northern diver were recorded on just two occasions and were represented by no more than two individuals (recorded in April). These counts also represented less than 1% (3/452 i.e., 0.0066) of the Tiree and Coll SPA population which is within 25km of the Proposed Development. The limited presence and low numbers of great northern diver in the survey area suggests that it is not of significant importance to this species.

All other species recorded in the survey area were typically coastal birds which included gulls, other seabirds (e.g., gannets, shags, cormorant and Manx shearwater) and waterfowl (e.g., Canada and greylag geese).

All of these species recorded are common and widespread and regularly occur in the coastal waters of west Scotland either throughout the year, or during the breeding or non-breeding season. All species were recorded in relatively low numbers compared to their national breeding populations.

The site and surrounding survey area are therefore only of local importance for all 16 species recorded.

Table 9-3 Monthly peak counts of intertidal and coastal birds recorded in the Iona Breakwater survey area

Species	SPA population	Month, Year					Peak Count	% SPA population
		April 2021	May 2021	June 2021	July 2021	August 2021		
SPA Qualifying species								
Great northern diver	452 individuals	2	1	-	-	-	2	<1
Black-legged kittiwake	4,512 pairs	-	-	-	-	1	-	<1
Non-SPA Species								
Cormorant	-	-	-	1	3	-	3	N/A
Canada goose	-	-	1	-	-	-	-	N/A
Common gull	-	3	2	5	4	6	6	N/A
Great black-backed gull	-	1	-	-	-	7	7	N/A
Greylag goose	-	-	9	24	130	42	130	N/A
Grey heron	-	-	-	-	1	-	1	N/A
European herring gull	-	8	6	9	1	57	58	N/A
Mallard	-	-	-	1	-	-	-	N/A
Manx shearwater	-	-	-	-	1	-	-	N/A
Eurasian oystercatcher	-	7	9	15	20	11	20	N/A

Species	SPA population	Month, Year					Peak Count	% SPA population
		April 2021	May 2021	June 2021	July 2021	August 2021		
Common ringed plover	-	4	-	-	-	-	-	N/A
Northern gannet	-	6	1	-	-	2	6	N/A
European shag	-	8	6	10	4	114	-	N/A
Common shelduck	-	-	5	-	9	-	9	N/A

9.5 Conclusion

From the desk study and surveys completed of the Proposed Development and surrounding survey area, the baseline information collated on birds show that all species recorded were in relatively low numbers compared to their national breeding populations.

The Proposed Development site and surrounding survey area are, in fact, only of local importance for all 16 species recorded.

Furthermore, there are no sites within or in proximity to the Proposed Development that have been designated to protect bird species, and there is no risk of any likely significant effect from the Proposed Development on any SPA, Ramsar site or SSSI within connectivity distance of the site.

