Galway Harbour Company

Galway Harbour Extension

NATURA IMPACT STATEMENT

ADDENDUM / ERRATA DOCUMENT II

JANUARY 2015

0 INTRODUCTION

A planning application, including an Environmental Impact Statement (EIS) and Natura Impact Statement (NIS), for a proposed Extension to Galway Harbour, were submitted to An Bord Pleanála for consideration on the 10th January 2014.

Subsequently, a Response to a Request for Further Information was submitted in 16th October 2014. The Response included documents outlining Errata and Addenda to the Natura Impact Statement and Environmental Impact Statement (these documents were dated October 2014).

Following review of submissions on the Response to Further Information, some additional information has been prepared in further Addendum/Errata documents to the NIS and EIS. This document presents the additional Addenda/Errata to the NIS, namely NIS Addendum/Errata Document II, January 2015. Where addenda or errata are presented, they are cross-referenced to their location in the October 2014 document, giving the previous page number and paragraph or table number.

Generally, the information presented in this NIS Addendum / Errata Document II, is new information which should be considered as ADDITIONAL to that included in the NIS and NIS Addendum/Errata Documents, January and October 2014, respectively.

0.1 APPENDICES TO NIS ADDENDUM / ERRATA DOCUMENT II

This document includes two Appendices, including Appendix 1 which is additional information with regard to the zone of potential impact associated with suspended solid during the capital dredging activity and Appendix 2 which is information regarding potential impacts on marine mammals and birds as a result of noise and vibration, which would have originally been included within Chapter 10 of the original EIS document and its relevant appendices. These addenda and chapters from the original EIS have been provided in the interests of clarity.

Galway Harbour Company

Galway Harbour Extension

Natura Impact Statement

Addendum / Errata Document II

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1 SCREENING FOR APPROPRIATE ASSESSMENT

Paragraph 3.1.4.6 on Page 6 of the NIS Addendum/Errata document, dated October 2014, has been replaced with the following information:

1.1.1.1 Legacy Issues

In addition to the in combination effects of current plans or projects, it is also prudent to assess the in-combination effects of previous developments on and within the vicinity of the proposed development site. The historic development of the site and surrounding area is considered to have had an effect on the Galway Bay Complex cSAC resulting in the loss of 8.58 ha of fucoid dominated intertidal reef complex, 0.28 ha of stony bank 7.39 ha of salt marsh and with regard to the Inner Galway Bay SPA the loss of 16.27 ha of wetland. There are areas of the site which were developed prior to designation and detailed baseline information is not available as to the condition or quality of the habitat which was lost. However, the impact of the loss of habitats due to the construction impact of the Galway Bay Enterprise Park on both the cSAC qualifying interests and the species of conservation interest is considered to be low. This is due to the small area in question in relation to the overall percentage of the area of the habitat in the cSAC or the total population of the bird species in the SPA. However, adopting the precautionary principal and on the basis that it cannot be said beyond reasonable scientific doubt that the impacts would not be significant, for the purpose of this assessment, such habitat loss and impact on species is being treated as significant.

2 ECOLOGICAL DESCRIPTION OF THE RECEIVING ENVIRONMENT

2.1.1 Physical, Chemical and Oceanographic Characteristics of the Area

From EIS Chapter 7 Section 7.4.1.3 – Zone of Potential Influence

Section 3.2.1 on Page 7 of the NIS Addendum/Errata document, dated October 2014, has been replaced with the following information:

A zone of potential influence on the aquatic environment was established to assist in the ecological impact assessment process. In order to predict the extent of marine habitat that will be affected by the proposed development in terms of variations in velocity, shear bed stress, turbidity and salinity, the modelled output for these parameters was examined (Chapter 8 of the EIS presents details of the modelling of velocity, shear bed stress, suspended sediment plume and salinity). These figures show that variations in velocity are restricted to within the upper area west of the new development and as a consequence this same area is that affected by shear bed stress. Examination of output data showing variations in salinity indicate that there is little change in the area affected by the construction of the new development due to its present variability. What these predictions do show is that salinities in the area to east of the new development will increase. The largest area affected by the development is that caused by sediments brought into suspension during construction and for this reason, this parameter was used to map the zone of potential influence. Figure NIS (A2) 1.1 is a conservative representation of this area *i.e.* the figure includes more area affected than the modelled predictions. It should be noted that as part of mitigation measures, dredging of sediments close to the mouth of Lough Atalia will be restricted to periods of ebb tides. This is to ensure that levels of suspended sediments entering the lough will be minimised.

In addition to the calculations presented in the EIS Section 8.4.2.8 which assessed a dredging rate of 3500m^3 per day, additional sediment transport simulations which have been carried out for the peak suction dredging rate of 17,000m^3 per day, which is presented in the EIS Addendum/Errata Document and also within Appendix 1 of this document. These simulations also include the proposed mitigation measure of restricting dredging in the proposed New Dock navigational channel to the ebbing tide.

Computer simulations of the suspended sediment plumes arising from losses from trailing suction hopper dredging at a number of locations (7) within the works areas were examined to establish the likely concentrations of sediments in the water column. The location of the highest predicted concentrations of suspended sediments represent the position of the observation point. These are presented within Appendix 1 of this document.

It must be noted that these simulations are very conservative as they represent the results of

- a four day 24 hour continuous dredging effort,
- a mean Spring tides and Summer low Corrib flow,
- a maximum daily dredge capacity of 17,000m^3,
- an allowance for a loss of sediment at the surface due to over spill and
- an assumption that all the sediment is a fine sand or finer.

In relation to the last assumption, sediments in the area to be dredged range have particle sizes greater than fine sands which range from 7 – 36%. These sediments will fall out very close to the dredge and will not be dispersed away for the dredge site. Regarding over spill, this is unlikely to occur as the dredged sediment will be pumped directly from the vessel to the lagoons for infilling. Considering next the River Corrib flow, it is possible that low flow conditions will not occur during the dredging periods that take place in late Autumn.

The modelled output shows a fairly similar plume shape with a greater east/west dimension than a north/south extent. The westward extent of the plume is greatest at low water and it is under high tide conditions that the plume extends furthest east. The largest extent of the plume has predicted values of less than *ca* 5 mg/l while greatest values (+10 mg/l) are restricted to areas close to the dredger.

Given the conservative modelling approach taken in developing these simulations, it is considered extremely unlikely that these suspended sediment loads will occur in reality.

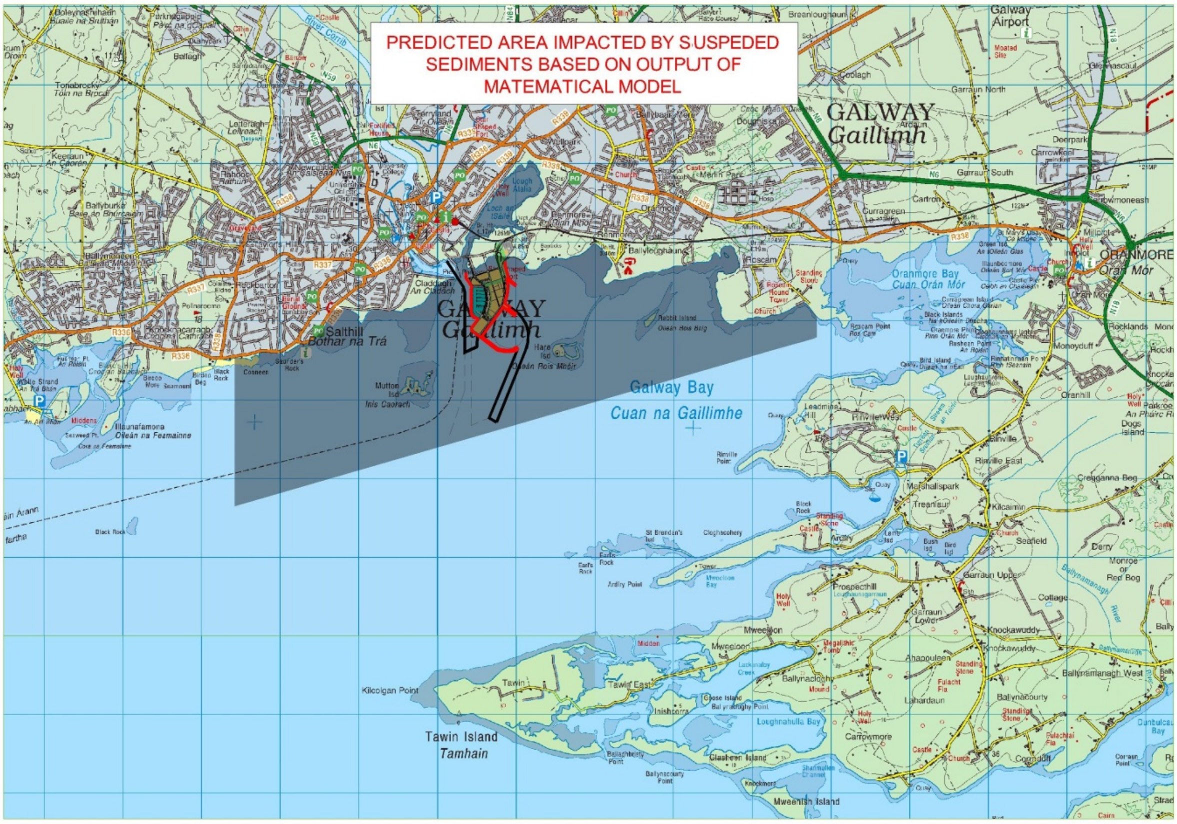

Figure NIS (A2) 1.1 Amended Zone of Potential Influence

Additional information with regard to terrestrial coastal habitats, which was originally presented in Section 3.2.2 on Pages 8 - 10 of the NIS Addendum/Errata document, dated October 2014, has been presented below:

2.1.2 Terrestrial (non-marine)Habitats

Dr. Michelene Sheehy-Skeffington, an acknowledged expert on salt marshes and stony bank habitats in Ireland and who is familiar with the shingle bank at Renmore since the 1980's, was commissioned to undertake a site visit and to prepare a report in the light of the comments raised within An Bord Pleanála's Request for Further Information and comments from DAHG, in March 2014 and December 2015. In order to respond to the relevant points, the site was visited on 22nd July, 2014, with the findings outlined below.

A visit was made to the seaward edge of L. Atalia to establish the changes in habitat brought about by the winter storms. The upper strandline, shingle area and habitat immediately north of this ridge were walked.

The shingle bank, formerly *ca* 1m in height, was observed to have been completely altered. Most of the shingle has been moved inland, forming a spit immediately to the south of Renmore Lough (site number 1 in Fig. NIS (A2) 1.2 and area outlined in blue in Fig. NIS (A2) 1.3. More shingle had spread along the inner edge of the grassy bank that used to form the inner (northern) edge of the shingle. It is likely that there were two sources of shingle : 1) that present on the shore line and 2) material thrown up from the sea floor to the south of Renmore Lough. The shingle has been moved to such an extent that the seaward edge now forms part of the strandline and vegetation comprises species tolerant of tidal submergence such as spear-leaved orache, sea rocket, sea mayweed and sea radish. On the higher ground, the vegetation and its soil was broken up, but still formed a band of grassy vegetation with creeping bent grass, perennial ryegrass, red fescue and false oatgrass forming the grass layer and a mixture of ruderal (weed) species such as colt's foot, nettle, ragwort, perennial sow-thistle and smooth sow-thistle, along with calcareous coastal grassland species such as ribwort plantain, field medick, bird's foot trefoil and kidney vetch.

The shingle, between sections of grassland, supports sea radish, spear-leaved orache and curled dock.

Notable on the strandline and shingle was the rare blue lettuce, once abundant on the shingle, but which had disappeared in recent years. This is the only known site for this alien species in Ireland. The disturbance of the storms has exposed the seed-bank and this and the rare native *Brassica nigra* (black mustard), have appeared, the latter occurring sporadically on the inner edge of the shingle. This is the first time black mustard has been recorded here, or in all of east county Galway (NIS (A2) Fig. 1.5), though it has been recorded on Inishbofin and on Inishmore, Aran Islands in the past. Another rare transient coastal species that used to be common on this shingle bar is henbane. It had disappeared since the 1980s, and was rediscovered in August of 2014. This illustrates the conservation interest of such naturally disturbed habitats as shingle. Such intermittent disturbance is essential to maintain this habitat. The proposed development is likely to significantly reduce this disturbance and therefore will reduce the extent and occurrence of the habitat and its constituent species.

Though the former shingle ridge has largely now been flattened and the shingle is close to the strand-line, observations indicate that the current High Water Spring Tide does not encroach on this shingle. In other words, it is not low enough to be susceptible to regular inundation by the sea from the south. Thus the effect of the proposed development, by decreasing exposure to storms, will stabilise the shingle, resulting in it being colonised by species from the adjacent grassland. The proposed development will not affect the frequency and extent of tidal inundation and the source of saline water will continue to be from the north, via L. Atalia. Only storm surges (extreme high tides) will wash over the shingle, but these, if regular enough, *i.e.* ca at least every 10 years, will prevent the spread and establishment of scrub with bramble sycamore and ash –all noted sporadically on this ridge. The complex of shingle and strandline vegetation comprises a mosaic of grassland and EU Habitats Directive Annex I habitats 1210 Annual vegetation of drift lines and 1220 Perennial vegetation of stony banks. This area is depicted in NIS (A2) Fig. 1.3, which also indicates the relevant extent of the cSAC in the area. The total area of this complex inside the blue boundary is 0.31ha, of which 0.18ha lies within the cSAC.

The southwest edge of the shingle merges into an eroded salt marsh. It is not clear to what extent it was intact before the storms, but it probably has been fragmentary for some time. Upper marsh species are present such as red fescue, sea milkwort, sea arrow-grass, salt marsh rush, scurvy grass and sea aster. The shelter provided by the proposed development may stabilise this salt marsh and result in it becoming less fragmented, though not significantly greater in extent.

Most of the vegetation at Renmore Lough landward of the shingle bar comprises marsh and wet grassland. A small, probably brackish, pond has abundant reedmace (Area 2 on map NIS (A2) Fig. 1.2) and areas possibly intermittently flooded support extensive creeping bent grass with a fringe of sea rush. The edge of the inlet south of the railway line is bordered by some sea rush and salt marsh rush as well as sea club-rush and all three species indicate that this is largely a lagoonal type salt marsh. All of this area is mapped as brackish saltmarsh in NIS (A2) Fig. 1.2. The drier –more elevated– parts of this area support bracken and some hawthorn bushes (disturbed grassland/hedgerow on NIS (A2) Fig. 1.2). Some reed also occurs nearer the railway line.

In summary, there is now a low area of cobbles on the sand below High Water Spring Tide (HWST) with strand-line species here as well as on the higher bank behind this. that the higher bank comprises mixed shingle and grassland on soil. This bank would only be overtopped by a storm surge. The proposed construction will attenuate the wave force and therefore it is less likely that the shingle bank will be structurally altered to any extent in the future, let alone to the extent it was in January 2014. The proposed construction will not affect the flooding of Renmore Lough, via the inlet from Lough Atalia to the north, and therefore the salinity of the lagoonal salt marsh and grassland will not alter significantly. The vegetation, already a mosaic of species tolerant of brackish or saline water (lagoonal marsh) is thus unlikely to alter to any great extent.

The area to the east of Renmore Lough, which comprises a narrow shingle bank above a rocky shore as far as Ballyloughan Beach will be afforded the same level of protection from the proposed development, i.e. reducing its exposure to and disturbance from storms. However, this shingle shore is narrower and does not support a wide assemblage of shingle species, aside from the ubiquitous sea radish and therefore its habitat quality will not be significantly altered. There is no significant area of shingle along Ballyloughan Beach itself. Further to the east, the promontory opposite Hare Island has been protected from storm action by rock revetment and is of little to no conservation value.

To conclude, it is considered that the significant effect of the proposed Galway Harbour extension development will be to stabilise the shingle habitat and thus to permanently alter its nature and plant species composition. The other important factor of salinity, on the other hand, is not likely to alter to any extent as a result of the proposed development and therefore the plant communities that are affected by this are not likely to significantly change.