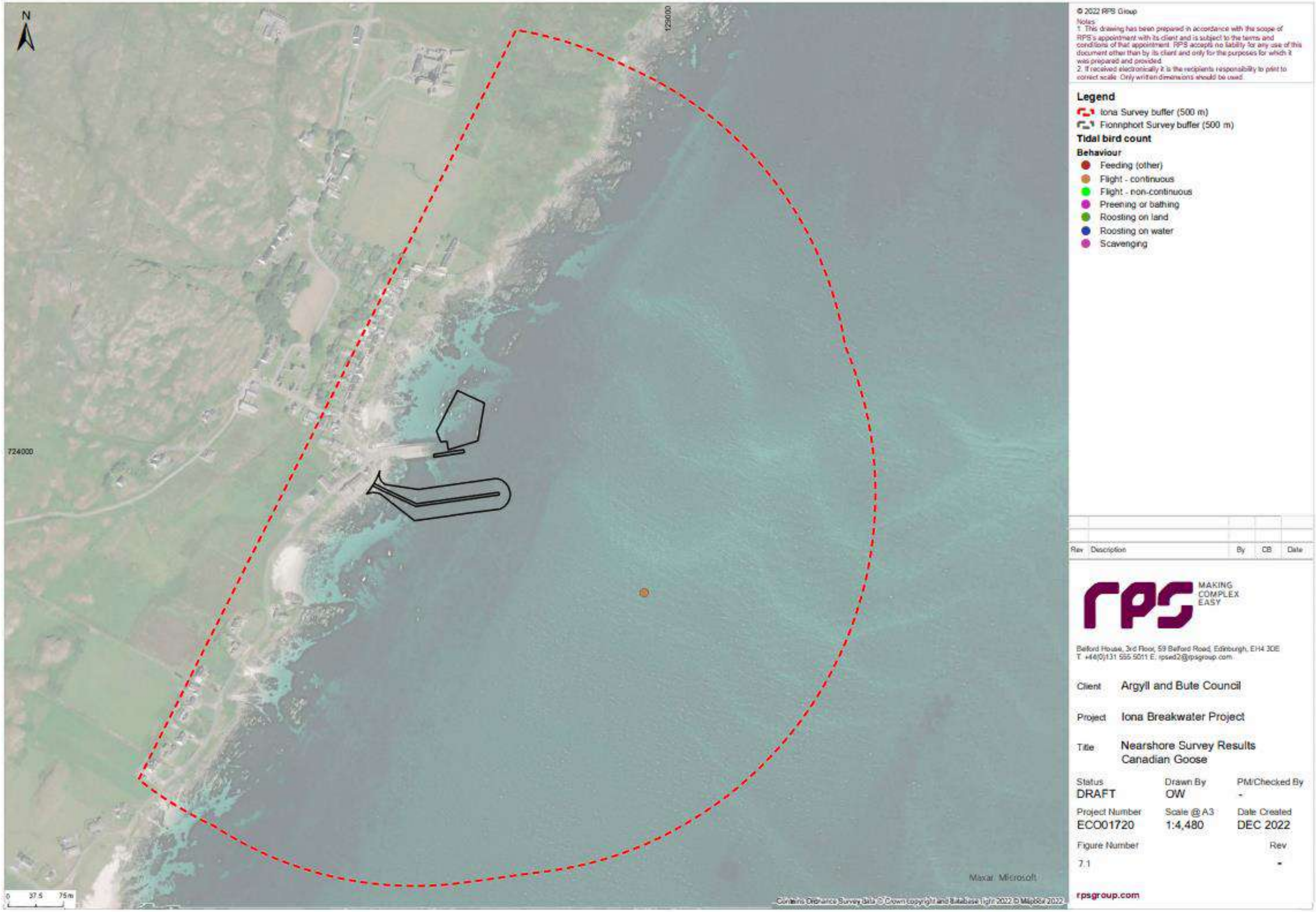

Figure 9-1 Nearshore survey results – Canada goose

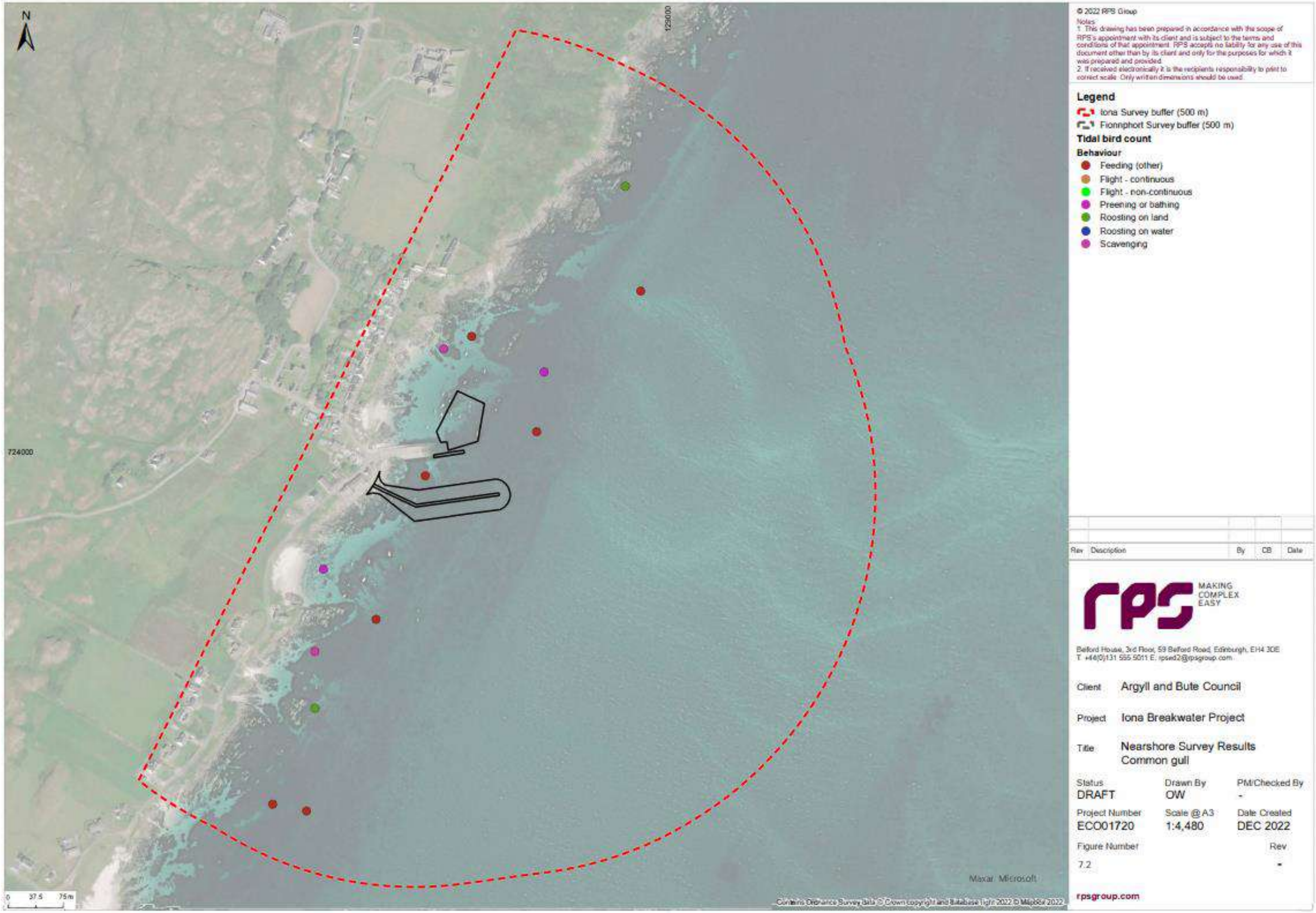

Figure 9-2 Nearshore survey results – Common gull

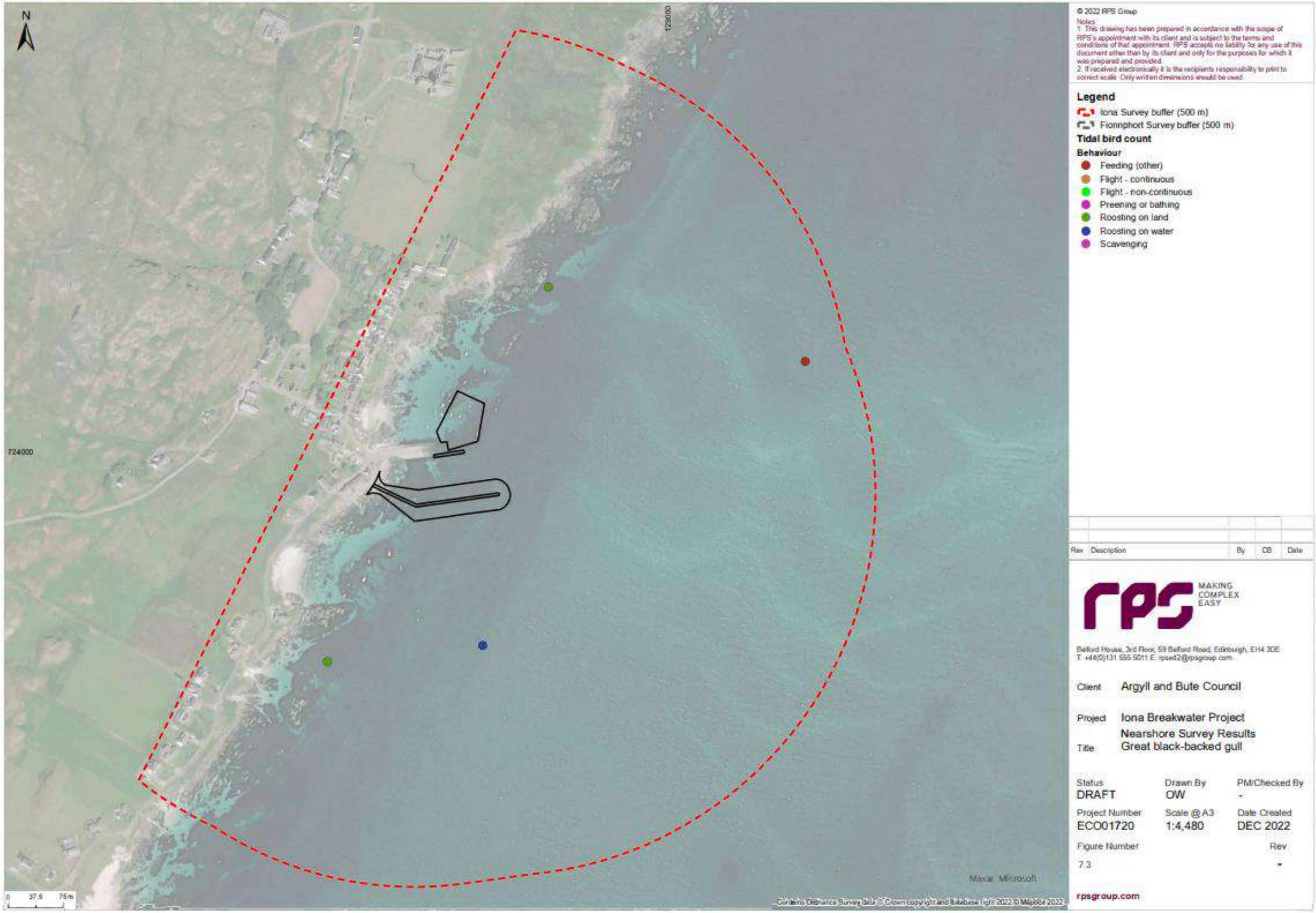

Figure 9-3 Nearshore survey results – Great black-backed gull

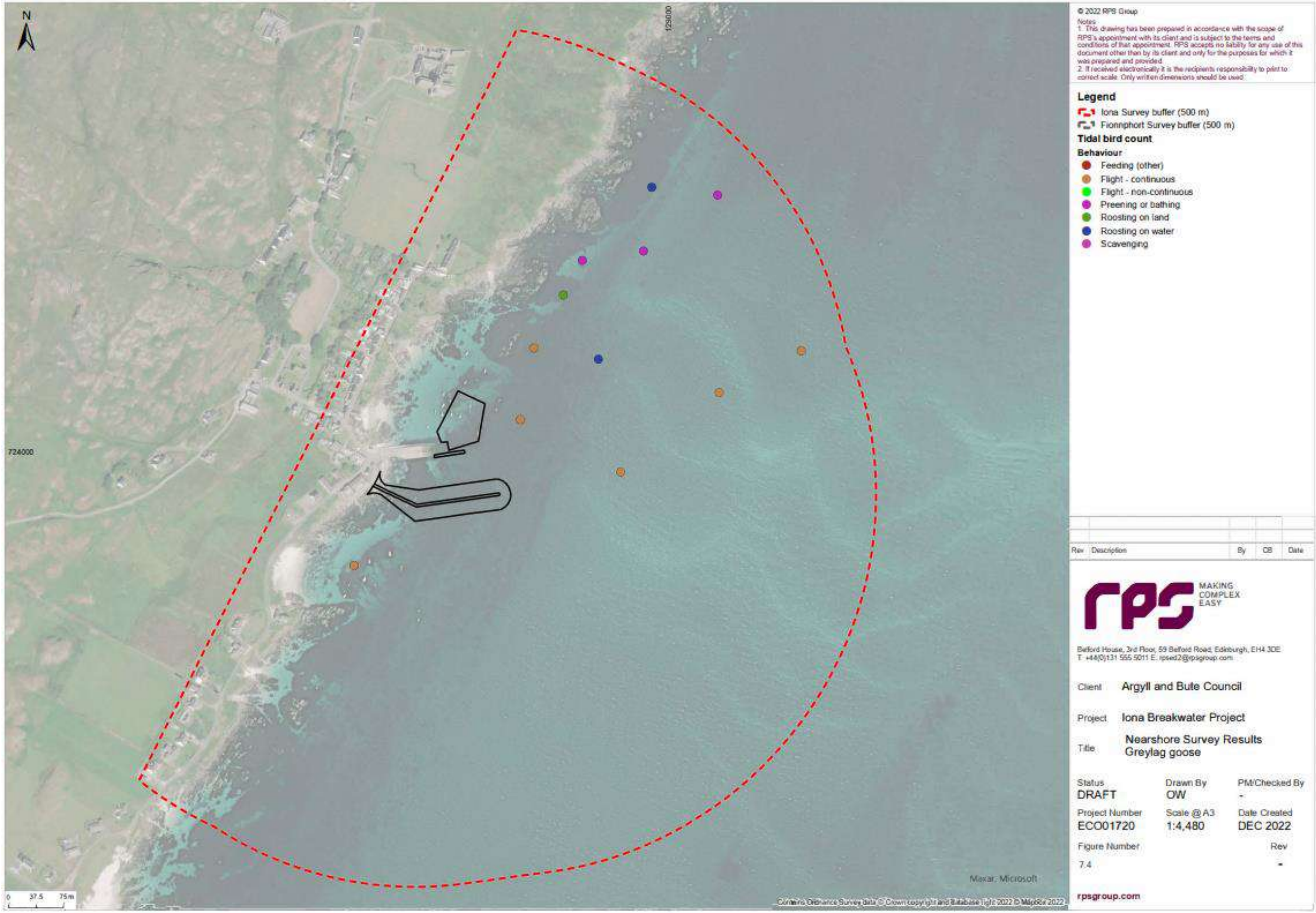

Figure 9-4 Nearshore survey results – Greylag goose

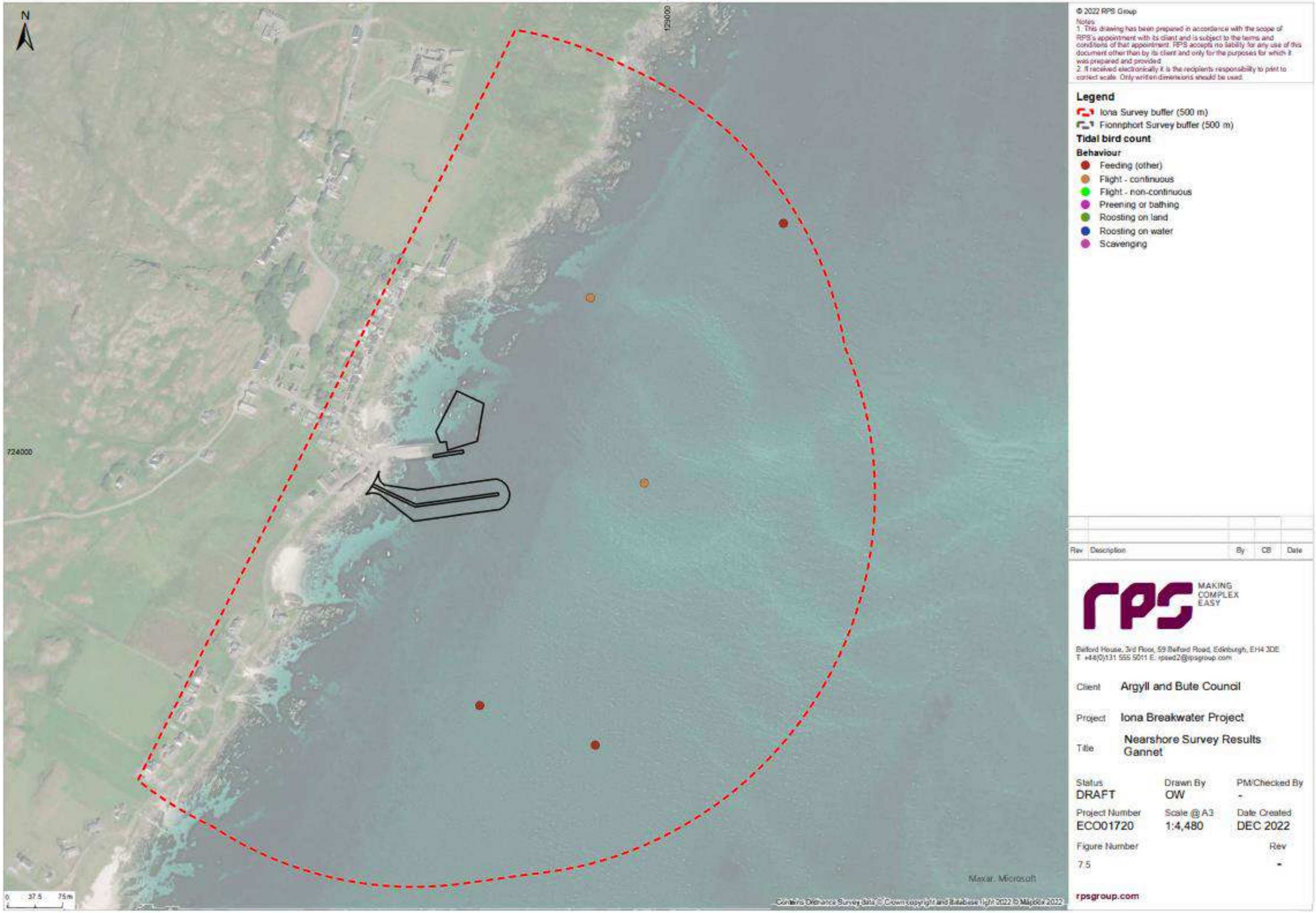

Figure 9-5 Nearshore survey results – Gannet

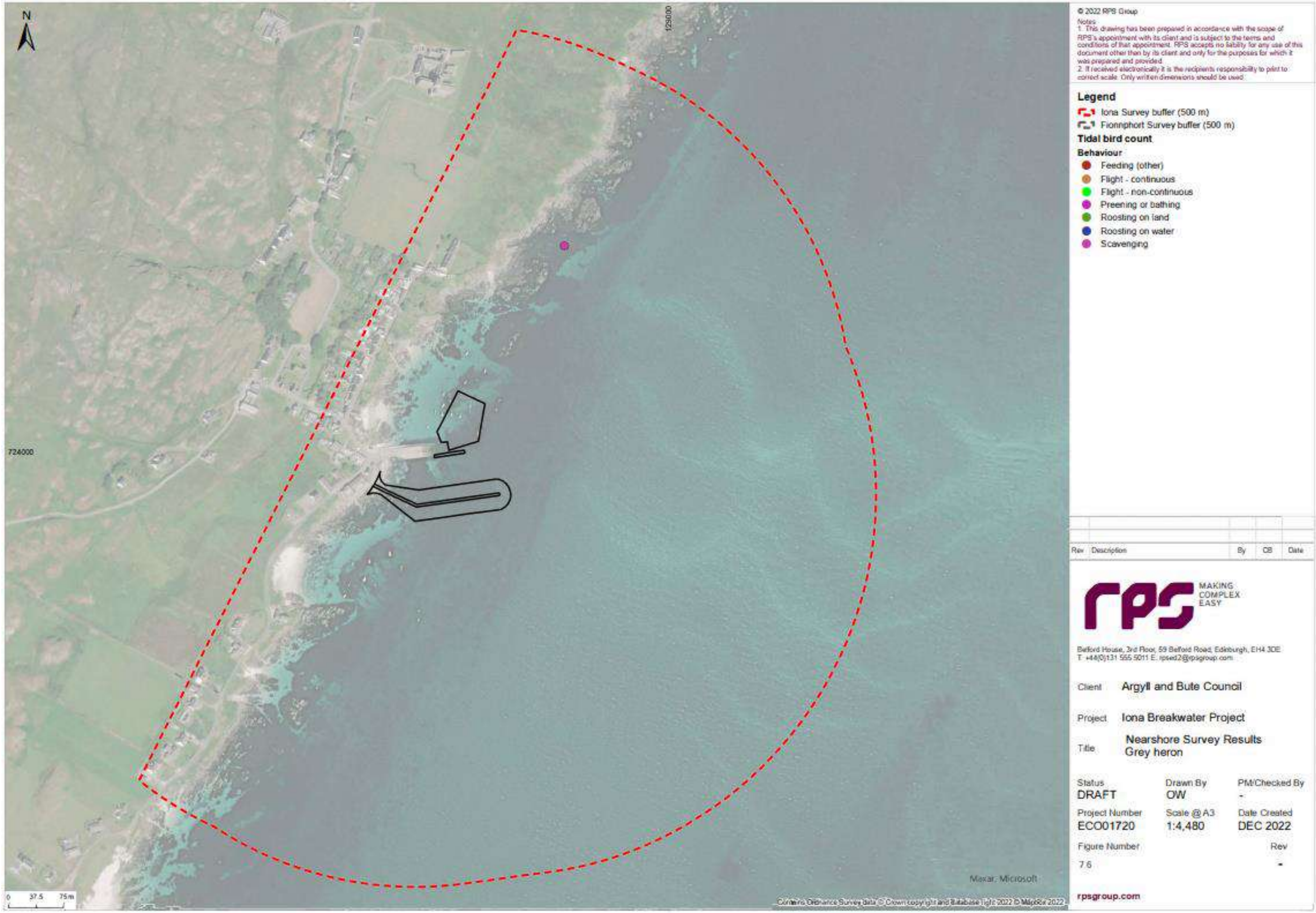

Figure 9-6 Nearshore survey results – Grey heron

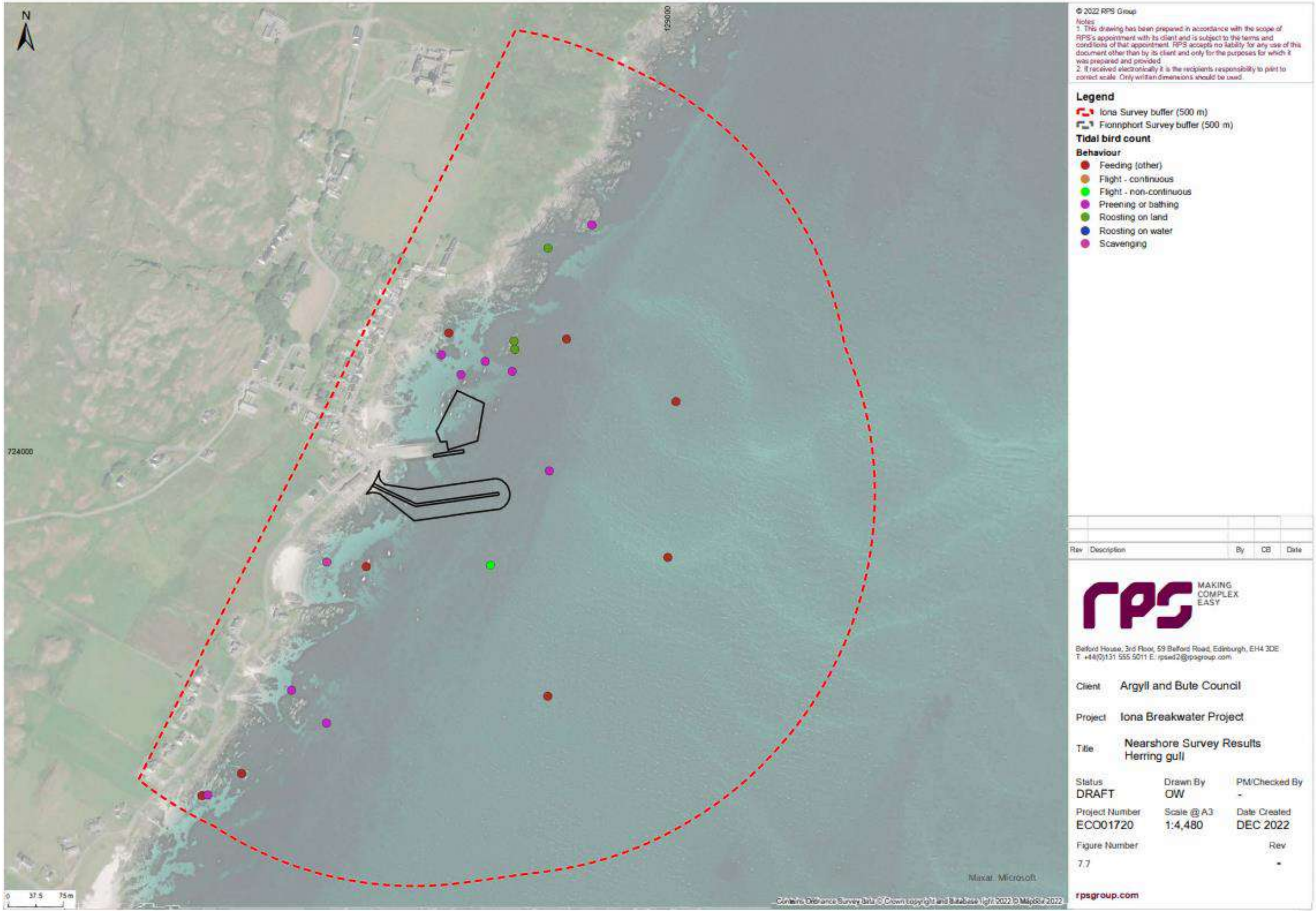

Figure 9-7 Nearshore survey results – Herring gull

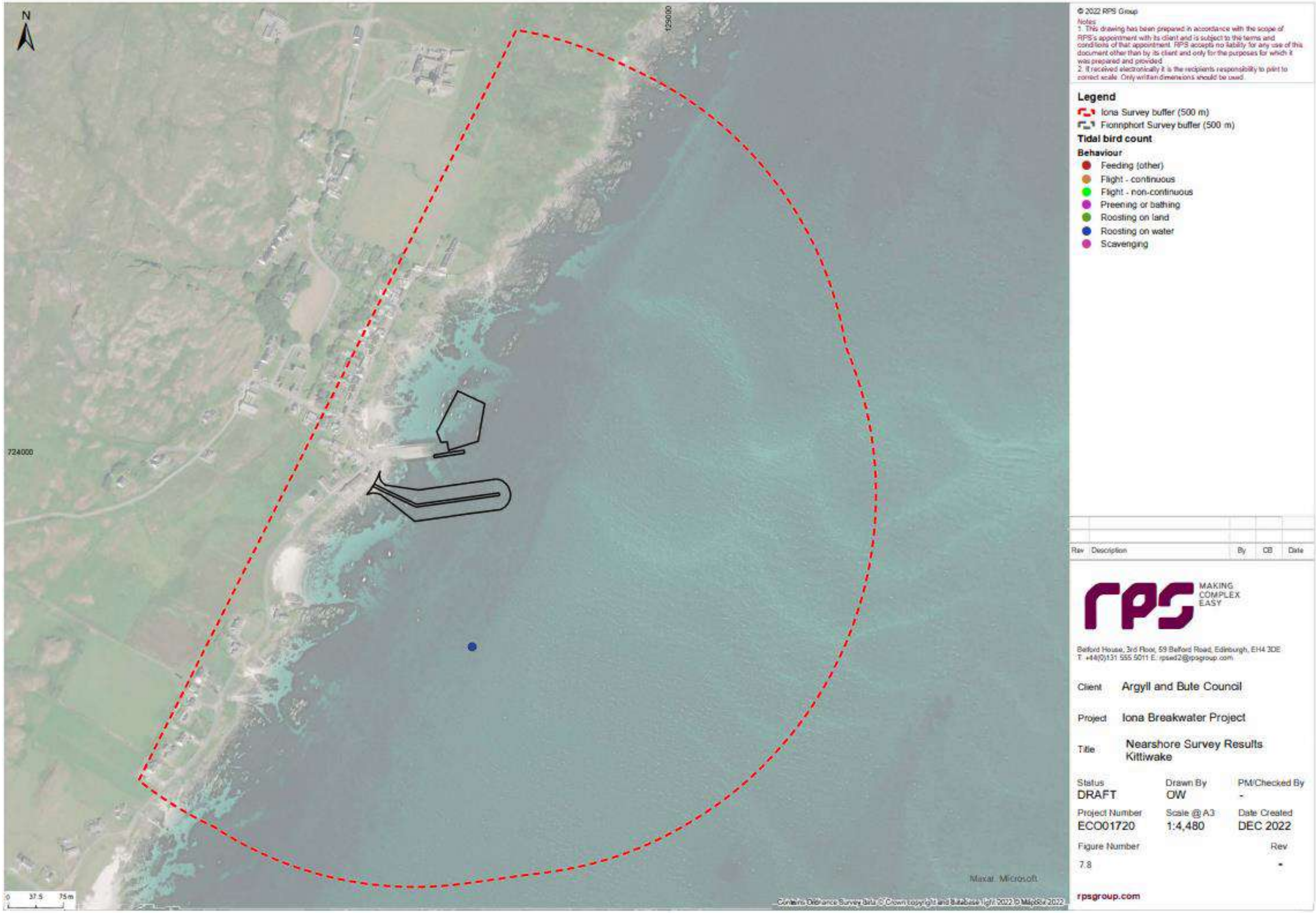

Figure 9-8 Nearshore survey results – Black-legged kittiwake

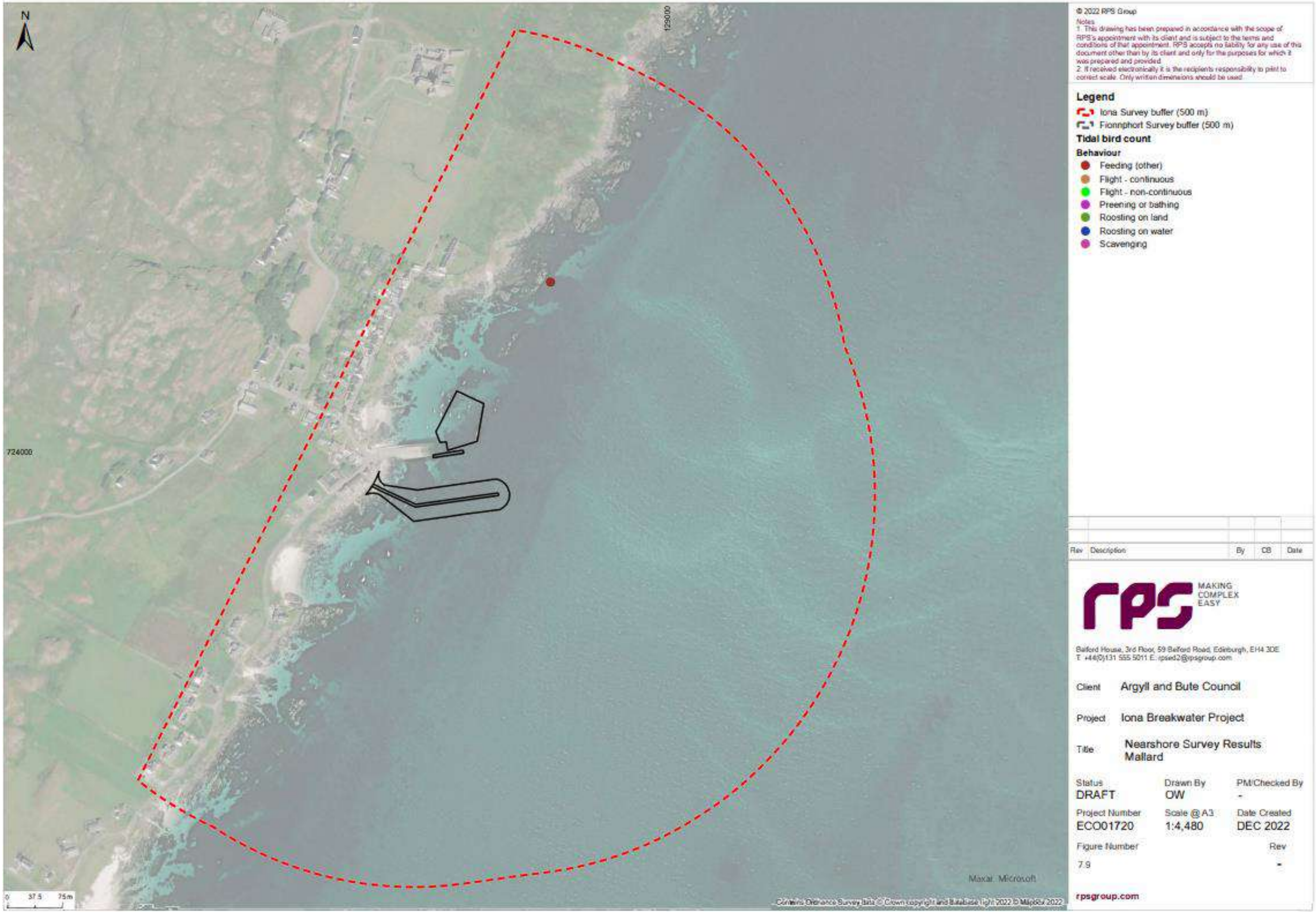

Figure 9-9 Nearshore survey results – Mallard

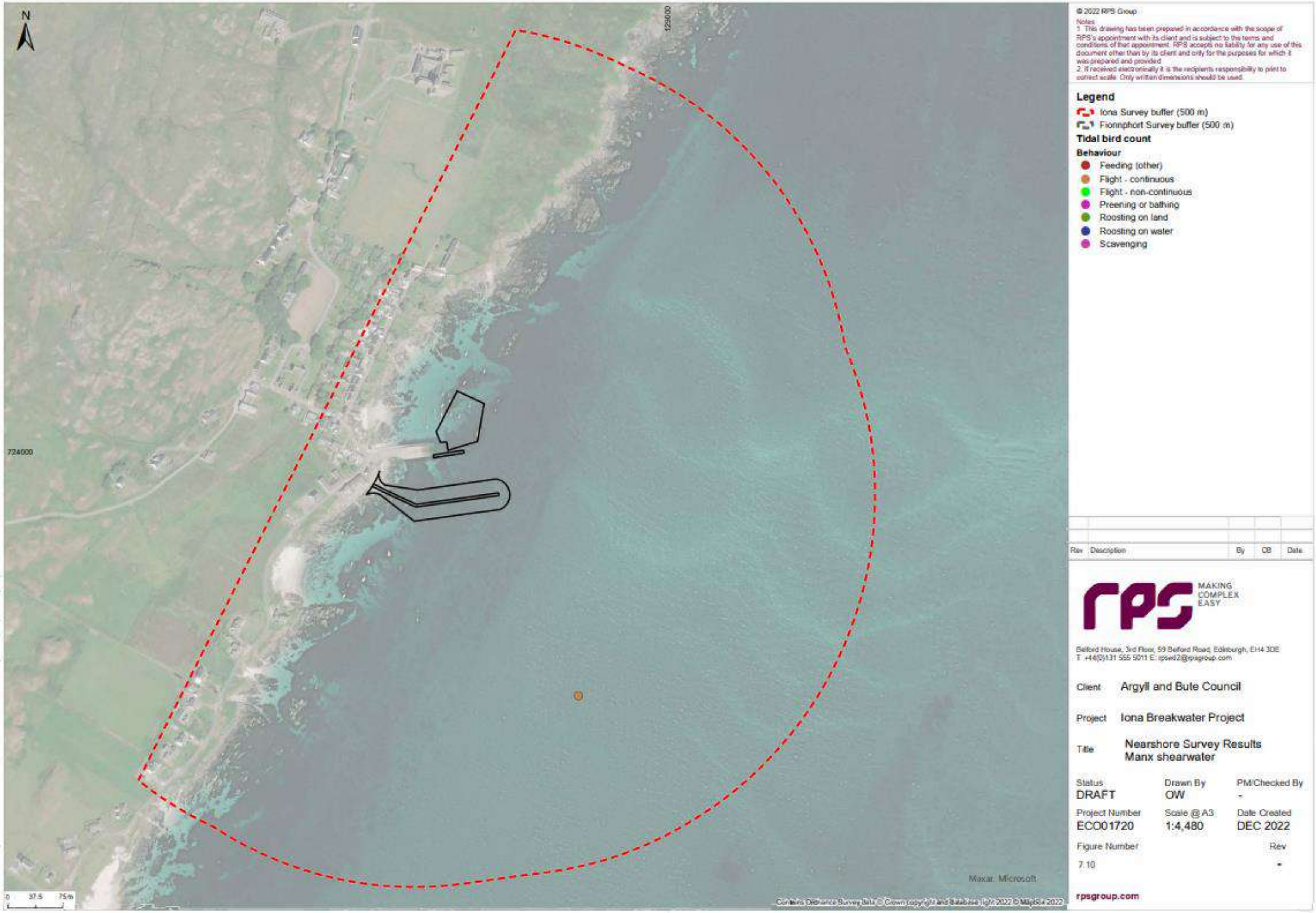

Figure 9-10 Nearshore survey results – Manx shearwater

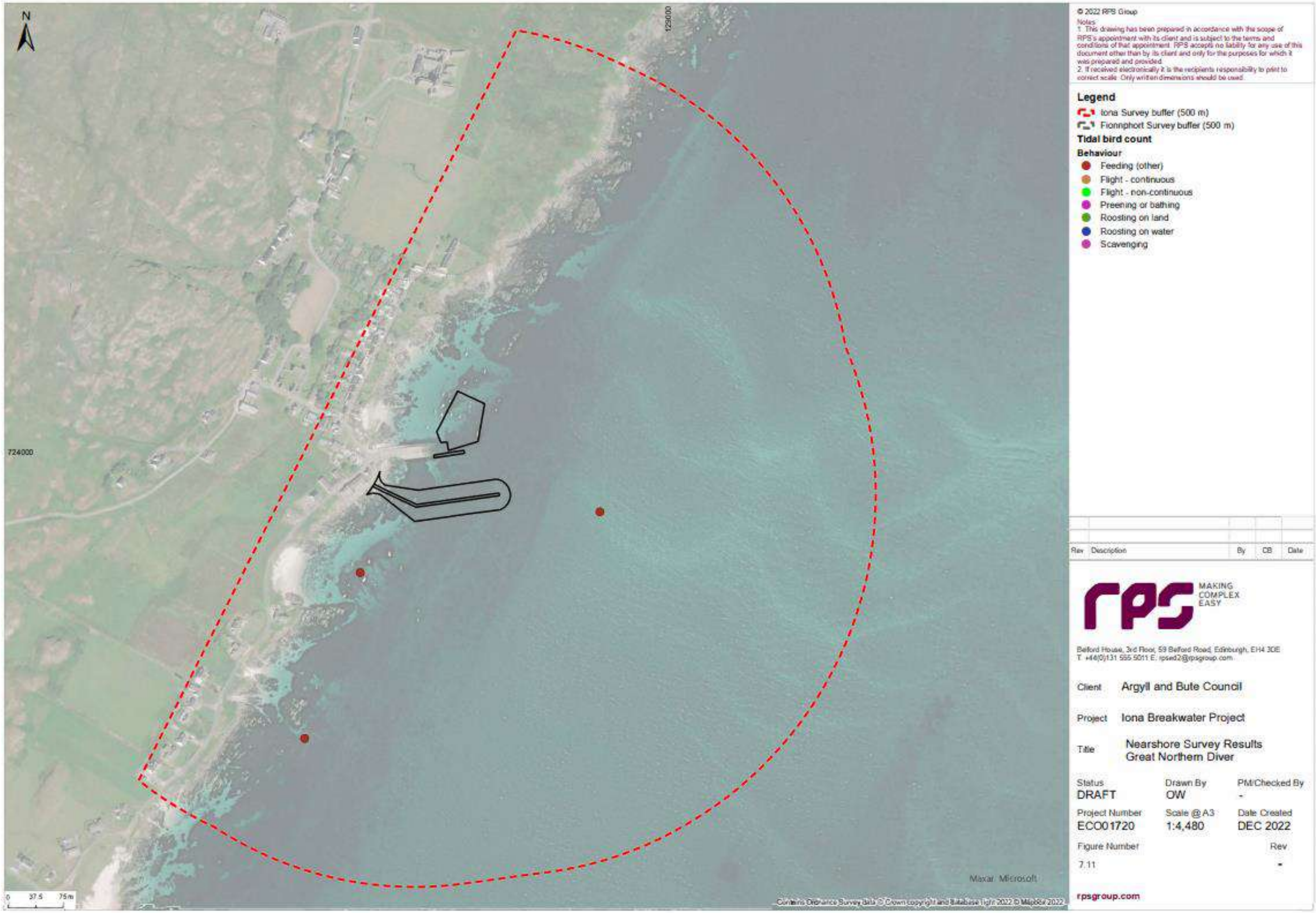

Figure 9-11 Nearshore survey results – Great northern diver

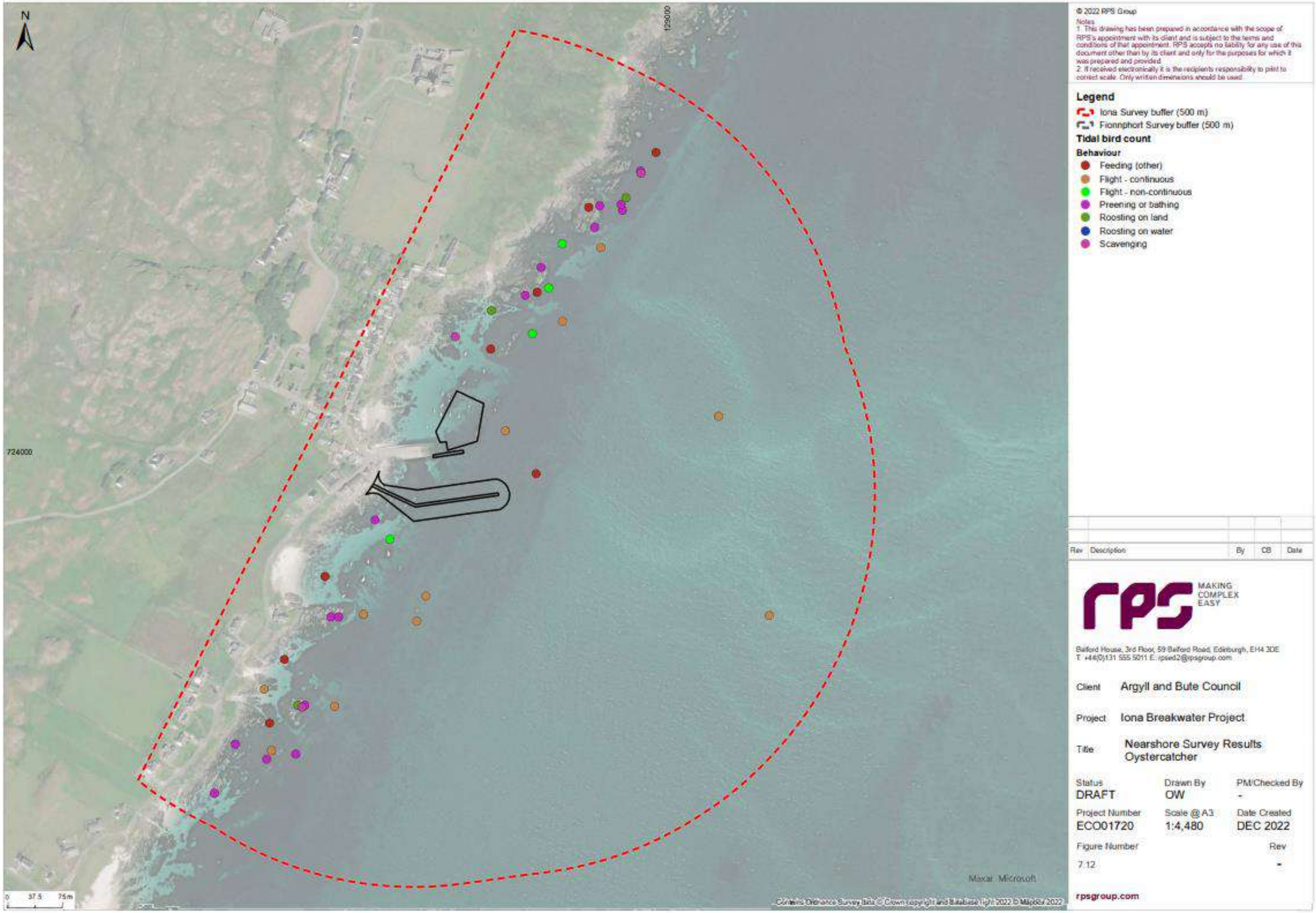

Figure 9-12 Nearshore survey results – Oystercatcher

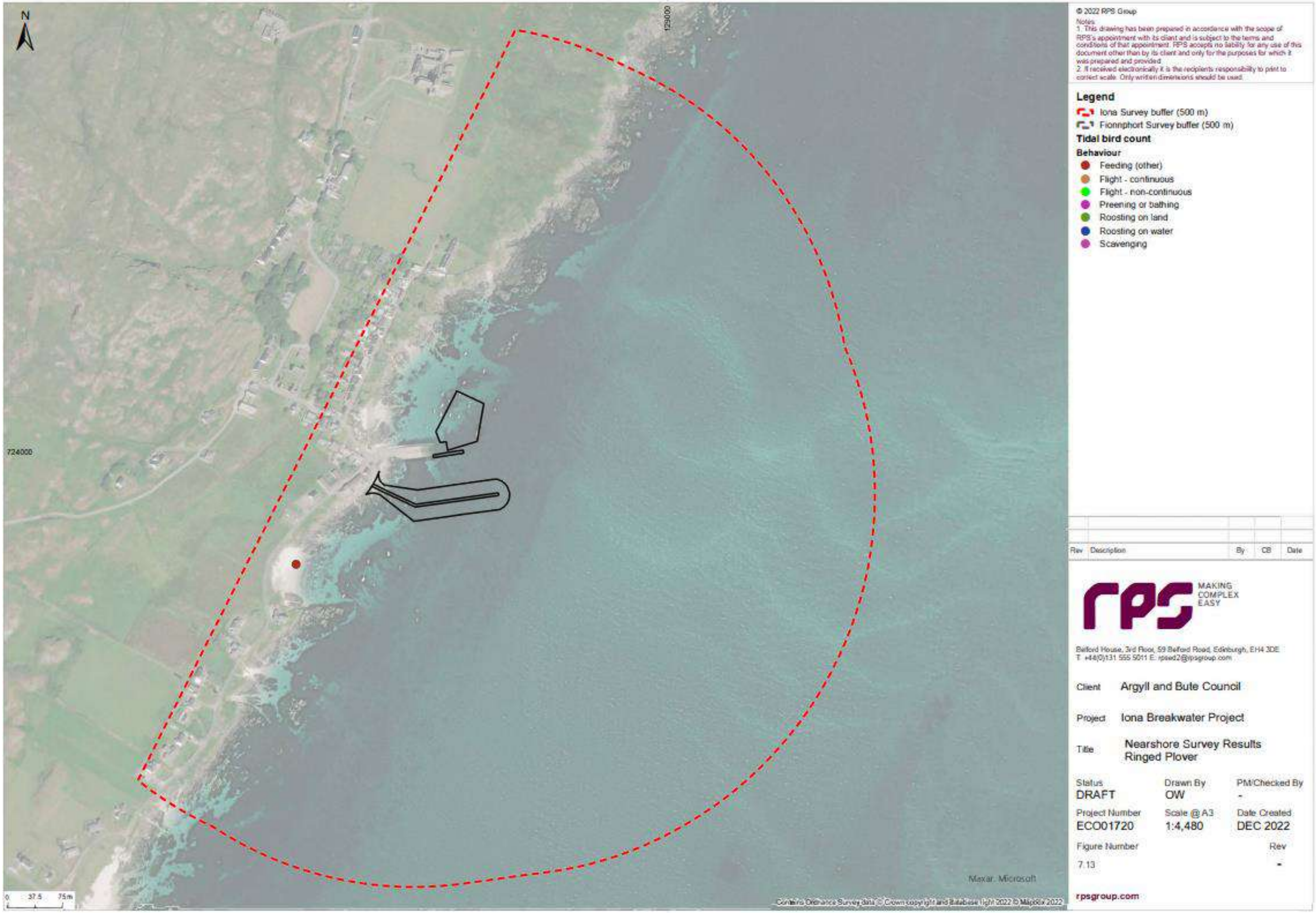

Figure 9-13 Nearshore survey results – Ringed plover

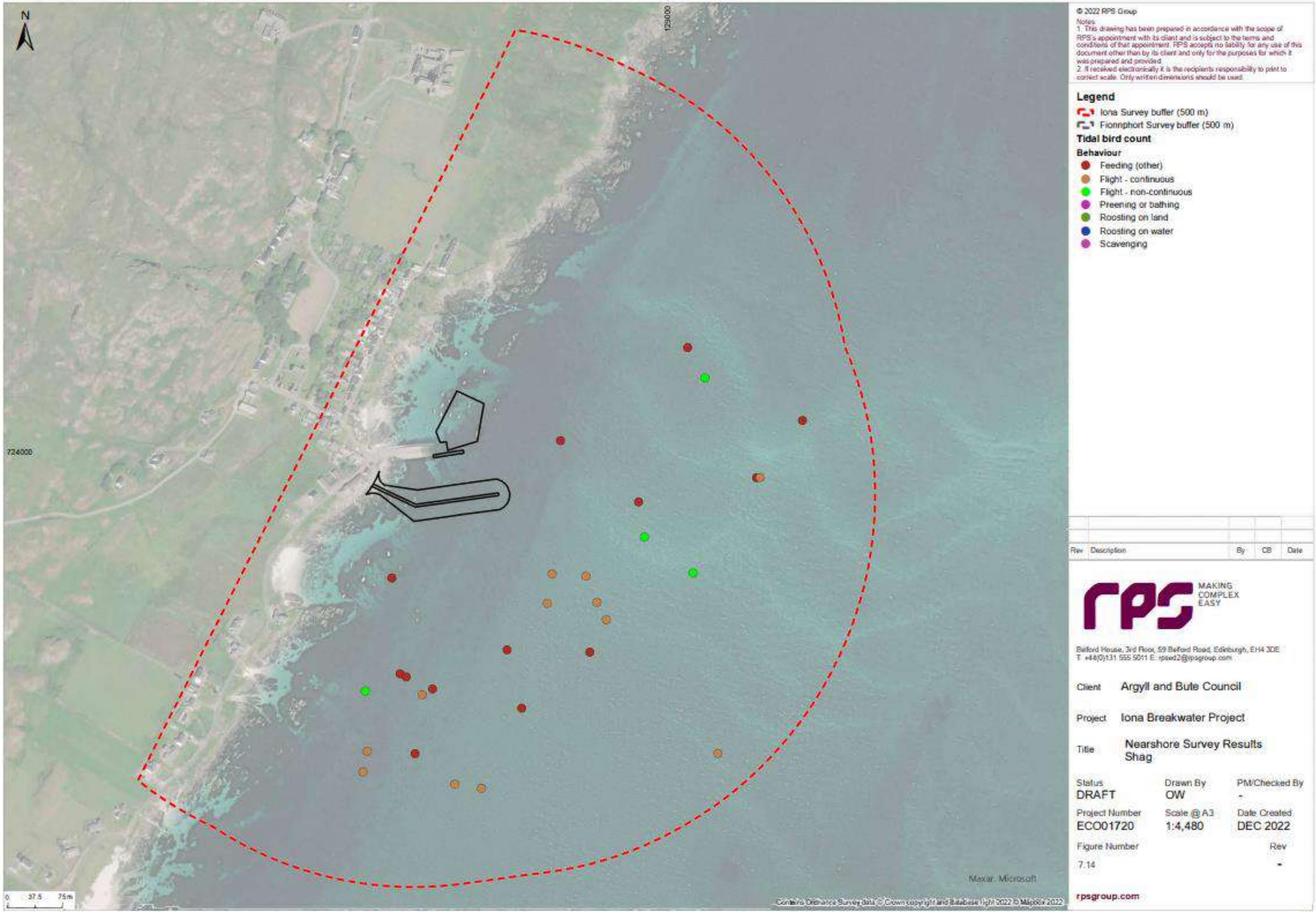

Figure 9-14 Nearshore survey results – Shag

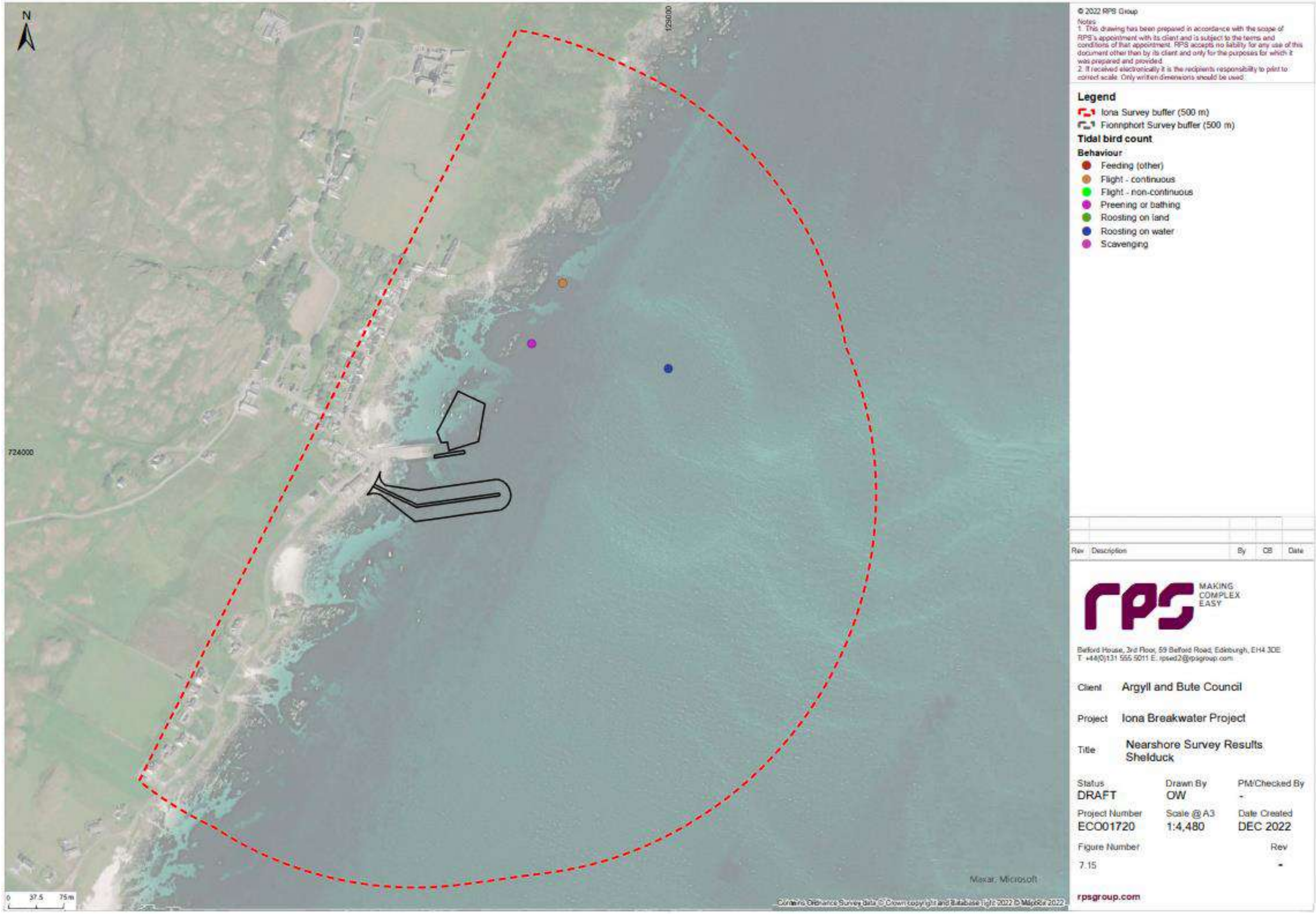

Figure 9-15 Nearshore survey results – Shelduck

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Scientific Names of Species Included in this Report

Greenland barnacle goose *Branta leucopsis*

Canada goose *Branta canadensis*

Greylag goose *Anser anser*

Common shelduck *Tadorna tadorna*

Mallard *Anas platyrhynchos*

Common eider *Somateria mollissima*

Oystercatcher *Haematopus ostralegus*

Ringed plover *Charadrius hiaticula*

Black-legged kittiwake *Rissa tridactyla*

Common gull *Larus canus*

Great black-backed gull *Larus marinus*

Herring gull *Larus argentatus*

Guillemot *Uria aalge*

Great northern diver *Gavia immer*

Gannet *Morus bassanus*

Cormorant *Phalacrocorax carbo*

Shag *Gulosus aristotelis*

European storm petrel *Hydrobates pelagicus*

Manx shearwater *Puffinus puffinus*

Grey heron *Ardea cinerea*

Chough *Pyrrhocorax pyrrhocorax*

APPENDIX 10.1

Noise Monitoring Methodology

Instrumentation

The noise monitoring instrumentation used for the baseline noise monitoring survey conforms to the requirements for integrating averaging sound level meters (Type 1) as specified in BS EN 60804. All noise monitoring equipment specifications ae illustrated below in Table 10.A.1 below.

Table 10 A.1: Noise Monitoring Equipment Specification

Noise Monitoring Location	Sound Level Meter Type	Sound Level Meter Serial Number	Date of Issue	Microphone Serial Number	Preamp Serial Number
1	Norsonic 140	1406913	30/05/2019	208201	21061

The microphone in the noise kits was protected with a foam windshield.

The noise kit has been calibrated by a UKAS accredited laboratory within the previous 24 months. The kit was also field calibrated at the commencement and conclusion of each survey using the calibrator, which had themselves been calibrated by a UKAS accredited laboratory within the previous twelve months. No significant drift in the calibration signal was noted.

Sound Level Meter Calibration Certificates

Figure 10.A.1: Norsonic Calibrator Calibration Certificate

Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
GREAT DUNMOW, CM6 1HD, England
www.campbell-associates.co.uk
info@campbell-associates.co.uk
Phone 01371 871030 Facsimile 01371879106

CALIBRATION 0789

Certificate number: U34705

Certificate of Calibration and Conformance

Test object: **Sound Calibrator**
Manufacturer: **Norsonic**
Type: **1251**
Serial no: **31060**

Customer: The Airshed Limited
Address: 5 Lauder Place, East Linton, East Lothian, EH40 3DB.