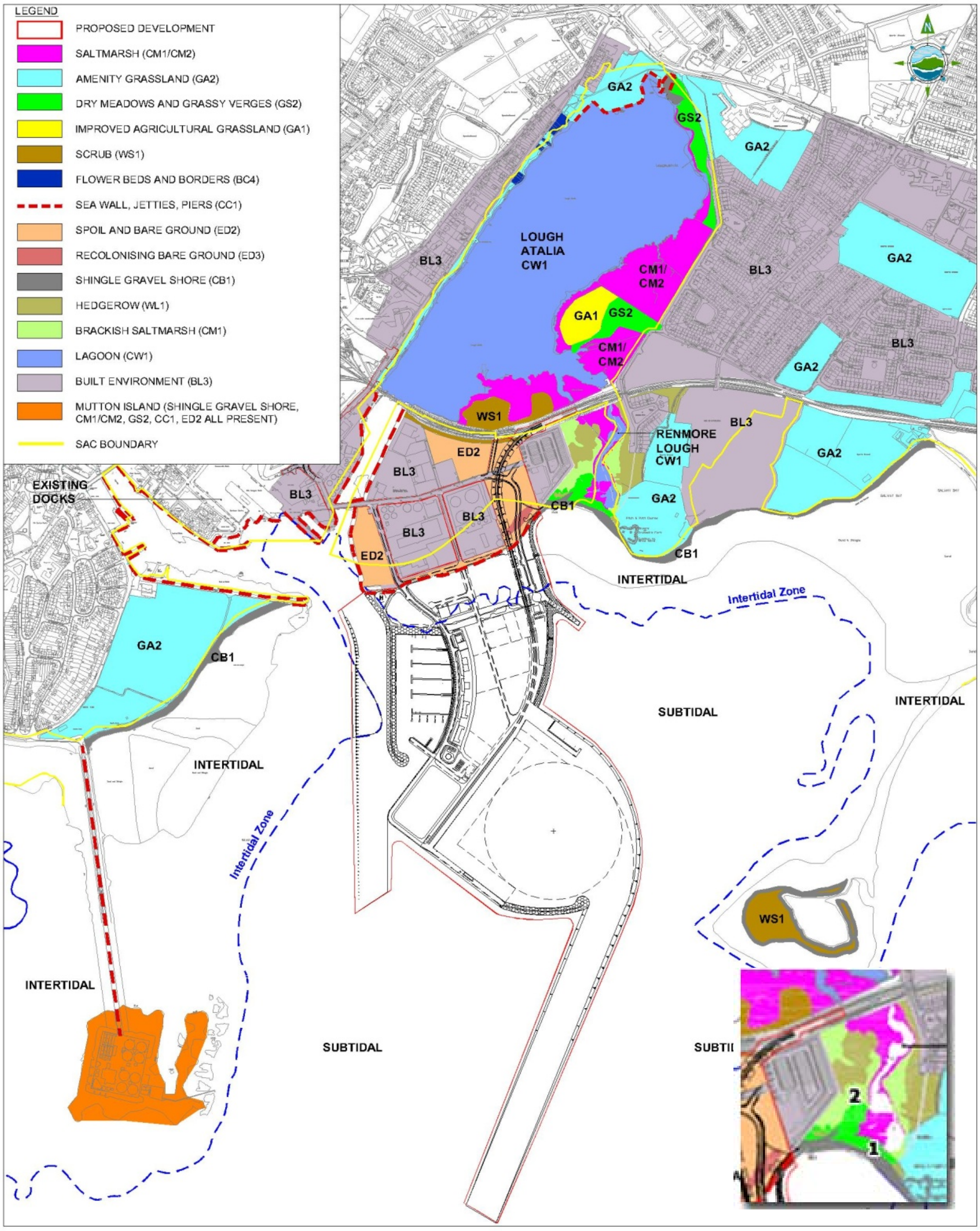

Figure NIS (A2) 1.2 (Previously Figure NIS (A) 3.2 from NIS Addendum/Errata Document I, October 2014 Terrestrial (non-marine) habitats present in the vicinity of the proposed harbour extension N.B. Brackish saltmarsh is not defined by Fossitt (2000).

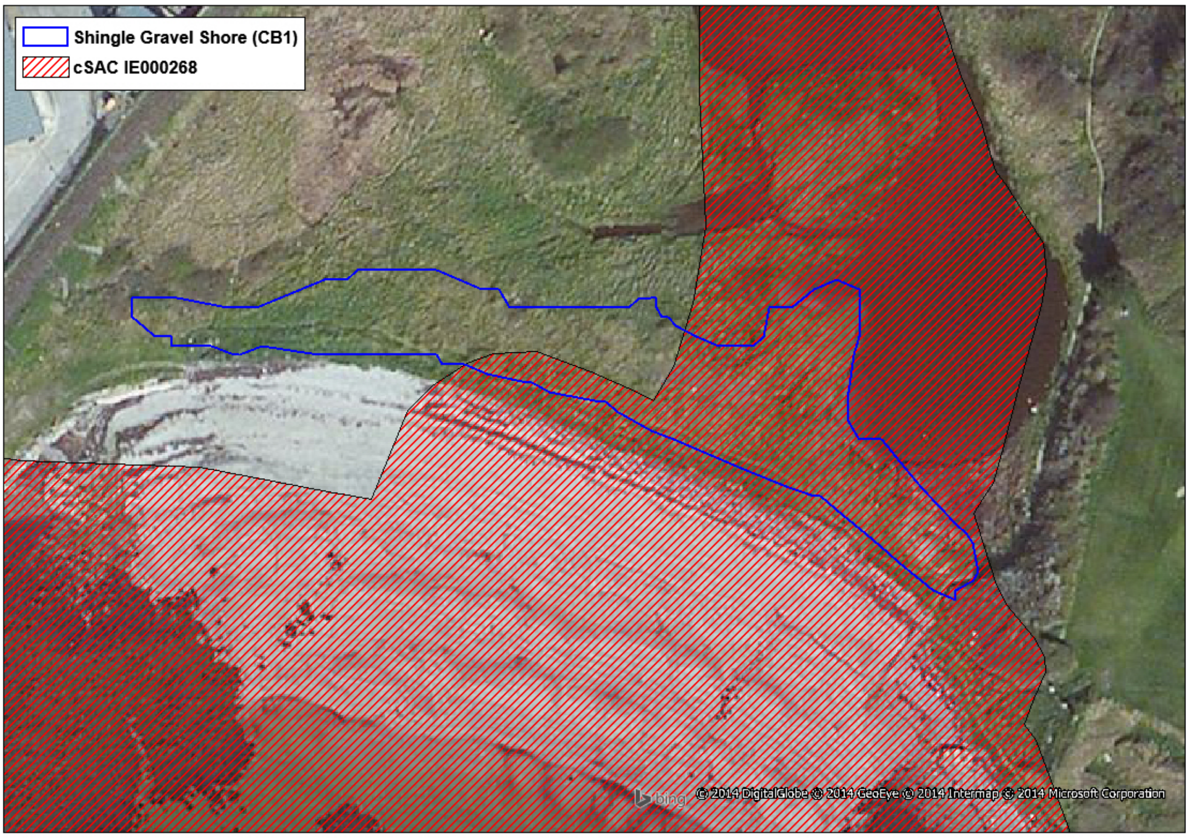

Figure NIS (A2) 1.3 Extended area of shingle outlined in blue and boundary of cSAC in striped red.

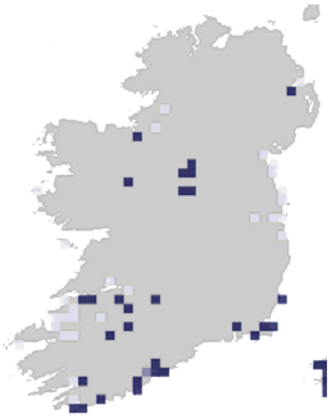

Figure NIS (A2) 1.4 ***BSBI map of 10 x 10km squares where Brassica nigra (black mustard) was recorded in Atlas 2000 (Preston et al 2001). Lighter squares represent pre-1970 records. Note its complete absence from mainland County Galway and from inner Galway Bay specifically.***

The coastal process models of Galway Bay used in the assessments were developed and applied to extreme return period hydrodynamic and wave climate conditions of a severity worse than observed in December 2013 and January 2014 and the results and impact findings presented remain valid over the full range of hydrodynamic and meteorological conditions.

With regard to Description of Operations, Table 2.1 (Page 32) of the Original NIS Document (January 2014) has been amended with the following Table i.e. the following table supersedes Table 2.1 from the NIS document.

Existing and Proposed Tonnages							
		Existing Harbour 2012		Galway Harbour Extension 2035			
	Vessel Types	Number of Vessels	Tonnage	Number of Vessels	Vessel Size T/dwt,000	Tonnage
Liquid	Refined Oil	123	384,132	100	5 – 25	1,200,000
	Bitumen	10	31,071	22	6 – 30	
Dry Bulk	Coal	0	0	2	3 – 12	732,000
	Steel	4	12,603	10	5 – 8	
	Scrap Steel	10	25,153	15	5 – 8	
	Project Cargoes	0	0	35	6 – 10	
	Limestone	12	47,802	25	6 – 10	
	Commercial Vessels Sub-Totals	**159**	**500,741**	**209**	**N/A**	**1,932,000**
	Passenger Liners	6 (moored in Bay)	0	30	30 – 150	N/A
	Passenger Ferry	0	0	2 daily (seasonal)	0.482	N/A
	Fishing Inshore	30	1 – 3	30 daily (seasonal – allow 100 days)	1 – 3	N/A
	Fishing Offshore	0	0	10 daily (seasonal – allow 60 days)	10 – 25	N/A
	Leisure Craft	70 (seasonal)	N/A	300 (seasonal)	N/A	N/A
	Total Tonnage 2012		**500,741**			
	Total Tonnage 2035					**1,932,000**

Amended Table 2.1 from Original NIS (January 2015) - Existing and proposed tonnages (Medium Growth Scenario)

3 APPROPRIATE ASSESSMENT (NATURA IMPACT STATEMENT)

Section 4.1.1.1 on Page 55 of the NIS Addendum/Errata document, dated October 2014, has been replaced with the following information:

3.1.1 Potential Impacts on Natura 2000 Sites

In addition to the information included regarding impact assessment on Marine Mammals within Section 4.3.2 (Pages 57 – 59) of the NIS Addendum/Errata document, dated October 2014, it should be noted that information within Chapter 10 of the original EIS document was also considered as part of the assessment process. Relevant extracts from Chapter 10 of the original EIS have therefore been incorporated into Appendix 1 of this document in the interests of clarity and completeness. This information was used as part of the assessment process of potential impacts on marine mammals, for which various references are included within the NIS Addendum/Errata document, dated October 2014.

3.1.1.1.1 Annex I Habitats – Perennial vegetation of Stony Banks

Section 4.3.2.2.2 on Page 65 of the NIS Addendum/Errata document, dated October 2014, has been replaced with the information previously described in Section 1.2.2 above (Terrestrial non marine Habitats) which discusses the impacts on stony banks and associated terrestrial habitats.

3.1.1.2 Blasket Islands cSAC (002172)

In addition to the information presented in Section 4.3.2.12 (Page 68 – 69) of the NIS Addendum/Errata document, dated October 2014, the following information with regard to Harbour Porpoise at the Blasket Islands cSAC has been provided.

The Harbour porpoise, *Phocoena phocoena,* is a QI of this cSAC. The conservation objectives attributes for Harbour porpoise within the Blasket Islands cSAC are:

Access to suitable habitat (measures of number of artificial barriers
Disturbance (measure of level of impact)

The proposed development will not create any artificial barriers for Harbour Porpoise that will restrict their use of the Blasket Islands cSAC (the site of the proposed development lies approximately 160 kilometres north-east of the Blasket Islands). Although land will be reclaimed within the Galway Bay Complex cSAC and a deepwater pier will be built, there will be no permanent artificial barriers for the potential use by Harbour Porpoise of the remaining areas of Galway Bay.

It is certain that (given the distance between the development and the Blasket Islands cSAC and the fact that areas of land lie across the direct sea route from the development site to the cSAC) disturbance within Galway bay will not affect Harbour Porpoises when they are within the Blasket Islands cSAC. Although satellite telemetry studies have revealed relatively large movements of tagged animals (at the scale of 100s of kilometres), including one from Danish waters into UK waters east of the Shetland Isles (a distance of some 1000 km in several weeks) it is to be expected that the Blasket Islands population spends the majority of its time in that area. The likelihood of single animals (from any population) being harmed by construction activities within Galway Harbour is considered to be low. Given that current information suggests that Harbour Porpoise occur either singly or in small groups of up to eight individuals, it is highly unlikely that a significant proportion of the Blasket Islands populations would be present in the small area of Galway Bay that will be intermittently affected by construction activities. Thus (due to the small area that will be affected and the distance between the site of the proposed development and the

Blasket Islands cSAC), the possibility of a negative impact on an individual of the Blasket Islands population is the product of two small probabilities and the likelihood of a significant impact at the population level will be even smaller. In addition the implementation of proposed mitigation measures which include the use of Marine Mammal Observers will ensure no significant impacts will arise.

3.1.1.2.1.1.1 Aquaculture

Information within Section 4.3.2.14.2.4.3. on Page 77 of the NIS Addendum/Errata document, dated October 2014, has been replaced with the following information with regard to in-combination effects with aquaculture:

The Inner Galway Bay SPA: Appropriate Assessment of Aquaculture and Shellfisheries & Fisheries Risk Assessment identified that there was a potential risk of impact to Sandwich Terns and Common Terns, due to mussel bottom culture in Rinville Bay, which is within the likely core foraging range of their colonies, and occurs partly within shallow water zones where benthic fish prey would be accessible to terns. As the GHE development is not considered likely to have measurable impacts on foraging resources for the Sandwich Tern colony, there is no potential for cumulative impacts in-combination with impacts from mussel bottom culture for this species. In the case of the Common Tern, the GHE development could possibly have a measurable, but not significant, impact, so, the assessment in the aquaculture AA, raises the possibility for significant cumulative impacts in-combination with impacts from mussel bottom culture for this species.

The aquaculture AA reviewed the biotope characteristics of the mussel bottom culture plots in Rinville Bay in relation to fish survey data from Kinvarra Bay and concluded that the plots could contain suitable benthic prey resources for terns. However, this conclusion was not informed by local knowledge of the area. More specific information on Rinville Bay indicates that, in fact, the area is not likely to provide important benthic prey resources for feeding terns:

Rinville Bay is of minor value as a feeding resource for terns as the sea bed is anoxic and benthic production is therefore low. This is due to the fact that water exchange with Galway Bay is restricted due to the narrow and shallow opening to the open sea. It behaves more like a mill pond than an open mouthed bay - the tide rises and falls quite passively giving rise to low current speeds. It also acts as a sink for suspended sediments - these fall out to the sea bed at slack high water and are not exported on the following ebb tide as bottom velocities are not high enough to re-mobilise them. However, there is no reason why juvenile fish (including sand eels) cannot enter the bay giving rise to at least some source of prey items for fish-eating birds.

3.2 MITIGATION MEASURES

3.2.1 Summary of Mitigation Measures

Mitigation measures additional to those set out in the *NIS Addendum/Errata document dated October 2014 (pages 100 – 102)* are outlined below.

Incorporation of Wildlife Pass into layout/footprint design - The layout and footprint of the proposed development has evolved over the course of the design process with a view to minimising impacts on Natura 2000 sites, including the Galway Bay Complex cSAC and Inner Galway Bay SPA and their conservation objectives.

A wildlife pass, presented in Figure NIS (A2) 2.1 has been incorporated into the design of the scheme, to allow for passage of wildlife including otter, eel and possibly salmon and seal, thereby reducing requirements to swim around the total extension footprint.

The wildlife pass will be formed at the junction of the 400m quay with the 260m quay as shown on Drawing 2139-1212A (Figure NIS (A2) 2.1 below).

The width of the pass between sheet piles varies 2.0m to 2.7m as per sheet pile corrugation and 1.2m between the circular piles.

The variation in texture and width will provide the baffle effect required to prevent wave transmission from the seaward side to the port side.

The bed level of the pass will be at -2.2m C.D. (-5.1 O.D.) i.e. 500mm above present seabed level to prevent seabed material migrating through into the lower dredged berth bed levels.

The soffit of the pass will be at 2.95m O.D. giving a height of 8.05m.

A free board of 0.75m will be available above M.H.W.S to the soffit of the quay.

A single vertical bar baffle between sheet piles inside of either end will prevent human / kayak use of the pass as a short cut in the interest of safety, while allowing approx.1.0m for wildlife species.