Contact Person: Hilary Fraser.

Measurement Results:	Level	Level Stability	Frequency	Frequency Stability	Distortion
1:	114.08 dB	0.05 dB	1000.11 Hz	0.00 %	0.36 %
2:	114.07 dB	0.05 dB	1000.10 Hz	0.00 %	0.37 %
3:	114.07 dB	0.05 dB	1000.10 Hz	0.00 %	0.36 %
Result (Average):	**114.07 dB**	**0.05 dB**	**1000.10 Hz**	**0.00 %**	**0.36 %**
Expanded Uncertainty:	0.10 dB	0.02 dB	1.00 Hz	0.01 %	0.10 %
Degree of Freedom:	>100	>100	>100	>100	>100
Coverage Factor:	2.00	2.00	2.00	2.00	2.00

The stated level is relative to 20µPa. The level is traceable to National Standards.
The stated level is valid at reference conditions. The following correction factors have been applied during the measurement: Pressure: 0.0005 dB/kPa Temperature: 0.003 dB/°C Relative humidity: 0.000 dB/%RH Load volume : 0.0003 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.
Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2020\NOR1251_31060_M1.nmf

Environmental conditions:	Pressure:	Temperature:	Relative humidity:
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.591 ± 0.042 kPa	24.1 ± 0.1 °C	33.9 ± 1.2 %RH

Date received for calibration: 30/04/2020
Date of calibration: 05/05/2020
Date of issue: 05/05/2020
Engineer

Michael Tickner

Supervisor

pp Darren Batten TechIOA

Page 1 of 2

Template UKAS_PE v2.10 DocR Cert-C0001

Figure 10.A.2: Norsonic Sound Level Meter Class 1 Calibration Certificate

Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
GREAT DUNMOW, Essex, GB-CM6 1HD
www.campbell-associates.co.uk
Phone 01371 871030 Facsimile 01371879106

CALIBRATION

0789

Certificate of Calibration and Conformance

Certificate number: **U31946**

Test object:	**Sound Level Meter, BS EN IEC 61672-1:2003 Class 1 (Precision)**
Producer :	**Norsonic**
Type :	**140**
Serial No.:	**1406913**
Customer:	**The Airshed Ltd**
Address:	**5 Lauder Place, East Linton. EH40 3DB.**
Contact Person:	**Hilary Fraser.**

Method :
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. These are based on the procedures for periodic verification of sound level meters as set out in BS EN IEC 61672-3:2006. Results and conformance statement are overleaf and detailed results are in the attached Test Report.

Tested

	Producer:	Type:	Serial No:	Certificate number
Microphone	Norsonic	1225	208201	31945
Calibrator*	Norsonic	1251	30873	U30563
Preamplifier	Norsonic	1209	21061	Included

Additional items that also have been submitted for verification
Wind shield -
Attenuator -
Extension cable -
These items have been taken into account wherever appropriate.

Instruction manual: Im140_1Ed6R3En Firmware version: 4.0.1282 The test object is a single channel instrument.

Conditions	Pressure	Temperature	Humidity
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.34 ±0.05 kPa	22.0 ±0.2 °C	47.0 ±0.7 %RH

Date received for calibration:	22/05/2019
Date of calibration:	30/05/2019
Date of issue:	30/05/2019

Engineer

Michael Tickner

Supervisor

Darren Batten TechIOA

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.
* The calibrator was complete with any required coupler for the microphone specified.

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APPENDIX 10.2

Noise Monitoring Location

Noise Monitoring Location (NML) 1 was located at Iona House, Iona. The baseline noise monitoring survey started at 17:00hrs on Tuesday 29th June 2021 and ended on Friday 2nd July 2021 at 12:45hrs.

Photograph 10.B.1: Noise Monitoring Survey at NML1

APPENDIX 10.3

Baseline Noise Monitoring Survey Data

Noise Monitoring Location 1

Attended Noise Monitoring at NML 1

The baseline noise monitoring survey started at 17:00hrs on 29/06/21 and ended at 12:45 on 02/07/2021. The survey was attended during the following periods:

- 10:08hrs – 11:13hrs on 30th June 2021;
- 22:00hrs – 00:00hrs on 30th June 2021;
- 18:00hrs – 20:00hrs on 1st July 2021; and
- 23:00hrs – 00:00hrs on 1st July 2021.