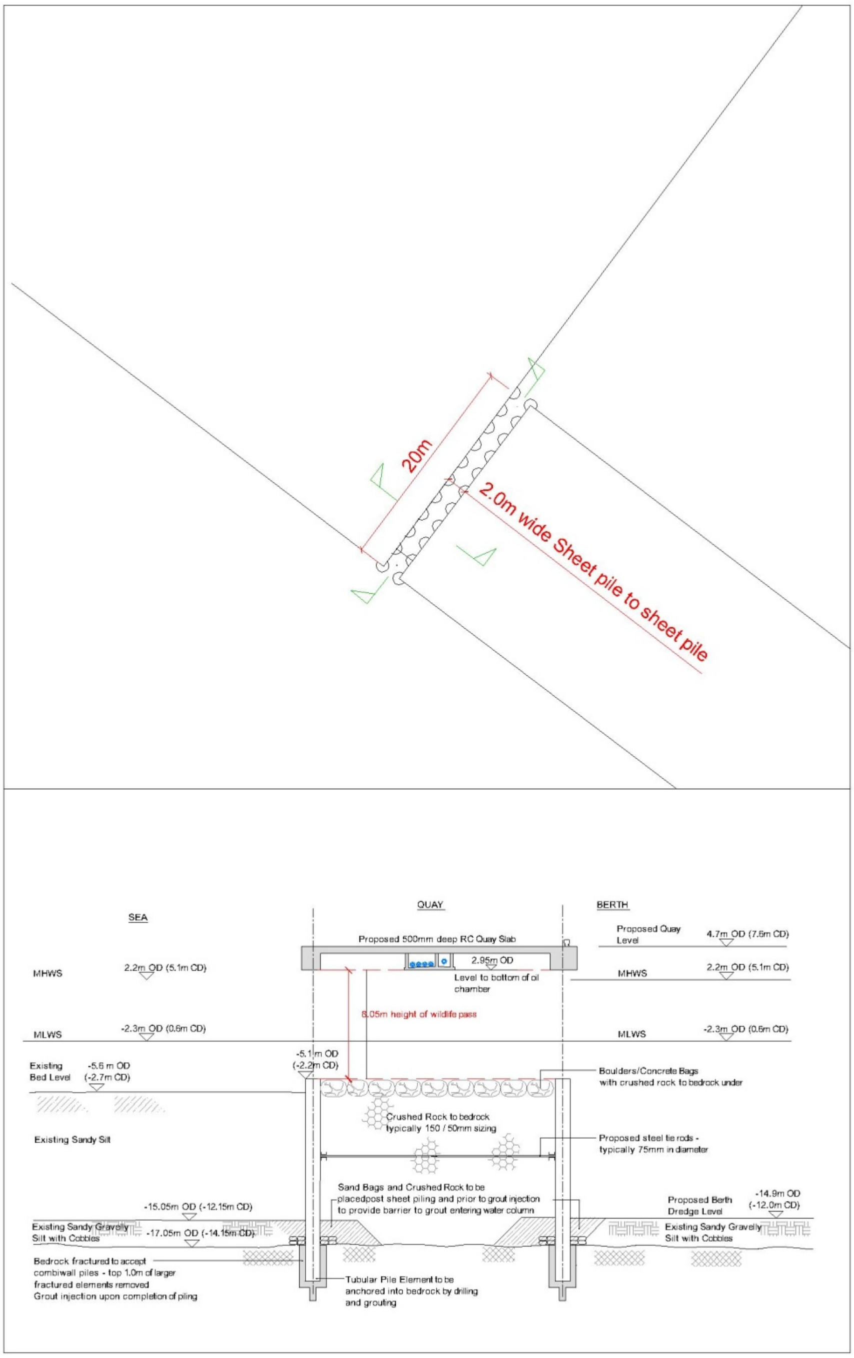

Figure NIS (A2) 2.1 Wildlife Pass Design Layout

Section 4.4 (from Page 102) of the NIS Addendum/Errata Document II should now also include the following additional information with regard to marine mammal monitoring.

Marine Mammal Monitoring

Since, studies carried out by the NPWS indicate that a minimum of 6-7 years of Harbour Seal count data are required to properly detect population trends, it is proposed that seals counts will be started on grant of permission and will continue through construction for a period of seven years after operation begins. The suggested method is haul-out site counting, carried out during a period from two hours before to two hours after low tide and following the conditions on weather and visibility that are used by NPWS staff for the seal haul-out monitoring that they currently conduct. It is proposed that the major sites at Oranmore Bay, Kinvara Bay, Tawin and Deer Island, along with the largest haul-out in the harbour area (Rabbit Island) will be counted and that this will be done on a quarterly basis in February, May, August (moulting period) and November. Comparison will be also be possible with the annual August counts made by the NPWS at Oranmore Bay and Kinvara Bay.

3.3 ANALYSIS OF IN COMBINATION EFFECTS

Information within Section 4.5.1 on Page 102 and the conclusion within 4.5.7 on page 104 of the NIS Addendum/Errata document, dated October 2014, has been replaced with the following information with regard to in-combination effects with aquaculture:

The Inner Galway Bay SPA: Appropriate Assessment of Aquaculture and Shellfisheries & Fisheries Risk Assessment identified that there was a potential risk of impact to Sandwich Terns and Common Terns, due to mussel bottom culture in Rinville Bay, which is within the likely core foraging range of their colonies, and occurs partly within shallow water zones where benthic fish prey would be accessible to terns. As the GHE development is not considered likely to have measurable impacts on foraging resources for the Sandwich Tern colony, there is no potential for cumulative impacts in-combination with impacts from mussel bottom culture for this species. In the case of the Common Tern, the GHE development could possibly have a measurable, but not significant, impact, so, the assessment in the aquaculture AA, raises the possibility for significant cumulative impacts in-combination with impacts from mussel bottom culture for this species.

The aquaculture AA reviewed the biotope characteristics of the mussel bottom culture plots in Rinville Bay in relation to fish survey data from Kinvarra Bay and concluded that the plots could contain suitable benthic prey resources for terns. However, this conclusion was not informed by local knowledge of the area. More specific information on Rinville Bay indicates that, in fact, the area is not likely to provide important benthic prey resources for feeding terns:

Rinville Bay is of minor value as a feeding resource for terns as the sea bed is anoxic and benthic production is therefore low. This is due to the fact that water exchange with Galway Bay is restricted due to the narrow and shallow opening to the open sea. It behaves more like a mill pond than an open mouthed bay - the tide rises and falls quite passively giving rise to low current speeds. It also acts as a sink for suspended sediments - these fall out to the sea bed at slack high water and are not exported on the following ebb tide as bottom velocities are not high enough to re-mobilise them. However, there is no reason why juvenile fish (including sand eels) cannot enter the bay giving rise to at least some source of prey items for fish-eating birds.

3.4 ASSESSMENT OF RESIDUAL IMPACTS

Following more critical analysis and inclusion of additional design refinements to the scheme which include a wildlife pass, the assessment of the residual impacts arising following the implementation of proposed mitigation measures are considered below. These are presented in the context of the residual impacts on the qualifying interests, special conservation interests and conservation objectives of the Lough Corrib cSAC, Lough Corrib SPA, Galway Bay Complex cSAC and Inner Galway Bay SPA.

3.4.1 Attributes and Targets to provide for Favourable Conservation Condition of Relevant Annex I Habitats and Annex II Species

An amended version of Table 4.14 (on Page 105) of the *NIS Addendum/Errata document dated October 2014, is presented below. This takes into consideration comments made by NPWS with regard to intertidal and subtidal areas.*

Summary Table of Impacts on Annex I Habitats, cSAC QIs and SCI Species								
Habitat Type/Species		Existing Galway Harbour Enterprise Park	Construction Stage				Operations	
			Permanent Loss	Totals	Temporary Loss	Permanent Gain	Temporary Loss	Permanent Gain
		A	B		C	D	E	F
1	Stony Banks	0.28 ha	0.18ha *	0.46 ha	None	None	None	None
2	Salt Marsh (incl Transitional)	7.39 ha	None	7.39 ha	None	None	None	None
3	Intertidal (including wetland for birds)	8.58 ha	5.93 ha	14.51 ha	0 ha**	1.69 ha	1.34 ha***	None
4	Otter	8.58 ha	5.22 ha	13.80 ha	None	18.8 ha	None	None
5	Seal	8.58 ha	26.93 ha	35.51 ha	51.78 ha**	None	51.78 ha***	None
6	Salmon	8.58 ha	26.93 ha	35.51 ha	51.78 ha**	None	51.78 ha***	None
7	Lamprey	8.58 ha	26.93 ha	35.51 ha	51.78 ha**	None	51.78 ha***	None
8	All SCI species	8.58 ha	26.93 ha	35.51 ha	51.78 ha**	None	51.78 ha***	Possible
9	Wetland for birds	16.27ha	26.93 ha	43.2 ha	51.78 ha**	None	51.78 ha***	Possible

Amended Table 4.14 of NIS Addendum/Errata Document (October 2014) – Summary Table of Impacts on Annex I Habitats, cSACs, QIs & SCI Species

Notes:
** Even though there is no direct loss of area of this habitat, adopting the precautionary principal and on the basis that it cannot be said without reasonable scientific doubt that potential impacts would not be significant, for the purpose of this assessment, such habitat loss and impact on species is being treated as significant.*
*** This denotes temporary loss of seabed during capital dredging of approach channels and turning circle*

***** This denotes temporary loss of seabed during maintenance dredging of approach channels and turning circle (which is estimated to be every 10 years).*
*****Cell references applied to identify source of areas of impact noted in Tables 3.15 to 3.29.*

On the basis of more critical analysis of impacts and inclusion of additional design refinements to the scheme which include a wildlife pass, the assessment of the residual impacts arising following the implementation of proposed mitigation measures are considered below. This information supersedes that previously presented within the NIS Addendum/Errata document dated October 2014.

The following tables have been updated:

Table NIS(A) 4.15 (Page 106-107) – Mudflats and Sandflats

Table NIS(A) 4.19 (Page 111-113) – Stony Banks and Annual Driftlines

Table NIS(A) 4.20 (Page 115) – Atlantic Salt Meadows

Table NIS(A) 4.21 (Page117 – 119) – Mediterranean Salt Meadows

Table NIS(A) 3.23 and 4.23 (Pages 121 -124) – Otter (should be Table 4.23)

Table NIS(A) 3.24 and 4.24 (Pages 121 -124) – Harbour Seal (should be Table 4.24)

Table NIS(A) 3.27 and 4.27 (Pages 140 – 141) SPA SCIs – Common Tern (should be Table 4.27)

Table NIS(A) 4.28 (Page 141) SPA SCIs – Wetlands

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annex I Habitat	**Mudflats and sandflats not covered by seawater at low tide [1140]** and reefs [1170]**** **NPWS describes the intertidal community at the proposed development site as "fucoid-dominated intertidal reef complex", these two habitats are considered together.	
	Attribute: Distribution **Target:** The distribution of reefs is stable or increasing, subject to natural processes.	Permanent loss of *5.93* ha (see 6B of table 4.14) of this habitat.
	Attribute: Habitat Area **Target:** The permanent habitat area is stable or increasing, subject to natural processes. The mud/sandflat habitat area was estimated using OSI data as 744ha. The reef habitat area was estimated as 2,773ha using survey data.	Permanent loss of *5.93* ha of this habitat.
	Attribute: Community Distribution **Target:** Conserve the following community types in a natural condition: intertidal sandy mud community complex and intertidal sand community complex	Permanent loss of *5.93* ha of this habitat.
	Attribute: Community Extent **Target:** Maintain the extent of the *Mytilus*-dominated reef community, subject to natural processes.	*Permanent loss of* 5.93 ha *of this habitat.*
	Attribute: Community Structure: *Mytilus* density **Target:** Conserve the high quality of the *Mytilus*-dominated community, subject to natural processes.	Permanent loss of *5.93* ha of this habitat.
	Attribute: Community Structure **Target:** Conserve the following community types in a natural condition: fucoid-dominated community complex, *Laminaria*-dominated community complex, and shallow sponge-dominated community complex.	Permanent loss of *5.93* ha of this habitat.
Impacts during Construction Phase	Permanent loss of intertidal plant and animal communities due to infilling in the construction site. Suspended sediment levels will temporarily increase around the construction site; this will have a minimal impact on the neighboring intertidal communities. There is the potential for contamination of the nearby intertidal area if spillages occur during the construction phase; however, strict adherence to the Environmental Management Plan will minimise the impact.	

Impacts during Operational Phase	The changes to the physical oceanography of the area will result in a change in grain size distribution and therefore faunal communities present; however, model predictions show these changes will only occur in the dredge site and approach channel and these are too far from the intertidal areas to have an impact. The predicted increase in traffic levels will have no impact on the intertidal areas. The intertidal communities to the east of the proposed development will experience increases in salinity and as a result euryhaline species will dominate in these areas. There will be no discharges from the development into the marine environment and therefore there will be no impact from this activity.
In Combination Effects	Permanent loss of 14.51 ha (3A+3B of table 4.14)
Proposed Mitigation	There are no specific mitigation measures available to reduce the loss of habitat.
Level of Residual Impact	The permanent loss of 5.93 ha (3B of table 4.14) of this Annex I habitat equates to a residual negative impact on one of the targets and attributes of the qualifying interest of the Galway Bay Complex cSAC. This is considered to be a negative impact on one of the conservation objectives of the Natura 2000 site. The level of residual impact is not considered to be significant as the habitats present are of poor quality. However, adopting the precautionary principal and on the basis that it cannot be said beyond reasonable doubt that the impacts would not be significant, for the purpose of this assessment, such habitat loss and impact on species is being treated as significant.

Amended Table 4.15 of NIS Addendum/Errata Document (October 2014) - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Mudflats and Sandflats

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annex I Habitat	**Perennial vegetation of Stony banks [1220] and Annual vegetation of drift lines (Natura 2000 Code 1210)**	
	Attribute: Habitat Area **Target:** Area stable or increasing, subject to natural processes, including erosion and succession.	Potential impact associated with increased shelter of area.
	Attribute: Habitat Distribution **Target:** No decline or change in habitat distribution subject to natural processes.	Potential impact associated with increased shelter of area.
	Attribute: Physical Structure: functionality and sediment supply **Target:** Maintain the natural circulation of sediment and organic matter, without any physical obstructions.	Reduced supply of sediment anticipated.
	Attribute: Vegetation structure: zonation **Target:** Maintain range of coastal habitats including transitional zone, subject to natural processes.	Potential impact associated with increased shelter of area. Numbers of species characteristic of stony banks likely to decrease.
	Attribute: Vegetation composition: typical species and sub communities **Target:** Maintain the typical vegetated shingle flora including range of subcommunities within the different zones.	Potential impact associated with increased shelter of area. Numbers of species characteristic of stony banks likely to decrease.
	Attribute: Vegetation composition: negative indicator species **Target:** Negative indicator species (including non-natives) to represent less than 5% cover.	Potential impact associated with increased shelter of area. Negative indicator species (including non-natives) to represent greater than 5% cover.
Impacts during Construction Phase	No loss of, or impact on this habitat is expected during the construction phase.	
Impacts during	***Impacts associated with increased shelter to the habitat following***	

Operational Phase	***construction of proposed development.***
In Combination Effects	An assessment of previous works completed at the Galway Harbour Enterprise Park has identified loss of this habitat, of a total extent of *ca* 0.28 ha (1A of table 4.14)
Proposed Mitigation	Further to mitigation by design, no additional suitable mitigation is considered available.
Level of Residual Impact	***Potential for residual negative impact on the targets and attributes of this habitat, a qualifying interest of the Galway Bay Complex cSAC exist. This is considered to be a negative impact on one of the conservation objectives of the Natura 2000 site. This will arise due to the greater level of protection afforded by the new structure preventing storms and waves surges from accessing the stony bank habitat. Stabilised shingle becomes colonised with a heath grassland and/or grassland community, with a reduction of the adventive ruderals that benefit from the regular disturbance of the cobbles.***

Amended Table 4.19 of NIS Addendum/Errata Document (October 2014) - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Stony Banks and Drift Lines

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annex I Habitat	**Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]**	
	Attribute: Habitat Area **Target:** Area increasing, subject to natural processes, including erosion and succession.	No impact anticipated.
	Attribute: Habitat Distribution **Target:** No decline or change in habitat distribution, subject to natural processes.	No impact anticipated.
	Attribute: Physical Structure: sediment supply **Target:** Maintain/restore natural circulation of sediments and organic matter, without any physical obstructions.	No impact anticipated.
	Attribute: Physical Structure: sediment supply **Target:** Maintain/restore natural circulation of sediments and organic matter, without any physical obstructions.	No impact anticipated.
	Attribute: Physical Structure: creeks and pans **Target:** Maintain creek and pan structure subject to natural processes, including erosion and succession.	No impact anticipated.
	Attribute: Physical Structure: flooding regime **Target:** Maintain natural tidal regime.	No impact anticipated.
	Attribute: Vegetation Structure: zonation **Target:** Maintain range of coastal habitat zonations including transitional zones, subject to natural processes, including erosion and succession.	No impact anticipated.

Amended Table 4.20 of NIS Addendum/Errata Document (October 2014) - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Atlantic Salt Meadows

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annex I Habitat	**Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]**	
	Attribute: Vegetation structure: vegetation height **Target:** Maintain structural variation within sward.	No impact anticipated.
	Attribute: Vegetation structure: vegetation cover. **Target:** Maintain more than 90% area outside creeks vegetated.	No impact anticipated.
	Attribute: Vegetation composition: typical species and sub-communities. **Target:** Maintain range of sub-communities with typical species listed in Saltmarsh Monitoring Project.	No impact anticipated.
	Attribute: Vegetation composition: negative indicator species – *Spartina anglica* **Target:** There is currently no spartina in this cSAC.	No impact anticipated.
Impacts during Construction Phase	No loss of, or impact on this habitat is expected during the construction phase.	
Impacts during Operational Phase	No impacts are expected during the operational phase.	
In Combination Effects	Permanent loss of *ca* 7.39 ha (This includes for both Atlantic and Mediterranean salt meadows).	
Proposed Mitigation	There are no specific mitigation measures available to reduce the loss of habitat.	
Level of Residual Impact	The permanent loss of 7.39 ha of this Annex I habitat equates to a residual negative impact on one of the targets and attributes of the qualifying interest of the Galway Bay Complex cSAC. This is considered to be a negative impact on one of the conservation objectives of the Natura 2000 site. However for the purpose of this assessment, given that the loss albeit of poor quality habitat is permanent, such habitat loss is being treated as significant.	