Notes from the attended periods of the baseline noise monitoring survey as summarised in Tables 10.C.1 – 10.C.4 below.

Table 10.C.1: Subjective Survey Notes during Attended period 10:08hrs – 11:13hrs on 30th June 2021

Date	Time	Subjective Survey Notes
30/06/21	10.08	Survey Start, Ferry at Iona slip
	10.10	Ferry departs, announcement
	10.11	Post van
	10.12	Van
	10.14	Outboard motor in Sound of Iona
	10.15	Van
	10.22	Van
	10.29	Car
	10.31	Van
	10.33	Car
	10.36	Engine, boat or aircraft
	10.37	Boat in SoI, car
	10.41	Ferry approaching slip
	10.49	Ferry departs, announcement
	10.54	Car
	10.55	Car
	10.56	Outboard motor in Sound of Iona
	11.05	Van
	11.08	Car
	11.10	Van
	11.13	Van

Table 10.C.2: Subjective Survey Notes during Attended period 22:00hrs – 00:00hrs on 30th June 2021

Date	Time	Subjective Survey Notes
30/06/21	22.00	Survey Start
	22.55	Tracked low frequency plant noise to rear of post office shed. Constant low hum.
	23.21	Car
	23.27	Car
	00.00	Survey End

Table 10.C.3: Subjective Survey Notes during Attended period 18:00hrs – 20:00hrs on 1st July 2021

Date	Time	Subjective Survey Notes
01/07/21	18.00	Survey Start
	18.01	Ferry departs, announcement
	18.02	Car
	18.04	Boat in SoI, then at slip
	18.05	Joiners at work approx 40 metres uphill. Power tools, saws.
	18.07	Boat leaves slip
	18.13	Generator running at joiners worksite
	18.17	Aircraft over SoI
	18.20	Car
	18.22	Car, Boat at slip
	18.30	Ferry at slip, Car
	18.32	Ferry departs, announcement, passengers near meter
	18.35	Car
	18.39	Chains being handled in boat park
	18.43	Outboard motor in SoI. Power tools continue.
	18.46	Car
	18.51	Aircraft over SoI
	18.52	Power tools continue
	19.04	Power tools continue
	19.14	Power tools continue
	19.27	Car
	19.37	Hammering from worksite
	19.39	Van - joiners leaving
	19.49	Angle grinder from the north
	19.52	Car
	19.54	Tractor
	19.55	Opera singer near field
	20.00	Survey End

Table 10.C.4: Subjective Survey Notes during Attended period 23:00hrs – 00:00hrs on 1st July 2021

Date	Time	Subjective Survey Notes
01/07/21	23.00	Survey Starts
	23.40	Pedestrians
	23.47	Pedestrians
	00.00	Survey Ends

Unattended Noise Monitoring at NML 1

Figure 10.C.1: Complete Noise Data Graph (29/06/2021 – 02/07/2021)

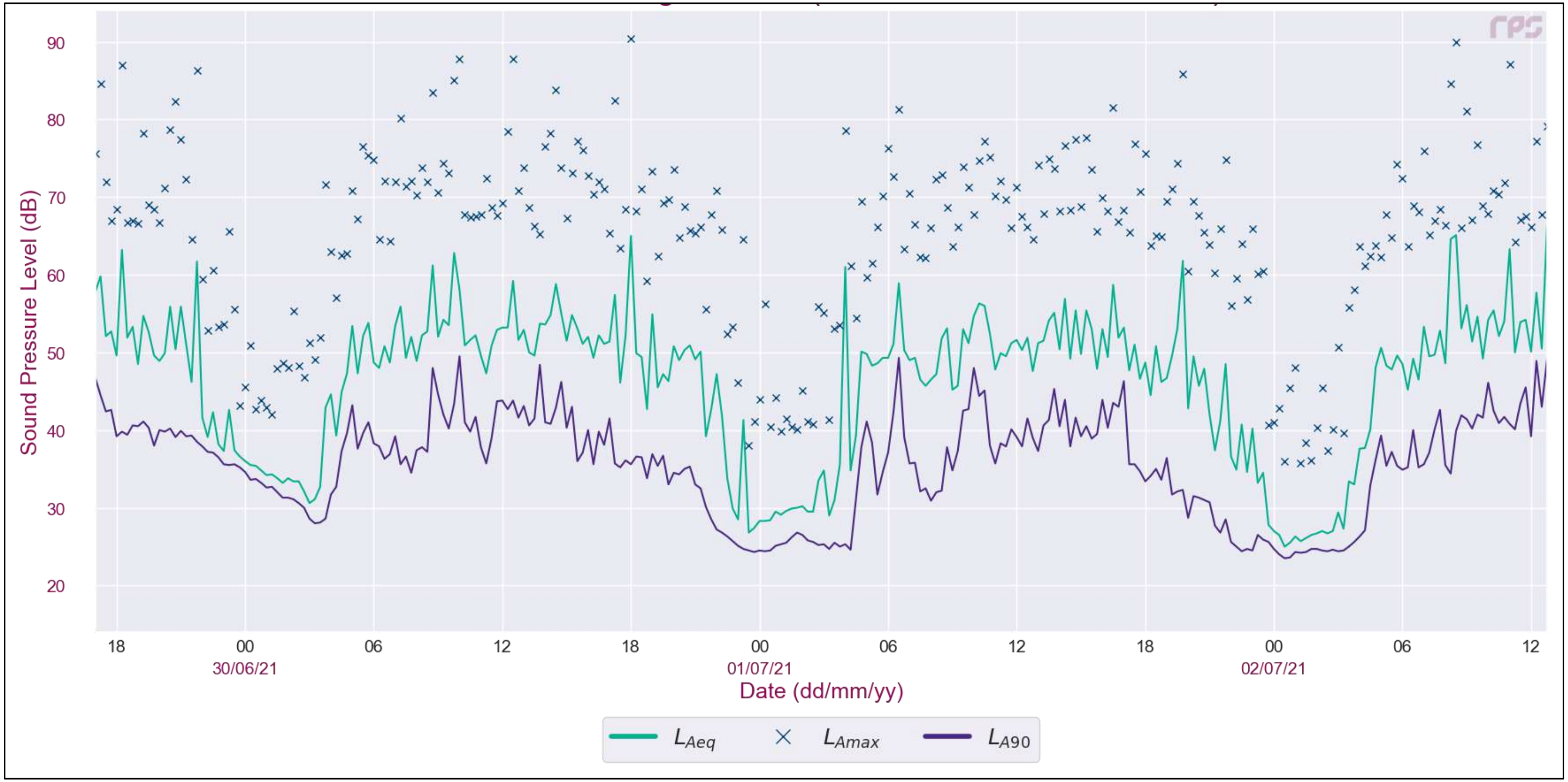


Figure 10.C.2: Complete Noise Data and Weather Data Graph (29/06/2021 – 02/07/2021)

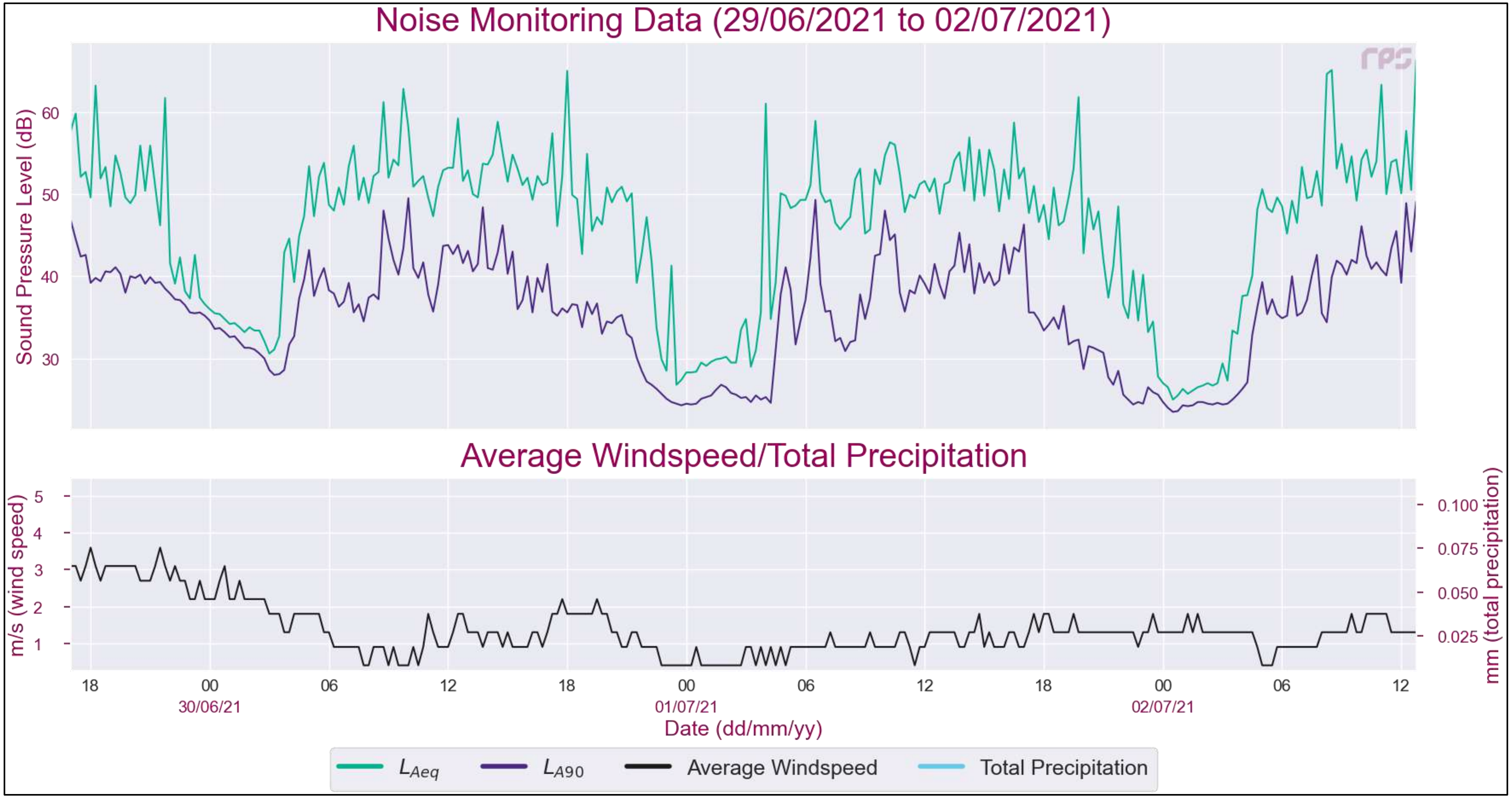


Figure 10.C.3: Frequency Daytime (1hour) Graph (29/06/2021 – 02/07/2021)

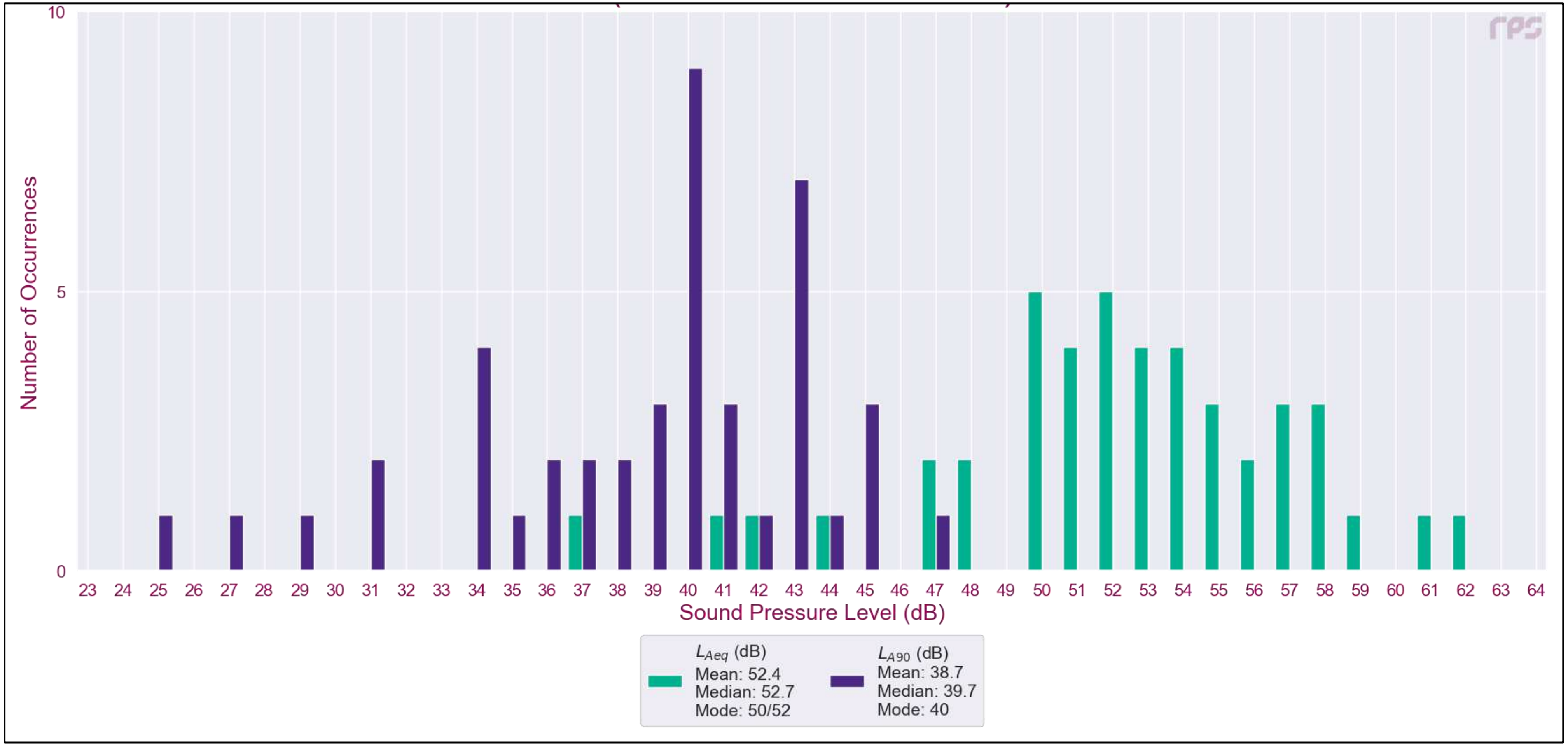
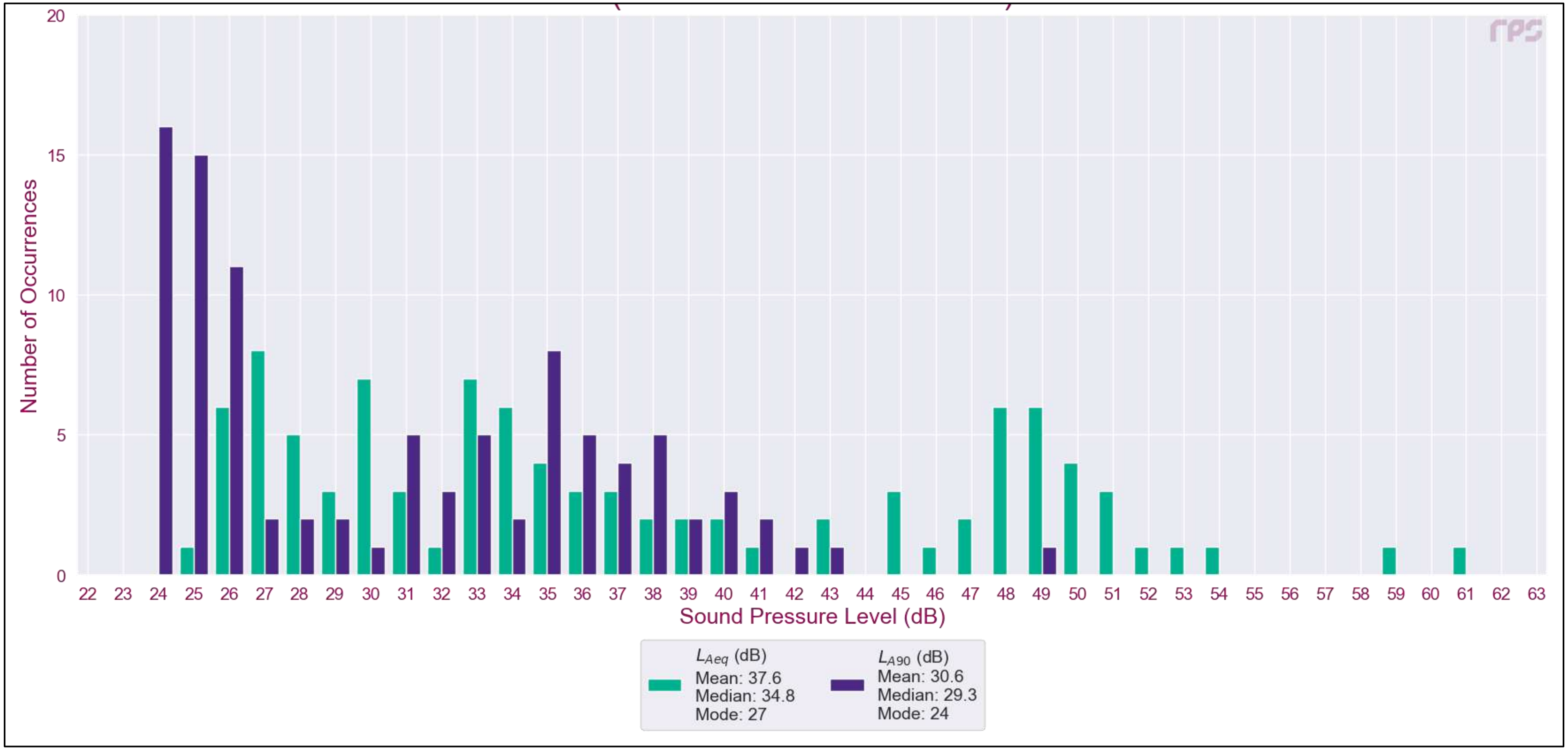


Figure 10.C.4: Frequency Night time (15minutes) Graph (29/06/2021 – 02/07/2021)



The typical background noise levels are summarised below in Table 9.C.5 including statistical analysis L_{A90} noise levels:

Table 10.C.5: Unattended Typical Daytime and Night time L_{A90} and L_{Aeq} Noise Levels NML 1 (29/06/2021 – 02/07/2021) (Mode)

Datasets	L_{A90} Analysis		L_{Aeq} Analysis	
	Daytime dB	Night time dB	Daytime dB	Night time dB
NML 1	40	24	50/52	27

APPENDIX 10.4

Construction Noise Receptors

Table 10.D.1: Noise Sensitive Receptors Details

Noise Sensitive Receptor ID	Easting (X)	Northing (Y)	Residential
1	128573	724560	Yes
2	128673	724525	No
3	128591	724456	No
4	128501	724431	Yes
5	128554	724373	No
6	128520	724378	No
7	128490	724337	No
8	128673	724251	No
9	128640	724245	Yes
10	128447	724268	Yes
11	128498	724253	No
12	128480	724215	No
13	128608	724179	Yes
14	128585	724128	No
15	128437	724120	Yes
16	128555	724058	No
17	128541	724036	No
18	128578	723992	Yes
19	128372	724052	Yes
20	128370	723997	Yes
21	128543	723958	No
22	128515	723941	No
23	128298	723992	No
24	128247	723961	Yes
25	128463	723775	Yes
26	128412	723769	Yes
27	128404	723732	Yes
28	128356	723694	Yes
29	128350	723678	Yes
30	128349	723660	Yes
31	128334	723641	Yes
32	128332	723609	Yes
33	128317	723591	No
34	128287	723571	Yes

Figure 10.D.1: Location of Construction Noise Sensitive Receptors

APPENDIX 10.5

Construction Noise Monitoring Assessment

Figure 10.E.1: Construction Noise Receptors and Locations of Proposed Construction Activity

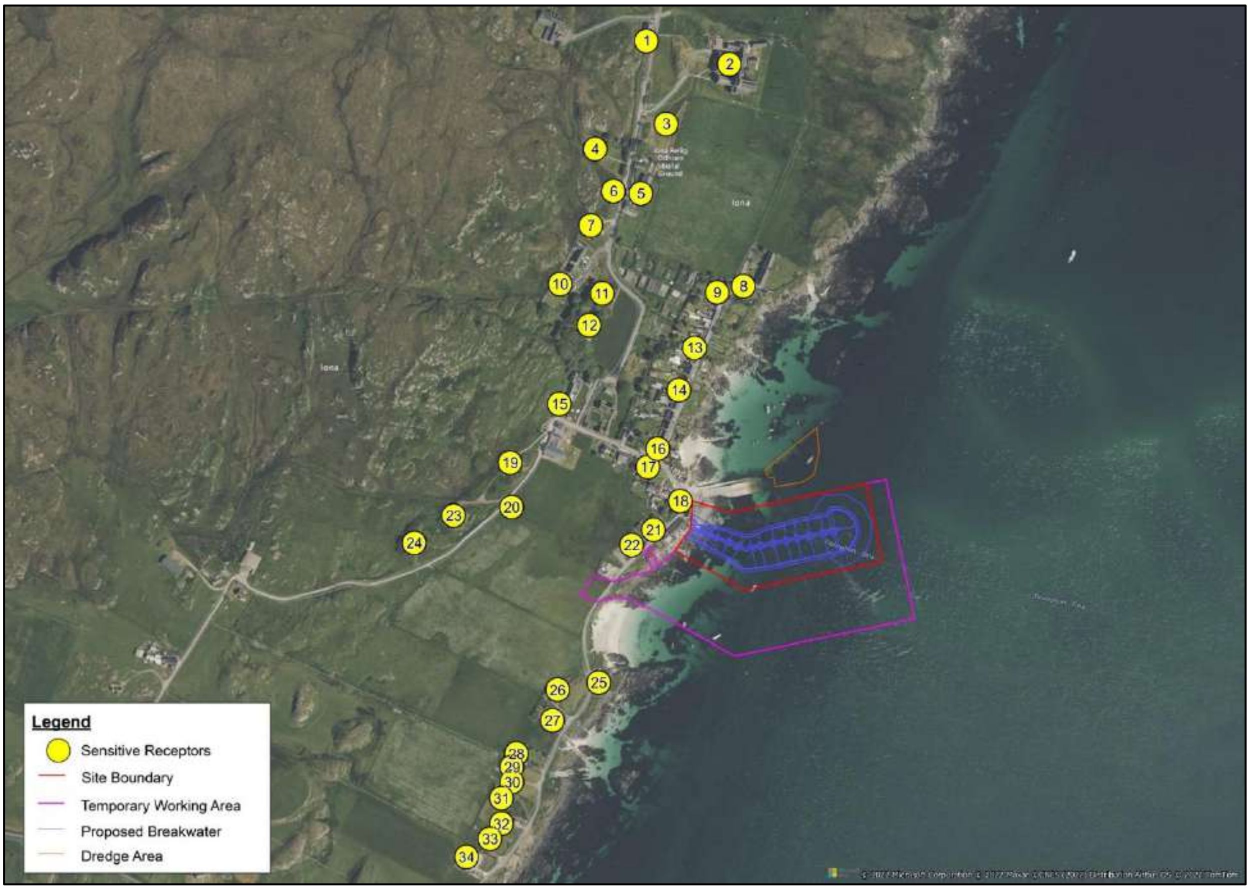


Table 10.E.1: Construction Noise Receptors and BS 5228 ABC Category

Construction Receptor ID	Easting	Northing	Residential	Sensitivity	BS5228 ABC Category A (daytime) dB	BS5228 Category A Guideline (Night time) dB
1	128573	724560	**Yes**	**High**	65	45
2	128673	724525	No	Medium	65	45
3	128591	724456	No	Medium	65	45
4	128501	724431	**Yes**	**High**	65	45
5	128554	724373	No	Medium	65	45
6	128520	724378	No	Medium	65	45
7	128490	724337	No	Medium	65	45
8	128673	724251	No	Medium	65	45
9	128640	724245	**Yes**	**High**	65	45
10	128447	724268	**Yes**	**High**	65	45
11	128498	724253	No	Medium	65	45
12	128480	724215	No	Medium	65	45
13	128608	724179	**Yes**	**High**	65	45
14	128585	724128	No	Medium	65	45
15	128437	724120	**Yes**	**High**	65	45
16	128555	724058	No	Medium	65	45
17	128541	724036	No	Medium	65	45
18	128578	723992	**Yes**	**High**	65	45
19	128372	724052	**Yes**	**High**	65	45
20	128370	723997	**Yes**	**High**	65	45
21	128543	723958	No	Medium	65	45
22	128515	723941	No	Medium	65	45
23	128298	723992	No	Medium	65	45
24	128247	723961	**Yes**	**High**	65	45
25	128463	723775	**Yes**	**High**	65	45
26	128412	723769	**Yes**	**High**	65	45
27	128404	723732	**Yes**	**High**	65	45
28	128356	723694	**Yes**	**High**	65	45
29	128350	723678	**Yes**	**High**	65	45
30	128349	723660	**Yes**	**High**	65	45
31	128334	723641	**Yes**	**High**	65	45
32	128332	723609	**Yes**	**High**	65	45
33	128317	723591	**No**	**High**	65	45
34	128287	723571	**Yes**	**High**	65	45

Table 10.E.2: Distance from Construction Noise Receptors to Construction Area Boundaries

Construction Receptor ID	Site Boundary (m)	Dredging Works (m)	Construction of Breakwater (m)
1	569	520	585
2	540	460	543
3	466	418	481
4	450	438	465
5	384	361	400
6	394	384	409
7	362	369	377
8	269	197	277
9	259	207	275
10	313	341	327
11	279	296	294
12	251	281	265
13	189	172	205
14	138	145	154
15	203	266	213
16	78	135	92
17	69	144	80
18	15	111	23
19	229	314	233
20	208	315	216
21	37	155	40
22	54	187	65
23	276	387	286
24	321	441	332
25	186	324	204
26	223	366	241
27	257	397	275
28	316	457	334
29	332	473	351
30	347	486	365
31	371	510	389
32	397	534	415
33	420	557	438
34	455	593	473

Table 10.E.3: Construction of Breakwater Noise Predictions

Construction Receptor ID	Closest Distance to Construction of Breakwater (m)	BS5228 Category A Guideline (Daytime)	BS5228 Category A Guideline (Night time)	Construction of Breakwater Total SPL (dB)
1	520	65	45	54.7
2	460	65	45	55.3
3	418	65	45	56.4
4	438	65	45	56.7
5	361	65	45	58.0
6	384	65	45	57.8
7	369	65	45	58.5
8	197	65	45	61.2
9	207	65	45	61.2
10	341	65	45	59.7
11	296	65	45	60.7
12	281	65	45	61.6
13	172	65	45	63.8
14	145	65	45	66.3
15	266	65	45	63.5
16	135	65	45	70.8
17	144	65	45	71.9
18	111	65	45	82.9
19	314	65	45	62.7
20	315	65	45	63.3
21	155	65	45	78.0
22	187	65	45	73.8
23	387	65	45	60.9
24	441	65	45	59.6
25	324	65	45	63.8
26	366	65	45	62.4
27	397	65	45	61.3
28	457	65	45	59.5
29	473	65	45	59.1
30	486	65	45	58.8
31	510	65	45	58.2

Construction Receptor ID	Closest Distance to Construction of Breakwater (m)	BS5228 Category A Guideline (Daytime)	BS5228 Category A Guideline (Night time)	Construction of Breakwater Total SPL (dB)
32	534	65	45	57.7
33	557	65	45	57.2
34	593	65	45	56.5

Table 10.E.4: Dredging Construction Noise Predictions

Construction Receptor ID	Closest Distance to Dredging Works (m)	BS5228 Category A Guideline (Daytime)	BS5228 Category A Guideline (Night time)	Predicted Noise Level Dredging SPL (dB)
1	520	65	45	50.7
2	460	65	45	51.7
3	418	65	45	52.6
4	438	65	45	52.2
5	361	65	45	53.9
6	384	65	45	53.3
7	369	65	45	53.7
8	197	65	45	59.1
9	207	65	45	58.7
10	341	65	45	54.4
11	296	65	45	55.6
12	281	65	45	56.0
13	172	65	45	60.3
14	145	65	45	61.8
15	266	65	45	56.5
16	135	65	45	62.4
17	144	65	45	61.8
18	111	65	45	64.1
19	314	65	45	55.1
20	315	65	45	55.0
21	155	65	45	61.2
22	187	65	45	59.6
23	387	65	45	53.3
24	441	65	45	52.1
25	324	65	45	54.8
26	366	65	45	53.7
27	397	65	45	53.0
28	457	65	45	51.8
29	473	65	45	51.5
30	486	65	45	51.3
31	510	65	45	50.9
32	534	65	45	50.5

Construction Receptor ID	Closest Distance to Dredging Works (m)	BS5228 Category A Guideline (Daytime)	BS5228 Category A Guideline (Night time)	Predicted Noise Level Dredging SPL (dB)
33	557	65	45	50.1
34	593	65	45	49.6

APPENDIX 11.1

Transitional and Coastal waters Morphological Impact Assessment System (TraC MiMAS)

TRAC MIMAS ASSESSMENT

MImAS Stage 1 Outputs

Waterbody Name	**Sound of Iona**
Size	12.1km2
TraC Type	CW2 (Exposed, meso-tidal)
MImAS Scale of Assessment	Stage 1. Preliminary scale - 0.5km^2
MImAS Type	Coastal, Moderately to exposed, macro-tidal. Sedimentary.
Existing Modications	
Existing slipway	0.001km^2
Zone	
Hydrodynamics	0% (Below 5% high status MCL)
Intertidal	0.03% (Below 5% high status MCL)
Subtidal	0.04% (Below 5% high status MCL)
Current Status	**High**
New Modifications	
Proposed Dredge	0.002017 km^2
Proposed Breakwater	0.197 km^2
Zone	
Hydrodynamics	5.5% (Exceeds 5% high status MCL)
Intertidal	29.6% (Exceeds 5% high status MCL)
Subtidal	24.1% (Exceeds 5% high status MCL)
Predicted Status	**Less than Good**

MImAS Stage 2 Outputs

Waterbody Name	**Sound of Iona**
Size	12.1 km^2
TraC Type	CW2 (Exposed, meso-tidal)
MImAS Scale of Assessment	Stage 2 - Water body scale
MImAS Type	Coastal, Moderately to exposed, macro-tidal. Sedimentary.
Existing Modifications	
Existing slipway	0.001 km^2
Existing Fionnphort	0.001 km^2
Zone	
Hydrodynamics	0% (Below 5% high status MCL)
Intertidal	0.% (Below 5% high status MCL)
Subtidal	0% (Below 5% high status MCL)
Current Status	**High**
New Modifications	
Proposed Dredge	0.002017 km^2
Proposed Breakwater	0.197 km^2
Zone	
Hydrodynamics	0.14% (Below 5% high status MCL)
Intertidal	0.76% (Below 5% high status MCL)
Subtidal	0.62% (Below 5% high status MCL)
Predicted Status	**High**

Stage 2 MImAS Cumulative Assessment with proposed Fionnphort development

Waterbody Name	**Sound of Iona**
Size	12.1 km^2
TraC Type	CW2 (Exposed, meso-tidal)
MImAS Scale of Assessment	Stage 2 - Water body scale
MImAS Type	Coastal, Moderately to exposed, macro-tidal. Sedimentary.
Existing Modifications	
Existing slipway	0.001 km^2
Existing Fionnphort	0.001 km^2
Zone	
Hydrodynamics	0% (Below 5% high status MCL)
Intertidal	0.% (Below 5% high status MCL)
Subtidal	0% (Below 5% high status MCL)
Current Status	**High**
New Modifications	
Proposed Dredge	0.002017 km^2
Proposed Breakwater	0.197 km^2
Proposed Dredge (Fionnphort)	0.013 km^2
Proposed Breakwater (Fionnphort)	0.175 km^2
Zone	
Hydrodynamics	0.27% (Below 5% high status MCL)
Intertidal	1.44% (Below 5% high status MCL)
Subtidal	1.18% (Below 5% high status MCL)
Predicted Status	**High**

APPENDIX 15.1

Photomontages

PHOTOMONTAGES

Iona Breakwater
October 2022

Baseline image

Map image

Tripod location

Camera	Sony ILCE-7RM3	Easting	128188	Title: VP01 Moal Farm Track Existing View	FIG ##		Drawn by:	PM	Project: Iona Breakwater	Client: Argyll & Bute Council
Date	22.10.21 - 13.45	Northing	723902		Projection:	OSGB	Checked:	RH		
View height	1.56 m AGL	Direction	90°		Data Source:	RPS 2022	Job Ref:	NI 2353		
Field of View	60°	Distance	425 m		Status:	Draft	Date:	Oct 2022		

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Photomontage

Map image

Tripod location

Camera	Sony ILCE-7RM3	Easting	128188	Title: VP01 Moal Farm Track Proposed View	FIG ##		Drawn by:	PM	Project: Iona Breakwater	Client: Argyll & Bute Council	rps Making Complex Easy Elmwood House, 74 Boucher Road BELFAST, BT12 6RZ 028 9066 7914
Date	22.10.21 - 13.45	Northing	723902		Projection:	OSGB	Checked:	RH			
View height	1.56 m AGL	Direction	90°		Data Source:	RPS 2022	Job Ref:	NI 2353			
Field of View	60°	Distance	425 m		Status:	Draft	Date:	Oct 2022			

Baseline image

Map image

Tripod location

-

-

Title:

Project:

Iona Breakwater

Client:

Argyll & Bute COUNCIL

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Photomontage

Map image

Tripod location

-
-

Title:

Project:

Iona Breakwater

Client:

Argyll & Bute COUNCIL

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Baseline image

Map image

Tripod location

-	Title:
-	
2353	Project: Iona Breakwater
2022	Client: Argyll & Bute Council

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Photomontage

Map image

Tripod location

-
-

Title:

2353

2022

Project:

Iona Breakwater

Client:

Argyll & Bute COUNCIL

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Baseline image

Map image

Tripod location

- -	Title:	PM RH NI 2353 Oct 2022	Project: Iona Breakwater	Client: Argyll & Bute COUNCIL

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

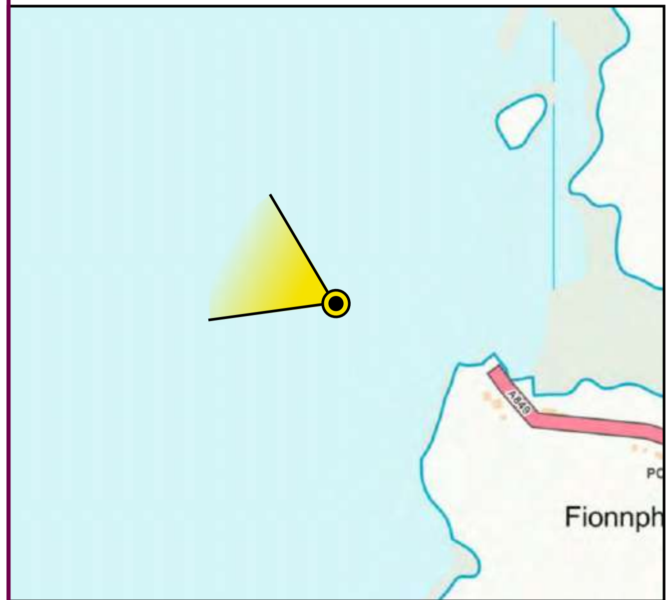
Photomontage

Map image

Tripod location

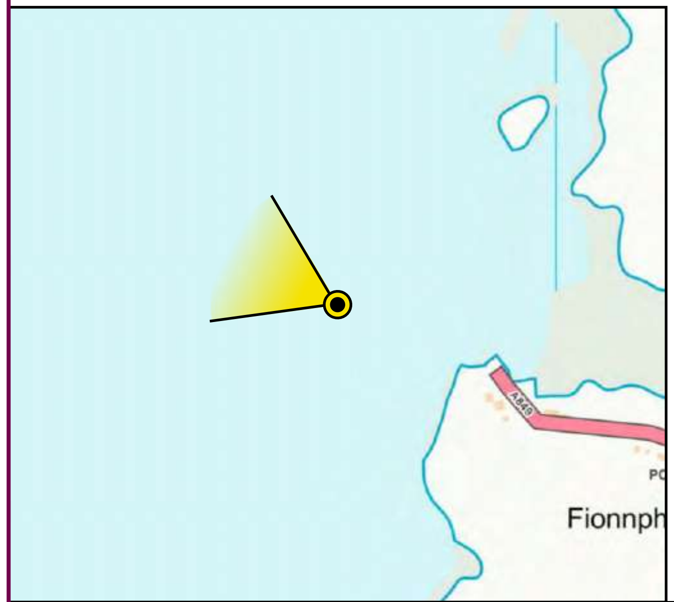
- -	Title:	PM RH NI 2353 Oct 2022	Project: Iona Breakwater	Client: Argyll & Bute Council

rps
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914



Map image

Camera	Sony ILCE-7RM3	Easting	129621	Title: VP05 On the Ferry Existing View	FIG ##	Drawn by:	PM	Project: Iona Breakwater	Client: Argyll & Bute Council	rps Making Complex Easy
Date	22.10.21 - 12.20	Northing	723584		Projection: OSGB	Checked:	RH			Elmwood House, 74 Boucher Road
View height	1.56 m AGL	Direction	305°		Data Source: RPS 2022	Job Ref:	NI 2353			BELFAST, BT12 6RZ
Field of View	60°	Distance	1000 m		Status: Draft	Date:	Oct 2022			028 9066 7914



Map image

Camera	Sony ILCE-7RM3	Easting	129621	Title: VP05 On the Ferry Proposed View	FIG ##		Drawn by:	PM	Project: Iona Breakwater	Client: Argyll & Bute Council
Date	22.10.21 - 12.20	Northing	723584		Projection:	OSGB	Checked:	RH		
View height	1.56 m AGL	Direction	305°		Data Source:	RPS 2022	Job Ref:	NI 2353		
Field of View	60°	Distance	1000 m		Status:	Draft	Date:	Oct 2022		

rps
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Baseline image

Map image

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Title:

wn by:	PM
cked:	RH
Ref:	NI 2353
e:	Oct 2022

Project:

Iona Breakwater

Client:

Argyll & Bute Council

rps
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Map image

Camera	Sony ILCE-7RM3	Easting	128999	Title:	VP06 On the Ferry Approaching Iona Proposed View
Date	22.10.21 - 12.25	Northing	723780		
View height	1.56 m AGL	Direction	305°		
Field of View	60°	Distance	265 m		

FIG ##		Drawn by:	PM
Projection:	OSGB	Checked:	RH
Data Source:	RPS 2022	Job Ref:	NI 2353
Status:	Draft	Date:	Oct 2022

Project: Iona Breakwater

Client: Argyll & Bute Council

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Baseline image

Map image

Tripod location

-
-

Title:

Project:

Iona Breakwater

Client:

Argyll & Bute COUNCIL

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Photomontage

Map image

Tripod location

Camera	Sony ILCE-7RM3	Easting	128462
Date	22.10.21 - 12.50	Northing	723830
View height	1.56 m AGL	Direction	60°
Field of View	60°	Distance	175 m

Title:
VP07
Martyrs Bay - Roadside
Proposed View

FIG ##		Drawn by:	PM
Projection:	OSGB	Checked:	RH
Data Source:	RPS 2022	Job Ref:	NI 2353
Status:	Draft	Date:	Oct 2022

Project:
Iona Breakwater

Client:
Argyll & Bute Council

rps MAKING COMPLEX EASY
Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Baseline image

Map image

Tripod location

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Title:

Project:

Iona Breakwater

Client:

Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

Photomontage

Map image

Tripod location

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Title:

Project:

Iona Breakwater

Client:

Elmwood House, 74 Boucher Road
BELFAST, BT12 6RZ
028 9066 7914

APPENDIX 16.1

Cultural Heritage Baseline

IONA BREAKWATER PROJECT

Heritage Baseline

JAC27210
Iona_DBA
1
November 2022

rpsgroup.com

Quality Management					
Version	**Status**	**Authored by**	**Reviewed by**	**Approved by**	**Review date**
[Text]	[Text]	[Text]	[Text]	[Text]	[Text]

Approval for issue		
[Name]	[Signature]	[Date]

File/Model Location	
Document location:	V:\Jobs Directory\27000-27999\27210_Iona and Fionnphort\Reports\DBA\JAC27210_Iona_DBA_1_221128_Report.docx
Model / Appendices location:	

Prepared by:

RPS

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Prepared for:

Argyll and Bute Council

Argyll and Bute Council
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EXECUTIVE SUMMARY

In keeping with relevant guidance, this baseline assessment draws together the available evidence in order to clarify the heritage significance and archaeological potential of the Iona Ferry Terminal and to identify heritage assets in the surrounding area that may be affected by the proposed upgrading of the terminal.

The Site lies partially within the Baile Mor Conservation Area and it is considered that the Proposed Development will affect the Conservation Area and the setting of St Mary's Abbey, which is both a Scheduled Monument and a Category A Listed Building, MacLeans Cross and Iona Nunnery, both of which are Scheduled Monuments, and the Replica of St John's Cross, which is a Category A Listed Building. It is considered that the proposed development will affect these. The assessment of impacts is presented in the EIAR Chapter.

The bays to the north and south of the terminal are natural landings and are likely to have seen activity through all periods, but given the conditions and the results of the review of hydrographic data it is considered that the potential for previously unrecorded heritage assets to be present below the high water mark is low in respect of the Medieval and earlier periods and negligible for Post-Medieval and Modern periods. The site of the proposed temporary construction compound lies adjacent to An Eala, the site an Early Medieval or Medieval cemetery, and the traditional line of the Street of the Dead. The results of a previous geophysical survey indicate that features associated with An Eala, namely a revetting wall or kerb and a possible ditch extend into the area of the temporary construction compound. No trace of features relating to the Street of the Dead has been recorded. It is considered that there is high potential for related archaeology to An Eala to be present within the temporary working area. The potential elsewhere is considered to be negligible.

Contents

Figures

Appendices

1 INTRODUCTION AND SCOPE OF STUDY

1.1 This report has been prepared by Richard Conolly MA(Hons) MCIfA of RPS on behalf of Argyll & Bute Council Ltd.

1.2 The subject of this baseline assessment, henceforth referred to as the Site, takes in the pier and slipway and adjacent land and seabed at Iona, Mull (Figure 1, site centre NGR NM 287 240). It is proposed to construct a rock armour breakwater and berthing piles. In addition, an area of approximately 3400m^2 will be dredged to a depth of 3m below chart datum (CD) to accommodate the navigation channel requirements. The dredged material will be disposed of at the nearest licenced site.

1.3 This assessment has been prepared in accordance with relevant policy and guidance and considers the potential effects of the proposed development upon heritage assets, both during the construction and operation. It draws upon the following data sources:

- Historic Environment Scotland designations downloads;
- National Record of the Historic Environment (NRHE);
- West of Scotland Archaeology Service (WoSAS) Historic Environment Records (HER);
- Maps and charts held by the National Library of Scotland;
- UK Hydrographic Office data (INSPIRE);
- Geotechnical data;
- Satellite imagery; and
- Readily available published sources.

1.4 The desk-based work was augmented and verified through a site visit and the archaeological assessment of hydrographic data (MSDS 2021). The study provides an assessment of the archaeological potential of the Site and the significance of heritage assets within and around the Site, and considers the potential impacts of the study upon these. The consideration of potential impacts upon designated heritage assets (Figure 2) in the surrounding area has been undertaken in accordance with the guidance provided in Managing Change in the Historic Environment: Setting (HES 2020), which advocates the use of a three-stage process:

- Stage 1: Identify the historic assets that may be affected by the proposed development.
- Stage 2: define and analyse the setting by establishing how the surroundings contribute to the ways in which the historic asset or place is understood, appreciated and experienced.
- Stage 3: evaluate the potential impact of the proposed changes on the setting, and the extent to which any negative impacts can be mitigated

Only Stage 1 and 2 are contained in this baseline. Where it is identified that assets will be adversely affected, Stage 3 is presented in the EIAR Cultural Heritage chapter.