Amended Table 4.20 of NIS Addendum/Errata Document (October 2014) Cont. - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Atlantic Salt Meadows

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annex I Habitat	**Mediterranean salt meadows (*Juncetalia maritimi*) [1410]**	
	Attribute: Habitat Area **Target:** Area stable or increasing, subject to natural processes including erosion and succession.	No impact anticipated.
	Attribute: Habitat Distribution **Target:** No decline, subject to natural processes.	No impact anticipated.
	Attribute: Physical Structure: sediment supply **Target:** Maintain/restore natural circulation of sediments and organic matter, without any physical obstructions.	No impact anticipated.
	Attribute: Physical Structure: Creeks and Pans **Target:** Maintain creek and pan structure, subject to natural processes, including erosion and succession.	No impact anticipated.
	Attribute: Physical Structure: flooding regime **Target:** Maintain natural tidal regime.	No impact anticipated.
	Attribute: Vegetation Structure: zonation **Target:** Maintain range of coastal habitat zonations including transitional zones, subject to natural processes, including erosion and succession.	No impact anticipated.
	Attribute: Vegetation structure: vegetation height **Target:** Maintain structural variation in the sward.	No impact anticipated.

Amended Table 4.21 of NIS Addendum/Errata Document (October 2014) - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Atlantic Salt Meadows

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annex I Habitat	**Mediterranean salt meadows (*Juncetalia maritimi*) [1410]**	
	Attribute: Vegetation structure: vegetation cover. **Target:** Maintain more than 90% of area outside creeks vegetated.	No impact anticipated.
	Attribute: Vegetation composition: typical species and sub-communities. **Target:** Maintain range of sub-communities with typical species listed in Saltmarsh Monitoring Project.	No impact anticipated.
	Attribute: Vegetation composition: negative indicator species – *Spartina anglica* **Target:** No *Spartina* in the SAC at present.	No impact anticipated.
Impacts during Construction Phase	No loss of, or impact on this habitat is expected during the construction phase.	
Impacts during Operational Phase	No impacts are expected during the operational phase.	
In Combination Effects	An assessment of previous works completed at the Galway Harbour Enterprise Park has identified loss of Salt Marsh habitat, of a total extent of *ca* 7.39ha (2A of table 4.14) - mosaic of Atlantic and Mediterranean Salt Meadows habitats).	
Proposed Mitigation	Further to mitigation by design, no additional suitable mitigation is considered available.	
Level of Residual Impact	The permanent historic loss of ca 7.39 ha (2A of table 4.14) of this Annex I habitat equates to a residual negative impact on one of the targets and attributes of the qualifying interest of the Galway Bay Complex cSAC. This is considered to be a negative impact on one of the conservation objectives of the Natura 2000 site. The level of residual impact is not considered to be significant as the habitats present are of poor quality. However and given the status of the overall site and adopting the precautionary principle, for the purpose of this assessment, such habitat loss is being treated as significant.	
Level of Residual Impact	The permanent historic loss of *ca* 7.39 ha (2A of table 4.14) of this Annex I habitat equates to a residual negative impact on one of the targets and attributes of the qualifying interest of the Galway Bay Complex cSAC. This is considered to be a negative impact on one of the conservation objectives of the Natura 2000 site. For the purpose of this assessment, such habitat loss is being treated as significant.	

Amended Table 4.21 of NIS Addendum/Errata Document (October 2014) Cont. - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Atlantic Salt Meadows

Annex II Species Tables

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annexed Species		
Annex II Species	**Otter (*Lutra lutra*) [1355]**	
	Attribute: Distribution **Target:** No significant decline	Standard Otter survey technique normally applied to riverine rather than purely marine sites. Current range in Western RBD estimated at 70% (Bailey and Rochford 2006). No decline in overall distribution expected.
	Attribute: Extent of terrestrial habitat **Target:** No significant decline	Area mapped to include 10 metre buffer above HWM on shoreline. HWM on shoreline is against the rock wall of the existing harbour park. Since the land above this rock wall is open dry spoil and bare ground (ED2), this terrestrial habitat is of low potential for Otter. 0.58 ha will be lost. A further 2.1ha will be created by the new land reclamation area. Thus, the development will result in an increase in the total area of the type of terrestrial habitat that is currently available to Otter in the harbour park phase I.
	Attribute: Extent of marine habitat **Target:** No significant decline	Area mapped based on evidence that Otter tend to forage within 80 m of shoreline (HWM). 4.64 ha will be lost (table 4.14). A further 16.08 hectares (table 4.14) will be created adjacent to new land reclamation area. Thus, the development will result in an increase in the total area of the type of marine habitat (*i.e.* within 80 m of shoreline) that is currently available to Otter in the harbour park area.
	Attribute: Extent of freshwater (river) habitat **Target:** No significant decline	Proposed development will not affect extent of freshwater habitat.
	Attribute: Extent of freshwater (lake/lagoon) habitat **Target:** No significant decline	Proposed development will not affect extent of freshwater habitat.
	Attribute: Couching sites and holts	No known sites/holts will be affected.

	Target: No significant decline	
	Attribute: Fish biomass available **Target:** No significant decline	Resident freshwater fish, anadromous and catadromous fish are not expected to be affected. No significant effects expected on coastal fish prey species (*e.g.* rockling and wrasse), except loss of 24.8 ha of shallow subtidal habitat at development site (excluding 5.6 ha of intertidal). This is 0.25% of the total designated subtidal area. Minor negative impact.
	Attribute: Barriers to connectivity **Target:** No significant increase	Otter will regularly commute across stretches of open water up to 500m wide. The development will lengthen some potential commuting routes (*e.g.* from river mouth to Renmore Lough) but no complete barriers will be formed. An Otter/fish pass will be built in to the harbour extension design at the base of the deepwater pier (i.e. at the point that this is joined to the reclaimed part of the harbour extension) that will shorten the route from the east to the west (or vice versa) of the extension by a distance of one kilometre. No significant loss of connectivity.
Impacts during Construction Phase	There will be direct disturbance within 76.6 ha of subtidal habitat (excluding 5.6ha of intertidal) as a result of the proposed development and disturbance in the wider area around this, although the available area of terrestrial habitat and subtidal foraging area within 80 metres of the shoreline will be increased by 18.09 hectares and offsets a loss of 5.22 hectares along the current shorelines (thus giving a net gain of 12.87 hectares of such habitat). There is potential for physical damage and/or disturbance to be caused to individuals by noise/vibration/shock waves during blasting, dredging and pile driving operations during construction. There is potential for disturbance to feeding by individuals as a result of suspended solids generated during the construction works. There is also potential for negative impacts due to pollution from work areas during construction.	
Impacts during Operational Phase	There will be the loss of 24.8ha of shallow subtidal habitat at development site (excluding 5.9ha of intertidal), although the available area of terrestrial habitat and subtidal foraging area within 80 metres of the shoreline will be increased. There is potential for physical damage and/or disturbance to be caused to individuals by noise/vibration/shock waves during regular maintenance dredging. There is potential for disturbance to feeding by individuals as a result of suspended solids generated during regular maintenance dredging.	
In Combination Effects	An assessment of previous works completed at the Galway Harbour Enterprise Park has identified a loss of suitable habitat for Otter of a total extent of 5.52ha.	
Proposed Mitigation	Exclusion of drilling, blasting and pile driving during the hours of darkness. Limiting individual sizes of blasting charges. Infill/reclamation area lined with geotextile membrane to minimize impacts from suspended solid run off. Environmental Management Framework including measures on the storage and disposal of oily wastes, maintenance procedures for machinery etc, monitoring of levels of suspended solids and best practice with respect to the pouring of concrete.	