2 PLANNING BACKGROUND AND DEVELOPMENT PLAN FRAMEWORK

Legislation

2.1 The Ancient Monuments and Archaeological Areas Act 1979 and the Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997 provide the legislative basis for the protection of the historic environment. Of particular relevance in the current context, are the statutory duties placed on the decision maker by the latter:

59. General duty as respects listed buildings in exercise of planning functions.

(1) In considering whether to grant planning permission for development which affects a listed building or its setting, a planning authority or the Secretary of State, as the case may be, shall have special regard to the desirability of preserving the building or its setting or any features of special architectural or historic interest which it possesses.

(2) Without prejudice to section 64, in the exercise of the powers of disposal and development conferred by the provisions of sections 191 and 193 of the principal Act, a planning authority shall have regard to the desirability of preserving features of special architectural or historic interest and, in particular, listed buildings.

(3) In this section, “preserving”, in relation to a building, means preserving it either in its existing state or subject only to such alterations or extensions as can be carried out without serious detriment to its character, and “development” includes redevelopment.

64. General duty as respects conservation areas in exercise of planning functions.

(1) In the exercise, with respect to any buildings or other land in a conservation area, of any powers under any of the provisions in subsection (2), special attention shall be paid to the desirability of preserving or enhancing the character or appearance of that area.

(2) Those provisions are—

(a) the planning Acts, and

(b) Part I of the Historic Buildings and Ancient Monuments Act 1953.

2.2 The above acts were amended by the Historic Environment (Amendment) (Scotland) Act 2011.

2.3 Marine historic assets of national importance within Scottish Territorial Waters (STW) are protected primarily by the Marine (Scotland) Act 2010 (content available on the UK Government Website accessed August 2022 - legislation.gov.uk), in particular Part 5 Section 73. This states that an area may be designated as an Historic Marine Protected Area (MPA) if Scottish Ministers consider it desirable to preserve a marine historic asset which is located in the area.

2.4 A marine historic asset is defined as a vessel, vehicle or aircraft (or part of), the remains of a vessel, vehicle or aircraft (or part of), an object contained in or formerly contained in a vessel, vehicle or aircraft, a building or other structure (or part of), a cave or excavation, and a deposit or artefact or any other thing which evidences previous human activity.

2.5 The purpose of Historic MPAs is to preserve by law, marine historic assets of national importance. There is no requirement for specific permission to carry out work inside a Historic MPA, however permission under the Town and Country (Scotland) Planning Act (1997) or a Marine Licence (ML) under the Marine and Coastal Access Act (MCCA) 2009 (in waters 12 nm to 200 nm), or under the Marine (Scotland) Act 2010 (from Mean High Water Springs (MHWS) to 12 nm) may be required (content available on the United Kingdom (UK) Government Website accessed August 2022 legislation.gov.uk).

2.6 Clear preservation objectives are provided for each Historic MPA and their boundaries define an exclusion zone to activities that could lead to disturbance of the marine historic asset.

2.7 In Scotland, the Marine Scotland Act 2010 has replaced Section 1 of the Protection of Wrecks Act 1973.

2.8 Section 2 of the Protection of Wrecks Act 1973 (content available on the UK Government Website accessed August 2021 legislation.gov.uk) provides guidance on the protection of wrecks that are designated as dangerous due to their contents. Protections are administered by the Maritime and Coastguard Agency (MCA) through the Receiver of Wreck (RoW).

2.9 The Protection of Military Remains Act 1986 makes it an offence to interfere with the wreckage of any crashed, sunken or stranded military aircraft or designated vessel, without a licence. This is irrespective of whether there was loss of life associated with the wreck, or whether the loss of the aircraft or vessel occurred during peacetime or wartime.

2.10 All crashed military aircraft receive automatic protection under this Act, but vessels must be individually designated. There are two levels of protection offered by this Act:

- designation as a Protected Place: Protected Places include the remains of any aircraft which crashed while in military service or any vessel designated (by name, not location) which sank or stranded in military service after 04 August 1914. Although crashed military aircraft receive automatic status as a Protected Place, vessels need to be specifically designated by name. The location of a vessel does not need to be known for it to be designated as a Protected Place; and
- designation as a Controlled Site: Controlled Sites are designated areas which encompass the remains of military aircraft or a vessel sunk or stranded in military service within the last 200 years. Diving operations are effectively prohibited in these sites without a specific licence granted by the Secretary of State in accordance with the provisions of the Act.

National Planning Policy

2.11 Scottish Planning Policy (SPP; June 2014) provides national policy for dealing with the historic environment in the planning process in paragraphs 135-151. SPP stresses that the planning system should promote the care and protection of the historic environment and that change should be sensitively managed to avoid or minimise adverse impacts on assets. Additional policy in relation to the historic environment is provided in Historic Environment Policy for Scotland (HEPS, 2019) and a strategy has been set out in 'Our Place in Time - the Historic Environment Strategy for Scotland' (2014).

2.12 GEN 6 Historic Environment of Scotland's National Marine Plan (Scottish Government 2015) states that:

Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance.

2.13 Paragraph 4.24 requires that development proposals that may affect the historic environment should be supported by information on the significance of known heritage assets and the potential for new discoveries to arise and how impacts will be avoided, minimised or mitigated. Where this is not possible the benefits of the proposal should be set out. Paragraph 4.25 requires that where substantial change to a heritage asset is accepted, applicants should be required to undertake suitable mitigating actions to record and advance understanding of the asset in a proportionate manner.

2.14 In July 2011, the government published the Planning Advice Note PAN 2/2011: Planning and Archaeology. It provides advice and technical information alongside SPP, HEPS and the Managing Change in the Historic Environment Guidance Notes, which together set out the Scottish Ministers' policies and guidance for planning and the historic environment.

2.15 Sections 4-9 of the PAN, entitled Archaeology and Planning provides guidance for planning authorities, property owners, developers and others on the policy of the Scottish Government relating to archaeological sites and monuments. Overall, the guidance can be summarised:

- Policy is to protect and preserve sites and monuments and their settings in situ where feasible. Where this is not possible planning authorities should consider applying conditions to consents to ensure that an appropriate level of excavation, recording, analysis, publication and archiving is carried out before and/or during development.
- In consideration of applications, planning authorities should take into account the relative importance of archaeological sites. Not all sites and monuments are of equal importance. In determining planning applications that may impact on archaeological features or their setting, planning authorities may balance the benefits of development against the importance of archaeological features.

2.16 Section 12 of the PAN notes that when determining a planning application, the desirability of preserving a monument (whether scheduled or not) and its setting is a material consideration. It reiterates that preservation in situ should be the objective but where not possible an alternative approach is recording and/or excavation followed by analysis and publication of the results.

2.17 Sections 13 and 14 note that prospective developers should undertake assessment to determine whether a property or area contains, or is likely to contain, archaeological remains as part of their pre-planning application research into development potential. Where it is known, or there is good reason to believe, that significant remains exist developers should be open to modifying their plans in order to preserve remains.

2.18 Section 17 notes that in many cases a desk-based assessment (this document) may be sufficient to allow authorities to make a planning decision. Where the judgement of the authority's archaeological advisor indicates that significant remains may exist, it is reasonable for the planning authority to request an archaeological evaluation before the application is determined. Planning authorities should require only the information necessary for them to make an informed decision on the proposal, and this should be proportionate to the importance of the potential resource.

2.19 Section 19 notes that developers should supply the results of desk-based assessments and evaluations as part of their planning applications.

2.20 The UK Marine Policy Statement (MPS) sets out high level marine objectives for ensuring that marine resources are used in a sustainable way. It was published by the UK Government in 2011.

2.21 Section 2.6.6 of the MPS sets out the aspects of the historic environment that merit consideration in marine planning and advises that heritage assets should be conserved through marine planning in a manner appropriate and proportionate to the significance of the asset. When considering the significance of a heritage asset and its setting, the marine planning authority should take into account the particular nature of the interest held in the asset and the value it might hold for this and future generations.

2.22 Designated heritage assets in coastal/intertidal zones and inshore/offshore waters may include Scheduled Monuments, Protected Wreck Sites and sites designated under the protection of the Military Remains Act 1986. Non-designated heritage assets of equivalent status should be considered under the same policy principles as designated heritage assets.

2.23 Where the loss of the whole or material part of a heritage asset's significance is justified, suitable mitigation measures should be put in place. Mitigation requirements should be based on advice from relevant regulators and advisors.

2.24 The Scottish National Marine Plan (NMP) was published in 2015 and reviewed in 2018 and 2021 and sets out high-level objectives for managing offshore development and advise for the preparation of future Regional Marine Plans.

2.25 General Policy 6 within the National Marine Plan relates to the historic environment and states that '*Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance*'.

2.26 The NMP advises that designated heritage assets should be protected in situ within an appropriate setting, and that substantial loss of harm to designated assets should be exceptional and should only be permitted 'if this is necessary to deliver social, economic or environmental benefits that outweigh the harm or loss '.

2.27 The NMP further identifies that non-designated heritage assets that meet designation criteria or make a positive contribution should also be protected in situ, wherever possible, and consideration given 'to the potential for new discoveries of historic or archaeological interest to arise'.

2.28 The NMP outlines that proposals for development that may '*affect the historic environment should provide information on the significance of known heritage assets and the potential for new discoveries to arise. They should demonstrate how any adverse impacts will be avoided, or if not possible, minimised and mitigated. Where it is not possible to minimise or mitigate impacts, the benefits of proceeding with the proposal should be clearly set out'*.

2.29 The NMP also states that 'where the case for substantial change to heritage asset is accepted, marine decision-making authorities should require applicants to undertake suitable mitigating actions to record and advance understanding of the significance of the heritage asset before it is lost, in a manner proportionate to that significance'.

Local Planning Policy

2.30 The Argyll and Bute Local Development Plan was adopted in 2015. Detailed policy is presented in Supplementary Guidance (adopted 2016) and contains the following policy relating to the historic environment that are relevant in the current context:

SG LDP ENV 20 – Development Impact on Sites of Archaeological Importance

1. There is a presumption in favour of retaining, protecting, preserving and enhancing the existing archaeological heritage and any future discoveries found in Argyll and Bute. When development is proposed that would affect a site of archaeological significance, the following will apply:

(a) The prospective developer will be advised to consult the Council and its advisers the West of Scotland Archaeology Service at the earliest possible stage in the conception of the proposal; AND,

(b) An assessment of the importance of the site will be provided by the prospective developer as part of the application for planning permission or (preferably) as part of the pre-application discussions.

2. When development that will affect a site of archaeological significance is to be carried out, the following will apply:

(a) Developers will be expected to make provision for the protection and preservation of archaeological deposits in situ within their developments, where possible by designing foundations that minimise the impact of the development on the remains; AND,

(b) Where the Planning Authority deems that the protection and preservation of archaeological deposits in situ is not warranted for whatever reason, it shall satisfy itself that the developer has made appropriate and satisfactory provision for the excavation, recording, analysis and publication of the remains.

3. Where archaeological remains are discovered after a development has commenced, the following will apply:

(a) The developer will notify the West of Scotland Archaeology Service and the Council immediately, to enable an assessment of the importance of the remains to be made; AND,

(b) Developers should make appropriate and satisfactory provision for the excavation, recording, analysis and publication of the remains. (Developers may see fit to insure against the unexpected discovery of archaeological remains during work).

Note: The West of Scotland Archaeology Service must be consulted for all sites in each category

2.31 In line with relevant planning policy and guidance, this desk-based assessment seeks to clarify the site's archaeological potential and the likely significance of that potential.

3 GEOLOGY AND TOPOGRAPHY

Geology

3.1 The Site is underlain by sandstone and metasandstone of the Iona Group with a dyke of camptonite and monchiquite at the southern end of St Ronan's Bay (www.bgs.co.uk). In St Ronan's Bay superficial deposits comprise marine deposits of sand, behind which are raised beach deposits of gravel, sand and silt. The sand in the bay is coarse with shell fragments (Causeway Geotech 2018 & Structural Soils 2020).

Topography

3.2 The proposed development is located at the southern end of St Ronan' Bay and northern end of Martyrs Bay. The bays have sandy beaches but around the existing jetty, including the area of the proposed breakwater there is only bare rock (Plates 1-7).

3.3 The greater part of the Site lies below Mean High Water Springs (MHWS). The seabed shelves gently. Within the area of proposed dredging, it lies between 0.8 and 3.4m below chart datum (CD). In the area of the proposed rock armour, it lies 4.2m below CD at its deepest.

4 DESIGNATED HERITAGE ASSETS

Introduction

4.1 This section presents Stages 1 and 2 of the three-stage approach to assessing the impact of change in the setting of heritage assets (HES 2016). Stage 3, evaluating the impact is presented in the EIAR chapter. The Stage 2 element focuses on those aspects that are relevant to the current assessment, in particular relationships with the wider landscape.

Stage 1: Identify Receptors

4.2 Within the study area there are:

- Three Scheduled Monuments:
  - Iona Nunnery (SM90350) – 150m to the north-west of the breakwater;
  - MacLean's Cross (SM90173) – 280m to the north-west of the breakwater;
  - St Mary's Abbey, Iona, monastic settlement (SM12968) – 280m to the north of the breakwater.
- Four Listed Buildings:
  - Iona Abbey (LB12310 – Category A) – 560m to the north of the breakwater;
  - Iona Kirk (LB12318 – Category B) – 300m to the north-west of the breakwater;
  - Iona Manse (LB12319 – Category C) – 280m to the north-west of the breakwater; and
  - Replica of St John's Cross (LB52541 – Category A) – 550m to the north of the breakwater.
- One Conservation Area:
  - Iona.

4.3 There are no Inventory Gardens, Designed Landscapes or Battlefields within the study area. Nor are there any Historic Marine Protected Areas or Protected Military Remains.

4.4 The cultural significance of the Scheduled Monuments and Category A Listed Buildings is inter-related by their common history relating to Iona as a place of pilgrimage and their location on the pilgrims' route to the abbey. Consequently, whilst there is no intervisibility between the Site and Iona Nunnery, McLean's Cross, and the replica of St John's Cross, development of the Site will affect their setting to some degree as all visitors will pass the proposed development when arriving on the island. The abbey, nunnery and crosses have therefore been identified as receptors and taken through to Stages 2 and 3.

4.5 The Site lies at the fringe of the Iona Conservation Area. It is seen both from within the Conservation Area and when approaching from the sea. The Conservation Area has therefore been taken through to Stages 2 and 3.

4.6 There is no intervisibility between the Site and Iona Kirk and Manse, both of which are of 19th century date. They are not inherently tied to the island's history as a place of pilgrimage and it is not considered that there is potential for the Proposed Development to affect their setting and they are not considered further.

4.7 The cultural significance of the scheduled monuments is detailed in the appended Statements of Significance and that of the Listed Buildings in the appended listing descriptions and statements of special interest. The summaries are provided in the following section.

Stage 2: Define and Analyse Setting

St Mary's Abbey, Iona, monastic settlement (SM12968 & LB12310)

Cultural Significance

Iona and its abbey, inextricably linked to St Columba, are recognised by people around the world as a special, sacred place. It has a universally acknowledged spiritual presence, which together with the heritage of sanctity contribute to a numinous and sublime quality perceived by most visitors. This sets it apart from other properties in care. The following bullet points outline the most important aspects which contribute to Iona's cultural significance:

- *Iona Abbey has had an important spiritual, cultural and political influence on Scotland (and sometimes further afield) for many centuries, from the time of Columba to the era of the Lords of the Isles.*
- *The legacy of St Columba can still be tangibly felt when visiting the site. The tiny shrine chapel (though extensively rebuilt) holds the greatest cultural significance of any of the buildings on Iona. It was created to contain Columba's relics which were the richest treasure of the monastery. It is probably the oldest church building in Scotland. Radiocarbon dating has confirmed that a structure atop Tòrr an Aba dates from Columba's time and thus is likely to be his writing hut.*
- *Iona contains the largest and most important collection of early sacred sculpture of any British monastery. This includes the spectacular high crosses such as St Martin's which has stood in its original position outside the monastery for 1250 years. The Lapis Echodi inscribed stone may be the oldest surviving memorial to a king in Britain. Eochaid Buide, king of Dal Riata died c 629.*
- *Iona was a major centre of literacy, the introduction of which revolutionised life in Scotland, especially in relation to governance. The Iona chronicles dating from 630-720 are amongst the oldest post-Roman chronicles in Europe and it is now widely accepted that the Book of Kells, the finest Gospel book of the western European church, was produced on Iona around 800.*
- *Adomnán's Life of Columba, written on Iona c 690, is a prime evidential resource which provides unique insights into the reality of the monastery and the island during his own lifetime and places associated with Columba. Another Adomnán work, De Locis Sanctis, is an account of Christianity's sacred places, including Jerusalem. It provides a framework for understanding how the planning and development of Iona and its liturgical landscape was conceived as a reflection of the heavenly Jerusalem.*
- *The site exhibits the best preserved and most complex physical remains of an early monastery in Britain; it is therefore of immense research value. The vallum, the shrine chapel, Sràid nam Marbh, Torr an Aba and the high crosses represent extraordinary, in-situ evidence of the reality of the Columban monastery.*
- *The Benedictine Abbey is the largest and most elaborate ecclesiastical foundation in the West Highlands and Islands. Its design features express particularly the importance of pilgrimage in the planning of the site. Contemporary with the abbey, the Nunnery is one of only two Augustinian nunneries in Scotland and is one of the best-preserved medieval convents in Britain. Its presence evidences the importance of women's participation in religious life and especially pilgrimage. For further details see HES Statement of Significance, Iona Nunnery, St Ronan's Church and MacLean's Cross.*
- *Reilig Odhrain is of considerable importance as the burial place of the monastic communities, and of some kings. In later medieval times it was the popular burial place of the best men of*

the clans, their graves covered by more than 100 beautifully carved slabs. Today it retains significance as the last resting place of people of national and local importance such as the burial here of John Smith, leader of the Labour Party, in 1994.

- *The patronage of the Gaelic-Norse lords and then the Lords of the Isles has led to the presence of a large and important collection of carved stones at the abbey, although it is difficult to know for certain which of the later graveslabs were produced here. The later medieval graveslabs can illuminate many aspects of life and society amongst the clergy and warrior elites of the West Highlands.*
- *Iona is also significant as a place of pilgrimage. Since the time of Columba's death people have come from afar and walked along Sràid nam Marbh, following in the footsteps of saints and hoping their prayers would be answered. Pilgrimage is a continuing tradition in the life of the island.*
- *The various phases of conservation and restoration at the abbey, particularly in the 19th and early 20th century, are testament to the continuing significance of Iona. In particular the circumstances around the creation of the Iona Cathedral Trust and the rebuilding work by Rev. George Macleod are of considerable social significance, particularly in regard to the development of so-called Celtic spirituality.*

(HES 2018, 3-5)

Contribution of Setting

4.8 The Abbey's setting makes a substantive contribution to its cultural significance. The relevant aspects comprise:

- Views of the Abbey when approaching the island on the ferry. This is the first view of the Abbey. The site of the abbey against the rugged backdrop of the island is striking and provides a distinct sense of arrival in a 'special' place. It is easy for the visitor to appreciate the sense of awe that must have been felt by Medieval pilgrims as when nearing the end of their journey they were confronted by the abbey.
- Views of the Abbey from the landing jetty. These are again aesthetically striking; the abbey is seen on the skyline above the houses in the foreground from the jetty and the bay to the north. Views from south of the jetty (ie Martyrs Bay) to the Abbey are possible, but the modern buildings at the fringe of these views rather clutter them and are likely to detract from their aesthetic appreciation. In addition to their aesthetic value, these views are important as they a provide a tangible connection between the historic landing points and the abbey and thereby contribute to a sense of continuity between modern day visitors and Medieval pilgrims. The modern buildings do not detract from this aspect.
- The approach to the Abbey. This has a processional quality and ties the abbey into other key elements of the ecclesiastical site. Most visitors will follow the sign from the jetty and walk along the road east, following the line of the Medieval Martyr Street, past the nunnery before turning north towards the abbey. Initially the abbey is partially obscured by trees, but is then clearly visible, appearing to stand at the end of the road. They then pass MacLean's Cross, where the road doglegs before heading north again past St Oran's Chapel and the associated graveyard, Reilig Odhrain.
- *The view east across the Sound from the front of the abbey is of great significance. This was where the monks expected to see the risen Christ appear on the last day. The view is spectacular, and entirely natural and unchanged since Columban times, with progressive bands of green field, shoreline, water, the blood red Mull granite, with a band of higher dark hills behind, then the sky* (HES 2018, 23).

Iona Nunnery (SM90350) and MacLean's Cross (SM90173)

Cultural Significance

- *Iona Nunnery is one of the best-preserved medieval nunneries in Britain, and one of only two houses of Augustinian nuns established in Scotland.*
- *Iona Nunnery forms part of an internationally-renowned group of monuments set within an almost wholly unspoilt landscape, attracting what is thought to be in excess of 100,000 visitors each year.*
- *The nunnery is built adjacent to an early Christian burial ground, which may be as old as the primary phase of missionary activity on Iona, forming a link between the early monastery and the later convent.*
- *Architectural details throughout the nunnery are of high quality indicating its importance and significance. The convent church possessed one of the few rib-vaults in the Western Highlands.*
- *The 15th century enlargements suggest the nunnery continued to flourish in the later Middle Ages, a time when many religious houses were declining.*
- *St Ronan's Church, adjacent to the nunnery, occupies the site of an early Christian church possibly dating from the 8th century, itself built on the site of an earlier burial ground. It houses an excellent collection of late medieval West Highland style graveslabs, all the work of masons of the Iona School of carving. Iona was instrumental in the creation of a distinctive West Highland style of carving, one of the most important cultural developments in late medieval Scotland.*
- *Several famous travellers have visited the monument since the Reformation, including Martin Martin, James Boswell and Dr Samuel Johnson, Sir Walter Scott, Prince Albert and Felix Mendelssohn.*
- *Prince Albert's visit in 1847 helped create an interest in the island as a fashionable holiday destination, much in the same way as Victoria and Albert's travels through the Highlands did.*
- *MacLean's Cross is one of a significant group of 15th-century carved stones produced by the Iona School of carvers.*

(HES 2005, 5-6)

Contribution of Setting

4.9 The nunnery has not been restored to the same extent as the abbey and its more modest ruins are much less visible in the landscape; although visible from the ferry, they are generally lost to view amongst the surrounding buildings. The ruins have a somewhat enclosed feel and some sense of seclusion. Consequently, direct visual relationships with the surroundings make a relatively slight contribution to their significance. However, as noted above, they are passed by visitors on their way to the abbey and will be experienced as a part of the wider ecclesiastical site. Consequently, despite the lack of visual relationships, the nunnery's setting makes a substantial contribution to its cultural significance.

Replica of St John's Cross (LB52541 – Category A)

Cultural Significance

The Mac-samhail Crois Naoimh Eòin / replica of St John's Cross meets the criteria of special architectural or historic interest for the following reasons:

- *It is unique as the only full-scale and accurate (as was known at the time) replica in the primary location of the original early medieval high cross.*
- *It is of significance because of the scholarly, artistic, engineering and craft skills that went into its unusual, materially 'authentic' design and execution in concrete to accurately resemble the exceptional quality and intricacy of the carvings of the original cross (as known at the time).*
- *It is an integral part of the history and contemporary experience of Iona, its authenticity, social, communal, sacred and spiritual values.*

Contribution of Setting

This replica cross has been erected in the composite box-like base of the original cross. It sits immediately in front of the west gable of St Columba's shrine-chapel. The shrine was and remains the most important building on Iona because it was built over Columba's burial. As in the past, the physical setting of the replica continues to affect how people encounter and experience it, generating diverse social, communal, sacred and spiritual values.

The positioning of Iona's high crosses within the symbolic and physical setting of the abbey is critical to understanding their significance. A feature of contemporary special interest is that the St John's Cross replica casts a shadow on the shrine in the late afternoon and evening as the original cross was designed to do. The interplay with natural phenomena such as sunlight and the casting of shadows onto other structures or locations is understood to be a deliberate design feature of these high crosses. The shadow positions of the crosses would have figured prominently in the daily lives of the monks, as a constant reminder of the canonical hours of worship.

Iona has the largest and most important collection of sacred sculpture of any early British monastery, long recognised as among the most significant collections of early medieval art in Europe. The St John's Cross is part of a group of historic high crosses on Iona, along with St Martin's Cross and St Oran's Cross. St John's Cross is the most ambitious and has become a symbol of Iona.[1]

Iona Conservation Area

4.10 There is no Conservation Area Appraisal. It is outside the scope of the current study to carry out a full appraisal of the Conservation Area and the following focuses on those elements that are relevant in the current context.

4.11 The Conservation Area is extensive and varied. In its north-eastern part it takes in the scheduled area of St Mary's Abbey. This area is grassy and open, dominated by the Abbey. The north-western part takes in craggy ground rising to the west, with scattered buildings. The central part takes in core of the settlement of Baile Mor. This consists of a row of primarily 19th century cottages and the Argyll Hotel along the western side of the village street. To the east of the street is a strip of land occupied by their gardens, beyond which is the sandy beach of St Ronan's Bay, fringed with rocks. To the rear are their gardens, open space and Iona Nunnery, beyond which is Main Street, leading to the Abbey. MacLean's Cross stands at the point Sraid nam Marbh (Street of the Dead), and St Ronan Street formerly converged. The former ran from Port nam Mairtir and the latter from St Ronan's Bay. To the west of the road is further open ground, the 19th century kirk and former manse, both Listed Buildings, and a row of modern cottages. The Conservation Area takes in the craggy rising ground to the west of these. The historic southern limit of the settlement

[1] http://portal.historicenvironment.scot/designation/LB52541

is marked by the road leading from the slipway to Main Street, this follows the line of the Medieval Martyr Street. The Conservation Area to the south of this road, is primarily occupied by fields, with buildings scattered along the road. These are a mixture of 19th century cottages and houses and modern buildings, most notably the Martyr's Bay restaurant next to the ferry slipway.

4.12 The Conservation Area's cultural significance derives from its unique character and appearance which are a product of its rich ecclesiastical history and its landscape setting, in particular:

- The visible remains of buildings and features associated with the island's ecclesiastical history, including the vallum bank and ditch, which defined the early monastic enclosure, the high crosses, Augustinian nunnery, Benedictine monastery, St Oran's Chapel and Reilig Odhrain cemetery.
- Landscape features with strong historical relationships with the monastery, including Tòrr an Aba (hill of the abbot), Port nam Mairtir and St Ronan's Bay.
- A street plan that reflects and incorporates elements of the Early Medieval and Medieval Sraid nam Marbh processional way, Martyr Street and St Ronan Way. This combined with the presence of the nunnery and MacLean's Cross which are passed on the way to the Abbey, which is the focus of northward views on Main Street, creates a strong feeling of continuity of religious practices. This street plan also includes numerous open areas allowing numerous views to the surrounding landscape and seascape.
- The scale and stye of the later, primarily 19th century, buildings and the materials is characteristic of western Scotland and complement the aesthetics of the earlier buildings and surrounding landscape creating a strong sense of place, which ties in to spiritual and religious associations of the island. This is experienced not only whilst moving around the Conservation Area, but also when approaching on the ferry.

4.13 There are few detracting features. The scattering of late 20th century buildings and structures includes several that are unsympathetic in their design and finish, most notable in the current context being the Martyrs Bay Restaurant adjacent to the jetty. These have only a very localised impact. Perhaps the largest detracting factor may be the very large numbers of tourists visiting the island, which at certain times of year may be felt to detract from the sense of the island being a place of religious contemplation.

5 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND WITH ASSESSMENT OF SIGNIFICANCE

Timescales used in this report

Prehistoric

Palaeolithic	450,000 -	10,000 BC
Mesolithic	10,000 -	4,000 BC
Neolithic	4,000 -	1,800 BC
Bronze Age	1,800 -	600 BC
Iron Age	600 -	AD 410

Historic

Early Medieval	AD 410 -	1100
Medieval	AD 1100 -	1560
Post Medieval	AD 1560 -	1745
Modern	AD 1745 -	Present

Introduction

5.1 This section briefly reviews the relevant archaeological evidence for the Site and the surrounding area, and, in accordance with SPP, considers the potential for any as yet to be discovered archaeological evidence on the Site. There is a very large body of archaeological and historical information for this area, reflecting the importance of Iona in the Early Medieval and Medieval periods as an ecclesiastical centre. However, the Site lies in the inter-tidal zone and below the low-water mark. That part in the intertidal zone comprises bare rock and hence has no archaeological potential. Consequently, the evidence of activity above the high-water mark is considered only so far as it is relevant to the potential of that part of the Site below the low-water mark.

5.2 This section considers data for a study area extending 500m from the Site (Figures 2, 3 & 4) from Historic Environment Scotland datasets, WoSAS Historic Environment Record (HER) and the National Record of the Historic Environment (NRHE), together with a historic map regression exercise charting the development of the study area from the 19th century. In addition, the INSPIRE Wrecks dataset maintained by the UK Hydrographic Office (UKHO), geotechnical data has been examined and bathymetry data has been reviewed (MSDS 2021).

Non-Designated Heritage Assets (Terrestrial)

5.3 No non-designated heritage assets have been recorded previously in the Site. Whilst the HER contains an entry for the slipway (46066), this 20th century structure cannot be considered to represent a heritage asset.

5.4 The HER contains 66 entries for the study area. They are discussed where relevant below.

Non-Designated Heritage Assets (Maritime)

5.5 There are no Canmore Maritime records for the study area.

5.6 The UKHO's Inspire dataset does not hold any records of wrecks or obstructions in the study area.

5.7 Bathymetry data has been assessed as part of this project (MSDS 2021) to identify potential anthropogenic material and anomalies that may be of archaeological interest. This identified no anomalies within the footprint of the proposed breakwater or dredging area. Three anomalies were identified in the wider study area. These were all considered to have low archaeological potential, with two being likely to be debris and one probably geological in origin (Figure 3).

Previous Archaeological Work

5.8 No intrusive works have been undertaken previously within the Site. However, a geophysical survey undertaken in 2016 (Rose 2016) took in the location of the proposed temporary construction compound (Figure 4). The survey comprised both gradiometer and resistivity surveys. The results are discussed below where appropriate.

5.9 Numerous, mostly small-scale interventions have taken place within the study area, mostly in Baile Mor. None have taken place on the shore. Again, these interventions are of limited relevance to the Site, beyond providing evidence of activity from the Prehistoric onwards. Those of greatest relevance in the current context comprise:

- Excavation of long cist cemetery comprising around 40 burials at An Eala immediately adjacent to the temporary working area (235, not recorded as an event by HER).
- Excavation (E5213 – Trench 2) of small trench on An Eala immediately adjacent to the temporary working areas.
- Excavation of a small trench approximately 130m from the temporary works area (E5213 – Trench 5) placed to intercept the Street of the Dead, found no trace of it;
- Geophysical survey (E6372) extending to within 30m of the temporary works area, this recorded an anomaly corresponding with the line of the Street of Dead as shown on historic mapping.
- Watching briefs (E5218) near and on the line of the Street of the Dead, recorded no features associated with the Street of the Dead.
- Watching briefs (E5216 & E6648) immediately adjacent to the temporary works area recorded no archaeology.
- Watching brief (E4325) undertaken approximately 100m to the north-west of the breakwater. This recorded undated midden deposits and wind-blown sand.

Prehistoric

5.10 The earliest evidence for human activity recorded in the study area is a Mesolithic scraper recovered 500m to the north of breakwater (254), whilst possibly Neolithic lithics were recovered during a watching brief approximately 175m to the north-west of the Site (E6648). The only other certainly prehistoric evidence recorded is substantially later, being an assemblage of late Prehistoric worked stone recovered from Medieval deposits 240m to the north of the breakwater (59899). The deposit they were found in had been reworked and it was unclear whether these finds were imported or residual.

5.11 These finds indicate that the area of Baile Mor saw activity throughout the prehistoric period. Archaeological features and deposits of this period are either obscured by later features and deposits or have been disturbed or removed by later activity. It may be assumed that the foreshore saw activity during the Prehistoric period; St Ronan's Bay and Martyrs Bay are both natural landings and are therefore likely to have seen use during this period. There is no evidence of structures or marine losses associated with this activity, nor has the 2016 geophysical survey recorded any features in the Site that might relate to this period.

Early Medieval and Medieval

5.12 There is extensive recorded archaeological evidence of Early Medieval and Medieval activity in the study area.

5.13 The bulk of the HER entries are focussed on the area occupied by the present-day settlement of Baile Mor and the abbey to the north, and have little direct relevance to the Site. To the south of Baile Mor evidence is sparse, despite several archaeological interventions having taken place. Whilst these interventions have been small the complete absence of Early Medieval and Medieval finds is strongly indicative of this area not having seen widespread intensive activity during this period. Nevertheless, there are several known foci of activity relating primarily to ritual activity and reflecting the traditional use of Martyrs Bay as a landing place for funeral parties; adjacent to the temporary compound area is a natural mound known as An Eala (WoSAS 235, Figures 3 & 6). Traditionally upon landing, the corpse would be placed on the mound and the funeral party would perform the 'deisiol' three times around the mound before proceeding to the Reilig Odhráin by way of the Street of the Dead or Sraid nam Marbh (WoSAS 217).

5.14 An Eala also served as a burial place. Around forty burials, including long cists, were excavated there in the 1960s. These were not well dated, but it was thought likely that they dated between the 6th and 10th centuries AD (Canmore 21641). A geophysical survey (Rose 2016) of the fields to the south of Baile Mor recorded a curving high resistance anomaly (Anomaly 10) around the mound suggestive of a kerb or revetment with a fainter anomaly possibly indicating the presence of an external ditch. These anomalies extend into the southern fringe of the temporary construction compound (Figure 3 inset).

5.15 There is no surface trace of the Street of the Dead in this area and its line as depicted on First Edition Ordnance survey (Figure 5) must be considered indicative. This indicative line intersects with the limit of the temporary works area. It appears unlikely, however, that there are any subsurface features present relating to it, as the geophysical survey (Rose 2016) recorded no anomalies corresponding with it either here or elsewhere and test-pitting targeting it has found no trace[2]. A second geophysical survey (E6372) recorded an anomaly that coincided with the indicative line, but seen in the context of the more extensive survey it seems unlikely that this relates to the Street of the Dead.

5.16 St Ronan's Bay and Martyrs Bay are both natural landings and are known to have seen use during this period. There is no evidence of structures or marine losses associated with this activity.

Post Medieval & Modern (including map regression exercise)

5.17 Again there are numerous entries for the Post-Medieval and Modern periods for the study area that relate to the settlement of Baile Mor. Martyr's Bay and St Ronan's Bay continued in use for landing boats. The Ordnance Survey map dated 1875 shows an 'Old Pier' to the north of the St

[2] https://www.cambridge.org/core/journals/antiquaries-journal/article/new-jerusalem-at-the-ends-of-the-earth-interpreting-charles-thomass-excavations-at-iona-abbey-195663/36F808DDF43B6311D307417A3B8D2434#r142

Ronan's Bay (Figure 5). No visible trace of this remains. It also shows a pier slightly to the north of the current jetty. This was much smaller than the current jetty and again no visible trace remains.

5.18 The 1897 Ordnance Survey map shows a slightly more substantial pier that coincides with the northern side of the existing jetty.

5.19 Between the road and Martyrs Bay stands a war memorial (WoSAS 43380).

5.20 Elements of the pier shown on the 1897 map may be subsumed within the current jetty, but would have no archaeological interest. It is considered that there is negligible potential for previously unrecorded assets to be present of Post-Medieval or later date to be present.

Assessment of Archaeological Potential

5.21 Within the construction footprint of the breakwater there are no superficial deposits present. There is therefore no potential for previously unrecorded archaeology to be present. In the area of dredging there is coarse sand and gravel, which are indicative of relatively high energy conditions. In such conditions, there is potential for residual artefacts to be present, but this potential is relatively low.

5.22 Within the Temporary Working Area there is high potential for previously unrecorded archaeology to be present in the construction compound area. This potential relates to features associated with An Eala, the site of an Early Medieval to Medieval cemetery. A geophysical survey undertaken previously indicates that such features are present at the limit of the area and hence smaller features not readily identified through geophysics may be present. Elsewhere within the temporary works area, the potential is negligible as the bedrock is exposed.

Significance (Non-Designated Assets)

5.23 As identified by desk-based work and previous geophysical survey, archaeological potential by period and the likely importance of any archaeological remains which may be present is summarised in table form below.

Period:	Identified Archaeological Potential	Identified Archaeological Importance
Prehistoric	Low	If present most probably of local importance
Early Medieval	High	If present most potentially of regional importance
Medieval	High	If present most potentially of regional importance
Post Medieval	Negligible	If present most probably of local importance

6 SUMMARY AND CONCLUSIONS

6.1 In keeping with relevant guidance, this baseline assessment draws together the available evidence in order to clarify the heritage significance and archaeological potential of the Iona Ferry Terminal and to identify heritage assets in the surrounding area that may be affected by the proposed upgrading of the terminal.

6.2 The Site lies partially within the Baile Mor Conservation Area and it is considered that the Proposed Development will affect the Conservation Area and the setting of St Mary's Abbey, which is both a Scheduled Monument and a Category A Listed Building, MacLeans Cross and Iona Nunnery, both of which are Scheduled Monuments, and the Replica of St John's Cross, which is a Category A Listed Building. It is considered that the proposed development will affect these. The assessment of impacts is presented in the EIAR Chapter.

6.3 The bays to the north and south of the terminal are natural landings and are likely to have seen activity through all periods, but given the conditions and the results of the review of hydrographic data it is considered that the potential for previously unrecorded heritage assets to be present below the high water mark is low in respect of the Medieval and earlier periods and negligible for Post-Medieval and Modern periods. The site of the proposed temporary construction compound lies adjacent to An Eala, the site an Early Medieval or Medieval cemetery, and the traditional line of the Street of the Dead. The results of a previous geophysical survey indicate that features associated with An Eala, namely a revetting wall or kerb and a possible ditch extend into the area of the temporary construction compound. No trace of features relating to the Street of the Dead has been recorded. It is considered that there is high potential for related archaeology to An Eala to be present within the temporary working area. The potential elsewhere is considered to be negligible.

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Cartographic

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Blaeu, J 1654 Mula Insula

Ordnance Survey 1880, 1881, 1899, 1900, 1976

Thomson, J 1832 Northern Part of Argyllshire

FIGURES

Legend

- Site Boundary
- Dredge Area

rev	ammendments	drawn	date

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TITLE

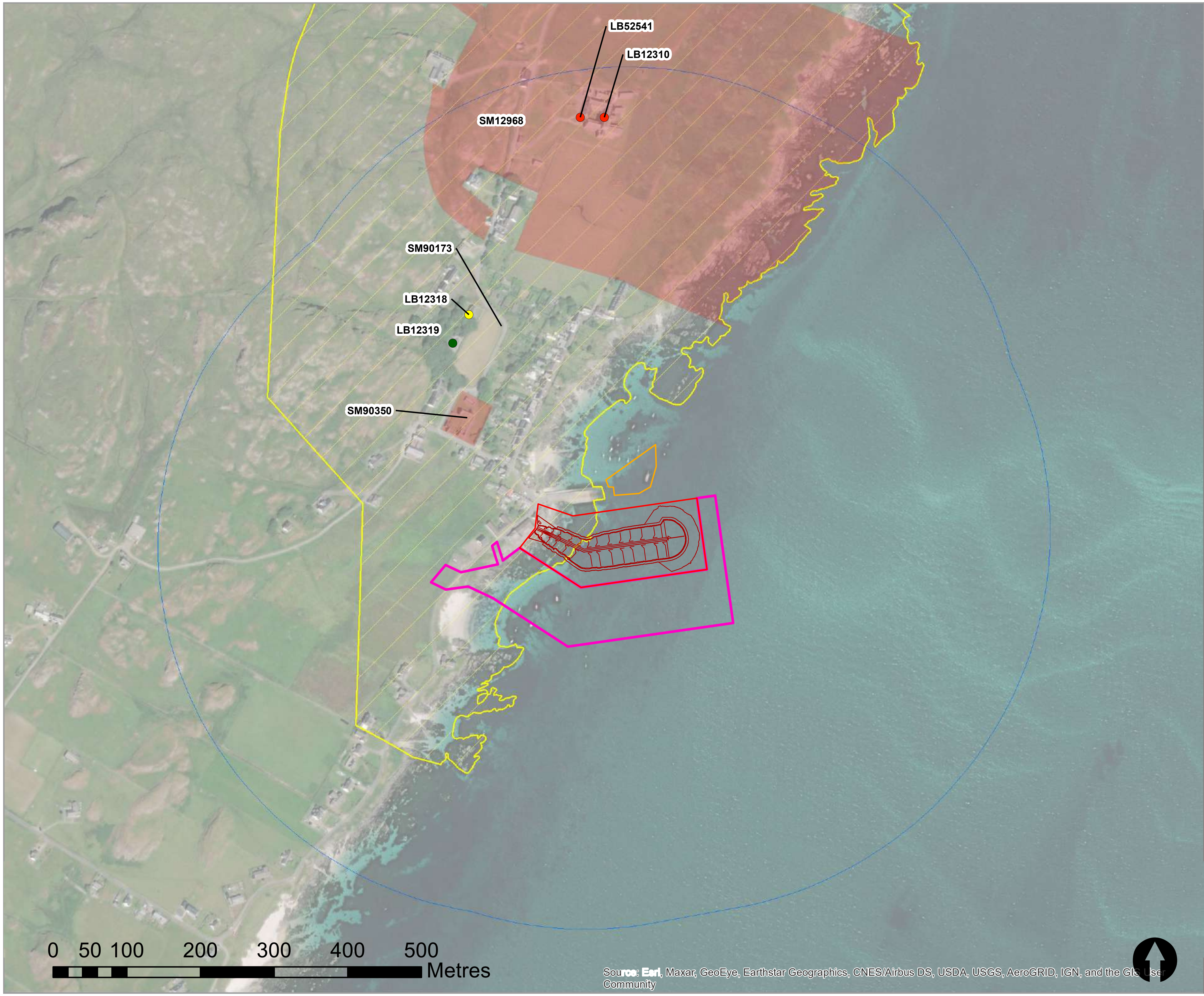
FIGURE 1
SITE LOCATION

Project Number	Sheet Size	Drawing Scale
--	A3	1:10000

Drawing Number	Datum
--	OSGB

Drawn by	Status	Revision
RJC	FINAL	--

Checked By	Approved By	Date
MF	MF	30/09/21



Legend

- Site Boundary
- Temporary Working Areas
- Dredge Area
- Proposed Breakwater
- Study Area
- Scheduled Monument
- Category A Listed Building
- Category B Listed Building
- Category C Listed Building
- Conservation Area

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FIGURE 2
DESIGNATED HERITAGE ASSETS

Project Number	Sheet Size	Drawing Scale
--	A3	1:5000

Drawing Number	Datum
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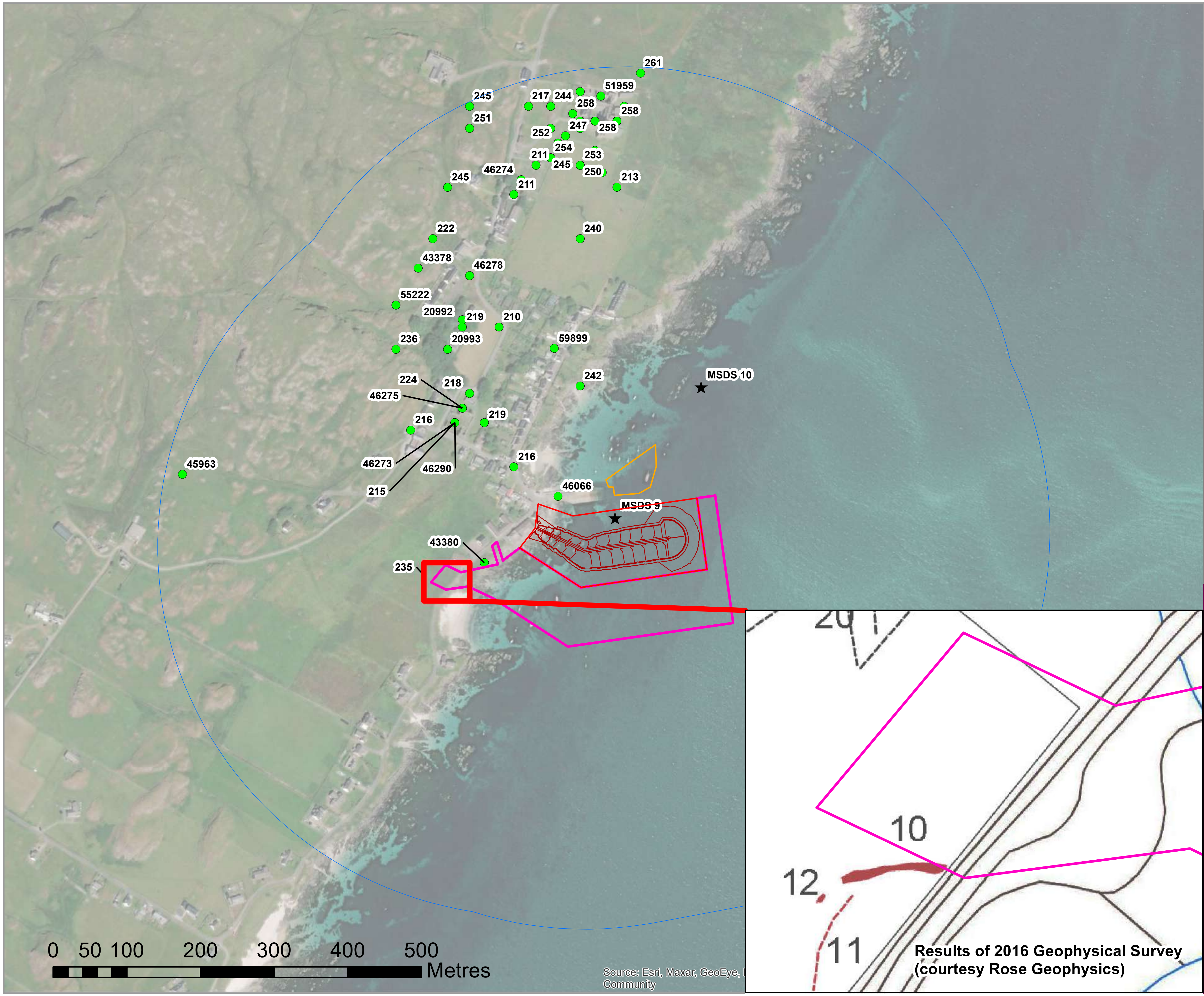
Drawn by	Status	Revision
RJC	FINAL	--

Checked By	Approved By	Date
MF	MF	16/11/22



Legend

- Site Boundary
- Proposed Breakwater
- Dredge Area
- Temporary Working Areas
- Study Area
- HER Entry

Anomaly

- Likely Geological
- Potential Debris

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FIGURE 3
HER ENTRIES, HYDROGRAPHIC & GEOPHYSICAL ANOMALIES

Project Number	Sheet Size	Drawing Scale
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Drawing Number	Datum
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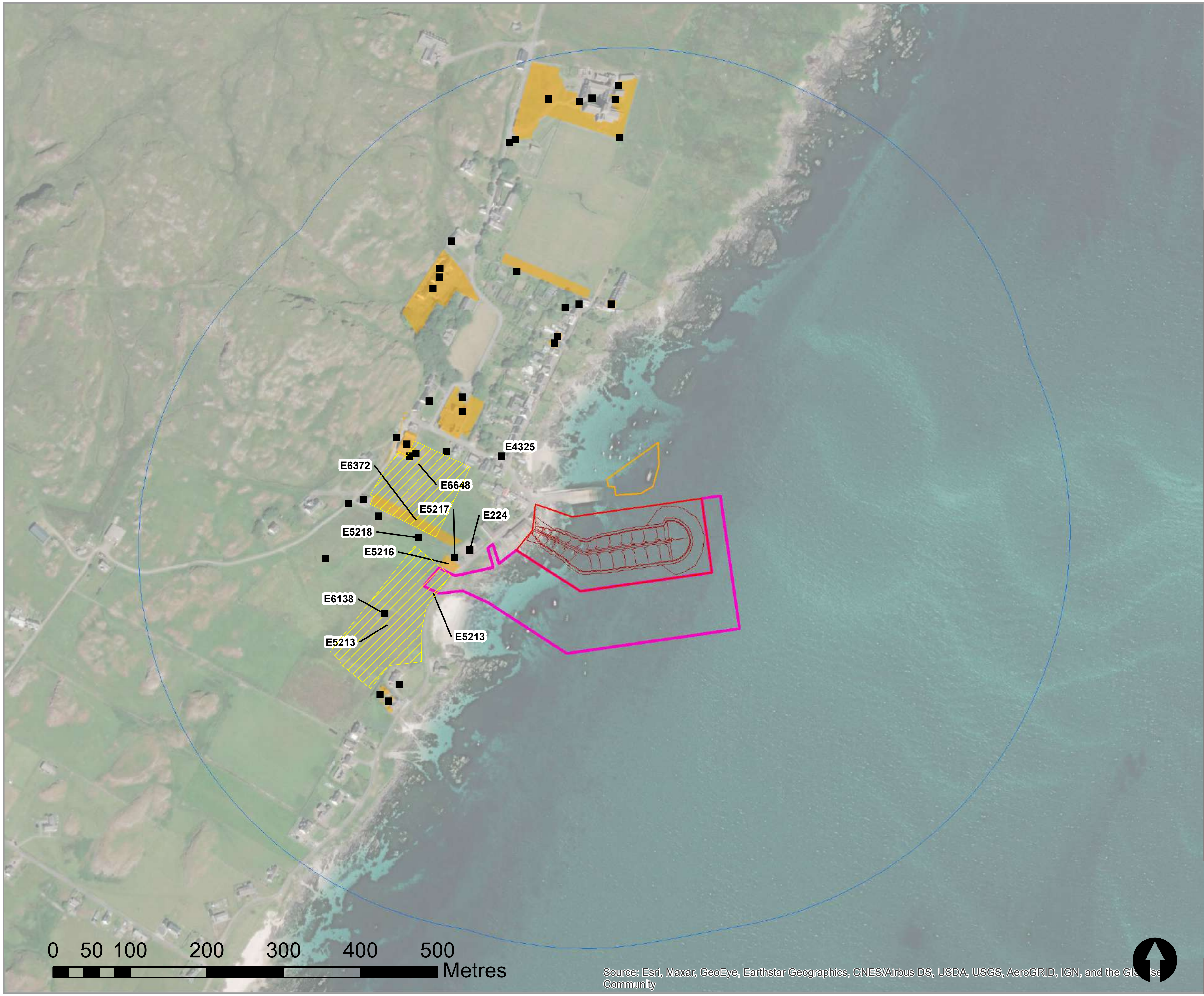
Drawn by	Status	Revision
RJC	FINAL	--

Checked By	Approved By	Date
MF	MF	16/11/22



Legend

- Site Boundary
- Temporary Working Areas
- Dredge Area
- Proposed Breakwater
- Study Area
- HER Event
- HER Event
- 2016 Geophysical Survey

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TITLE

FIGURE 4
HER EVENTS AND 2016 SURVEY

Project Number	Sheet Size	Drawing Scale
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Drawing Number	Datum
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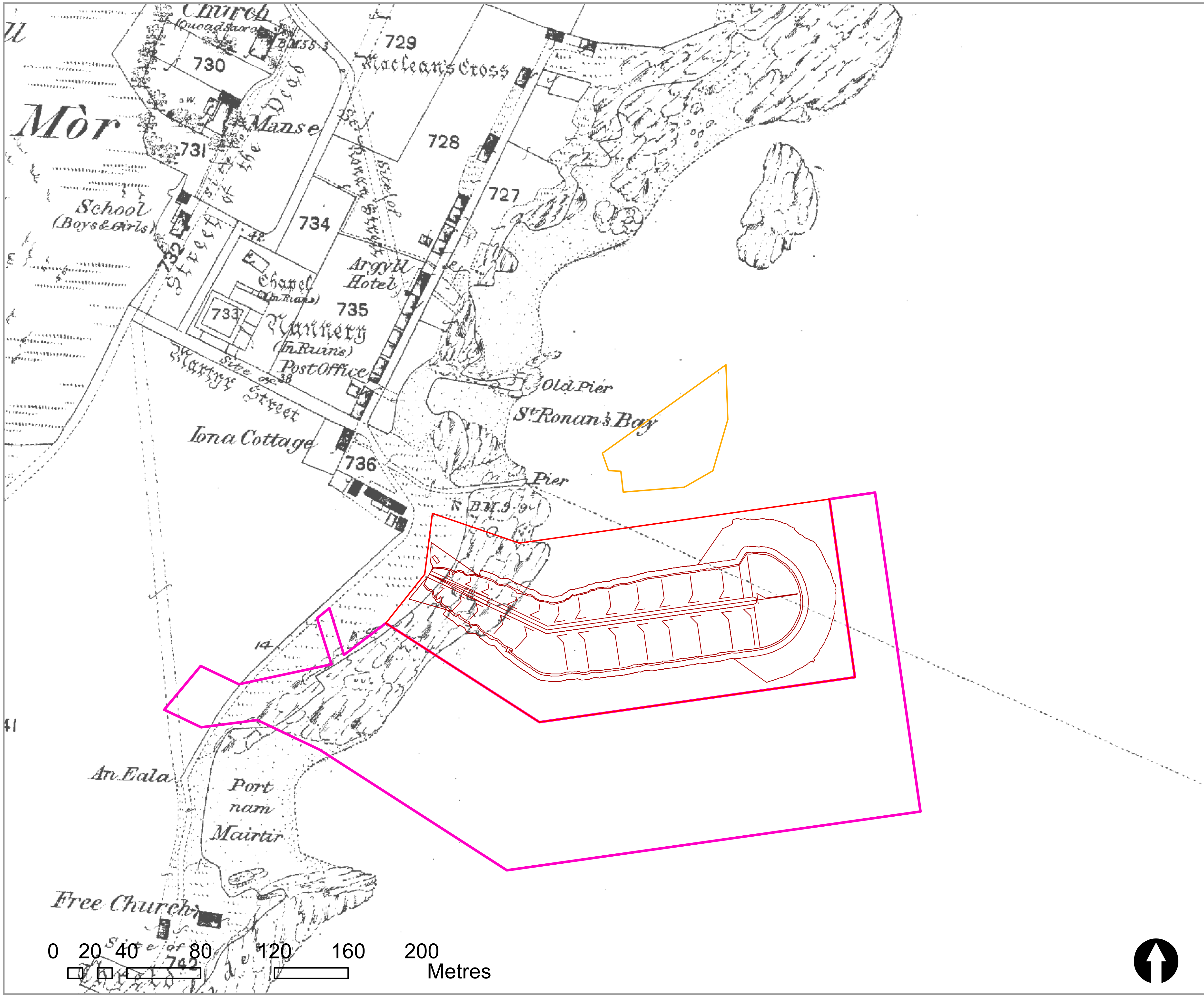
RJC	FINAL	--

Checked By	Approved By	Date
MF	MF	16/11/22



Legend

- Site Boundary
- Dredge Area
- Proposed Breakwater
- Temporary Working Areas

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TITLE
FIGURE 5
ORDNANCE SURVEY (1875)

Project Number	Sheet Size	Drawing Scale
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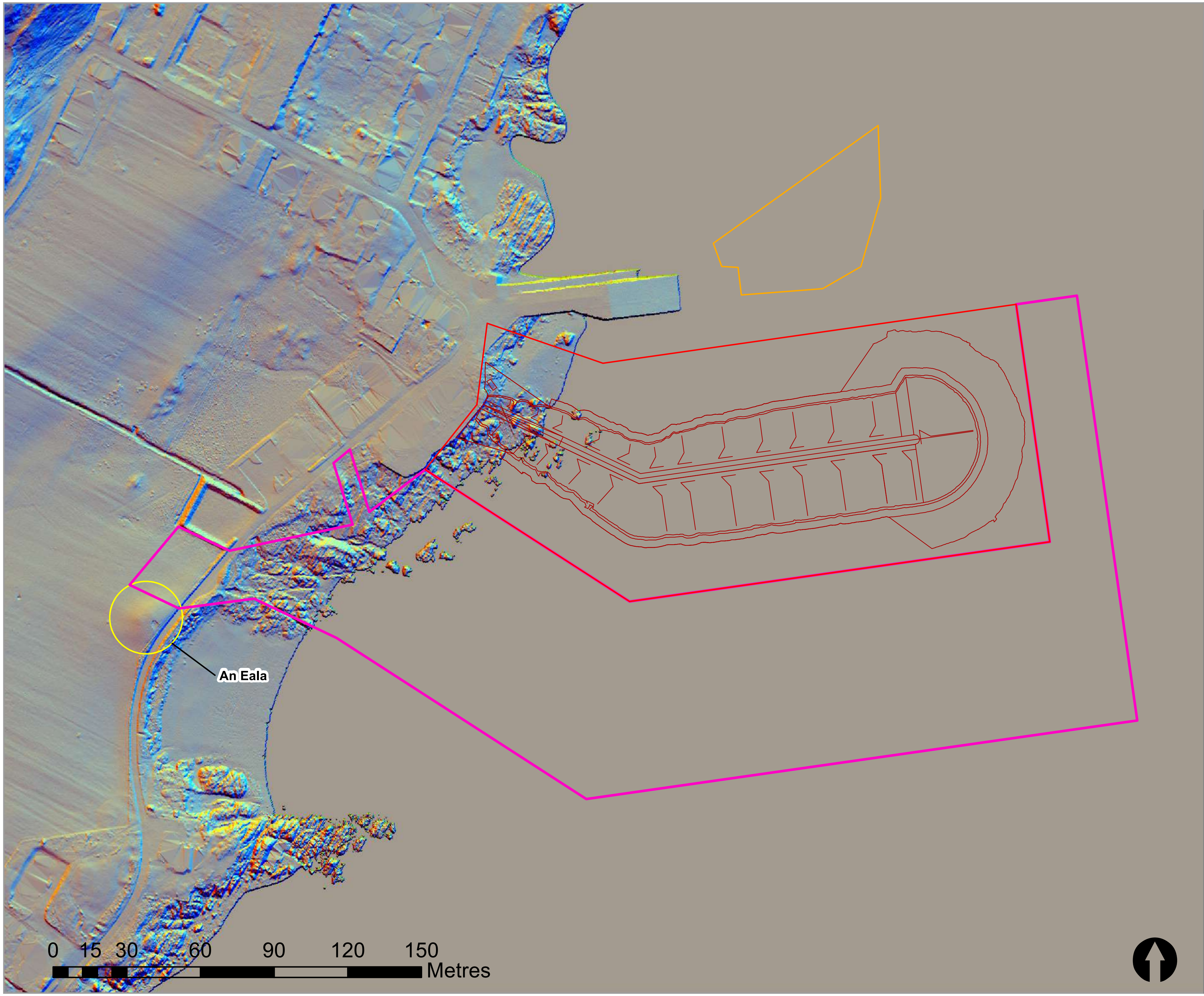
Drawing Number	Datum
--	OSGB

Drawn by	Status	Revision
RJC	FINAL	--

Checked By	Approved By	Date
MF	MF	16/11/22



Legend

- Site Boundary
- Temporary Working Areas
- Dredge Area
- Proposed Breakwater

rev	ammendments	drawn	date

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TITLE
FIGURE 6
LIDAR DATA (MULTI-DIRECTIONAL HILLSHADING)

Project Number	Sheet Size	Drawing Scale
--	A3	1:1500

Drawing Number	Datum
--	OSGB

Drawn by	Status	Revision
RJC	FINAL	--

Checked By	Approved By	Date
MF	MF	16/11/22

PLATES

Plate 1: Existing jetty seen from the south

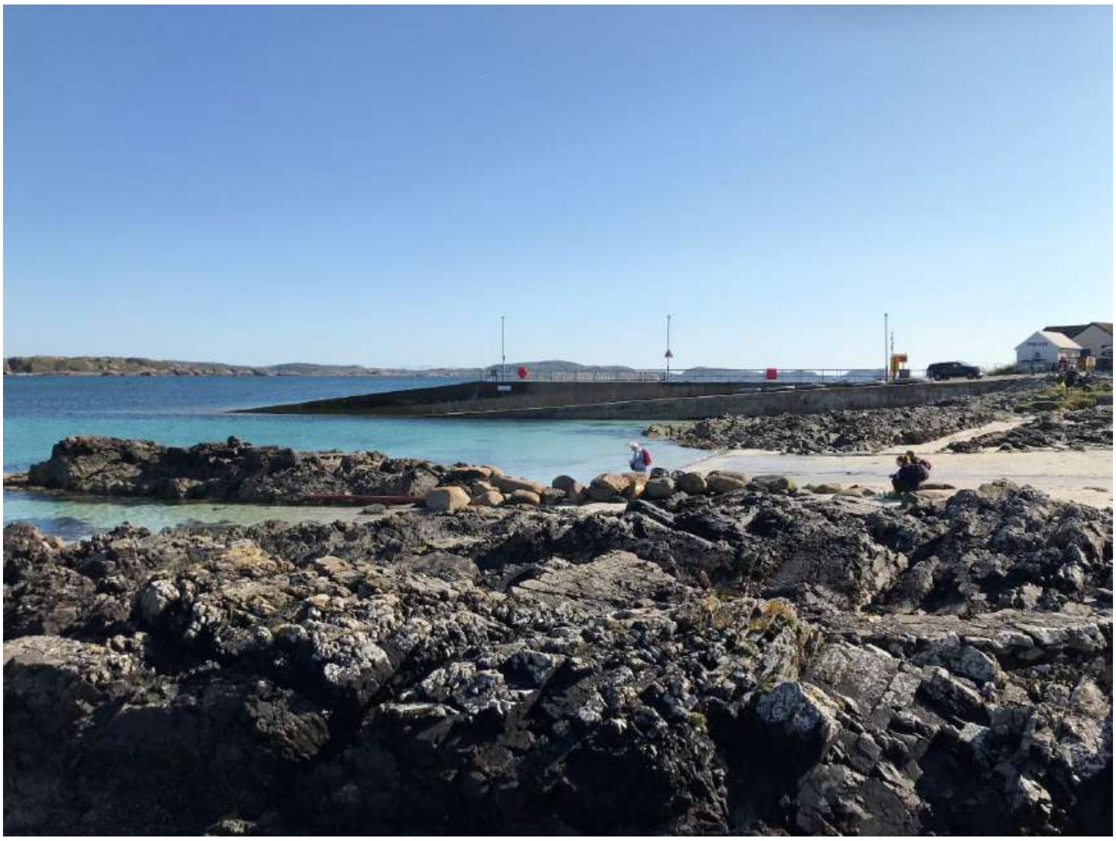

Plate 2: Existing jetty seen from the north

Plate 3: Existing jetty seen from ferry

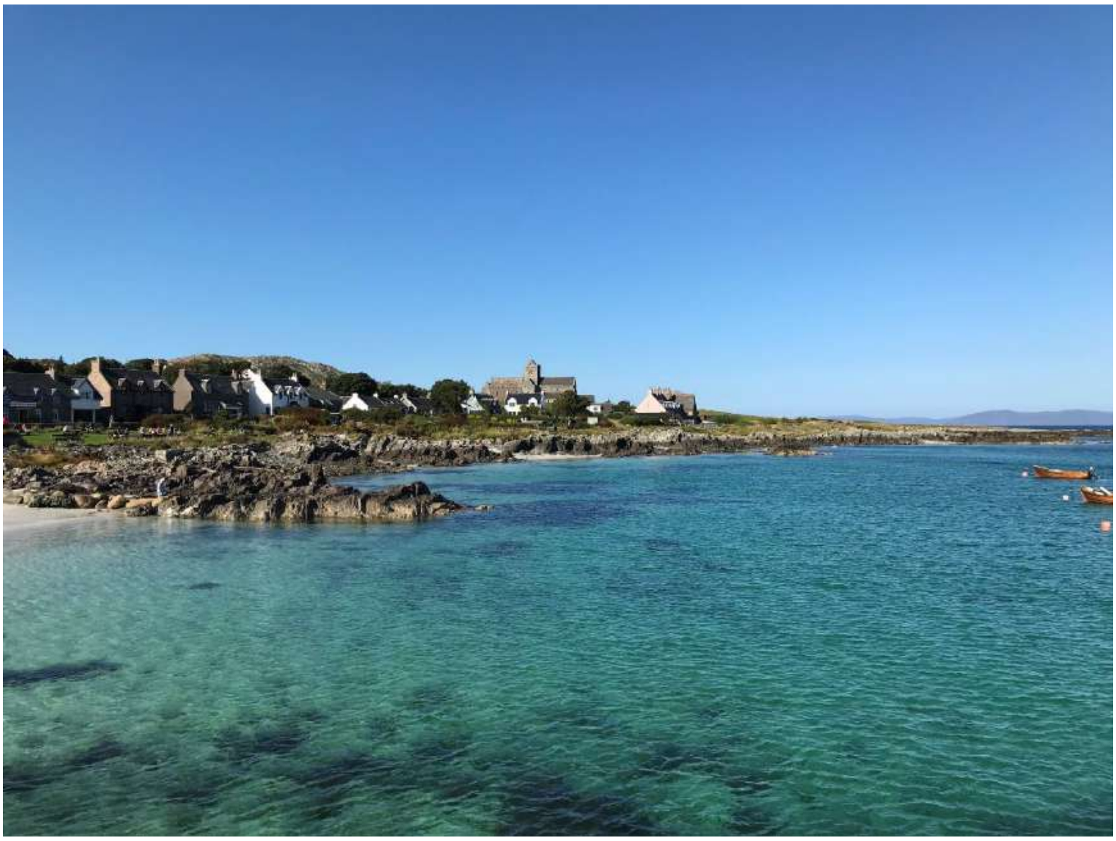

Plate 4: The Abbey seen from jetty

Plate 5: The Abbey seen from area immediately to the south of the jetty

Plate 6: View across Martyrs Bay to the Abbey, Baile Mor and the existing jetty.

Plate 7: View south over Martyrs Bay from the jetty

Plate 8: View from the grounds of the nunnery towards the jetty, showing limited visibility

Plate 9: View towards the jetty from road adjacent to the Nunnery

Plate 10: The jetty seen from in front of cottages to its north