	Construction of an Otter/fish pass to save a distance of one kilometre of travel to get from one side (i.e. east to west or vice versa) of the development to the other.
Level of Residual Impact	The permanent loss of 24.8ha of shallow subtidal habitat at development site (excluding 5.6ha of intertidal), and disturbance within an area of a further 51.8ha of subtidal habitat equates to a residual negative impact on one of the targets and attributes of otter, a qualifying interest of the Galway Bay Complex cSAC and Lough Corrib cSAC. Similarly, a previous historic loss of *ca 8.58* ha associated with previous development within the Galway Harbour Enterprise Park has resulted in cumulative impacts associated with the development (Drg. 2139-2118 for Habitat Map of Lands pre 1990). This is considered to be a negative impact on one of the conservation objectives of the Natura 2000 site. The NPWS considers that Otter in the marine environment do the majority of their foraging within 80 metres of the shoreline. There will be an initial loss of 4.64 hectares of such habitat. After 2-5 years (the time taken for the newly constructed coastline to be fully colonised by algae, invertebrates and fish), 16.08 hectares of new shoreline habitat will suitable foraging habitat for Otter. Thus, the initial loss of 4.64 hectares of main foraging habitat will be short-term, followed by a permanent gain of 12.87 hectares of prime Otter foraging habitat. Thus, the level of residual impact is not considered to be significant, given the mitigation of the barrier to easy passage through the area given by the pass and the net gain in the main foraging habitat for Otter. In addition, the habitats present at the site of the proposed development are extensive in the surrounding area and usage of the site by otter was recorded but not extensive.

Amended Table 4.23 of NIS Addendum/Errata Document (October 2014) - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Otter

Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs		
Attributes	**Targets**	**Comment on Potential Impact on Attribute/Target**
Annexed Species		
Annex II Species	**Harbour seal (*Phoca vitulina*) [1365]**	
	Attribute: Access to suitable habitat **Target:** Species range within the site should not be restricted by artificial barriers to site use.	The proposed development will alter potential commuting routes for this species in the river mouth area, but the proposed development will not constitute an effective barrier to the movement of this species.
	Attribute: Breeding behaviour **Target:** Conserve breeding sites in a natural condition.	It is considered unlikely that haul out sites where pups are born will be significantly affected. Mating occurs in water with male visual and vocal displays (probably lekking) occurring near to haul out sites. The nearest significant breeding haul-out site is in Oranmore Bay, which is 5 kilometres from the construction site. A minor site (at which a pup or pups have apparently been recorded) is at rabbit Island, 1.5 kilometres from the construction site. Noise and Vibration Modelling as presented in Chapter 10 of the EIS and Appendix 1 of this document has indicated that disturbance will be low at distances of greater than one kilometre from the construction site.
	Attribute: Moulting behaviour **Target:** Conserve moult haul-out sites in a natural condition.	It is considered unlikely that moult haul-out sites will be affected by proposed development. The nearest moult site is at Earl's Rock, 2.3 kilometres from the construction site. Noise and Vibration Modelling as presented in Chapter 10 of the EIS and Appendix 1 of this document has indicated that disturbance will be low at distances of greater than one kilometre from the construction site.

	Attribute: Resting behavior **Target:** Conserve resting haul-out sites in a natural condition.	It is considered unlikely that significant resting haul-out sites will be directly affected by proposed development. The nearest such site is a Rabbit Island, 1.5 kilometres from the construction site. Noise and Vibration Modelling as presented in Chapter 10 of the EIS and Appendix 1 of this document has indicated that disturbance will be low at distances of greater than one kilometre from the construction site.
	Attribute: Disturbance **Target:** Human activities should occur at levels that do not adversely affect the harbour seal population at the site.	Important breeding sites will not be affected by the development. These sites are lie in shallow bays, which will not be affected by commercial shipping. Most smaller haul-outs are at distance from development footprint. No significant disturbance effects expected post-construction although the effect of increased ship sizes, while considered unlikely to have a significant impact, is difficult to predict given the research data available. However, applying the precautionary principle, this impact is treated as significant for the purposes of this assessment.

Impacts during Construction Phase	There will be direct disturbance within 76.6ha of subtidal habitat (excluding 2.1ha of intertidal habitat) (and disturbance in the wider area around this) as a result of the proposed development. There is potential for physical damage and/or disturbance to be caused to individuals by noise/vibration/shock waves during blasting, dredging and pile driving operations during construction. Research from the U.K. suggests that there is the potential for seals to be killed by ducted propellers if barges etc. with this propeller type are used in the construction works and perform manoeuvres while either static or moving slowly (*i.e.* while still operating the propeller/propellers). Examination of seal corpses found in the U.K. (eastern Scotland, north Norfolk and Strangford Lough) has led researchers (Thompson *et al*., 2010) to believe that the seal had been killed by being drawn through ducted or cowled ship propellers, such as fixed Kort or Rice nozzles, or ducted azimuth thrusters. Indications are that these accidents are unlikely to have happened as a result of casual collisions. The workers have theorised that the seals were killed after being attracted to the vicinity of the propellers, either as a result of concentrations of prey fish close to vessels, or as an inappropriate response to the acoustic output of the propellers. This type of propeller is common in tugs, construction vessels and construction barges and is used when such vessels are either manoeuvring slowly, or trying to maintain position. This situation could occur for long periods during the construction phase. It should be possible to specify that vessels used by contractors are fitted with grilles or guards to prevent seals being pulled through the ducts. However, there is no way of stopping vessels fitted with such propellers from using the port of Galway and (if the mechanism is as the Sea Mammal Research Unit have posited) speed limits would not have any effect on the impact. It is worth stating that:

	(1) no dead seals with similar injuries have been found in Galway Bay (2) the impact, as suggested by the report, is theoretical in nature and may not actually exist, (3) it is not possible knowing if the port development will lead to an increase in the use of these types of propeller, or if the use of these types of propeller will change over time even if the development does not go ahead. There is potential for disturbance to feeding by individuals as a result of suspended solids generated during the construction works. There is also potential for negative impacts due to pollution from work areas during construction.

Amended Table 4.24 of NIS Addendum/Errata Document (October 2014) - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Harbour Seal

<table>
<tr><th colspan="3">Attributes and Targets to Provide for Favourable conservation Condition of Relevant Qualifying Interests of cSACs</th></tr>
<tr><th>Attributes</th><th>Targets</th><th>Comment on Potential Impact on Attribute/Target</th></tr>
<tr><td colspan="3">Annexed Species</td></tr>
<tr><td>Annex II Species</td><td colspan="2">Harbour seal (Phoca vitulina) [1365] contd/..</td></tr>
<tr><td>Impacts during Operational Phase</td><td colspan="2">4 There will be a loss of 26.93 ha (5B of table 4.14) of potential sub-tidal and intertidal foraging habitat.
5 There is potential for physical damage and/or disturbance to be caused to individuals by noise/vibration/shock waves during regular maintenance dredging.
6 There is potential for disturbance to feeding by individuals as a result of suspended solids generated during regular maintenance dredging.
Research from the U.K. suggests that there is the potential for seals to be killed by ducted propellers if the volume of shipping traffic with this propeller type that is either static or moving slowly while still operating propellers is increased as a consequence of the development.</td></tr>
<tr><td>In Combination Effects</td><td colspan="2">An assessment of previous works completed at the Galway Harbour Enterprise Park has identified loss of suitable habitat for Harbour Seal of a total extent of 35.51 ha (5A+5B of table 4.14)</td></tr>
<tr><td>Proposed Mitigation</td><td colspan="2">7 Blasting, drilling and pile driving will be carried out during daylight hours and at low tide. This blasting schedule will coincide with the time when the maximum number of seals are hauled out of the water and will thus be less at risk from blasting activities.
8 The individual sizes of blasting charges will be limited to minimize the size of the area of the zone of potential effect from any individual blast event.
9 If barges with ducted propellers are used during the construction stage and these are likely to be making the types of manoeuvres mentioned above, the fitting of acoustic deterrent devices (ADDs) to them will be considered or vessels will be fitted with mesh screens at the ends of the ducts to prevent seal entry to ducts.
10 Infill/reclamation area lined with geotextile membrane to minimize impacts from suspended solid run off.
Environmental Management Plan including measures on the storage and disposal of oily wastes, maintenance procedures for machinery etc, monitoring of levels of suspended solids and best practice with respect to the pouring of concrete.</td></tr>
</table>

Level of Residual Impact	Behavioural effects as a response to the construction phase are considered likely to arise, but significant effects will be mitigated by proposed mitigation measures. The permanent loss of 26.93ha (5B of table 4.14) of subtidal and intertidal habitat and disturbance within an area of 76.6ha of subtidal habitat (excluding intertidal) equates to a residual negative impact on one of the targets and attributes of Harbour Seal, a qualifying interest of the Galway Bay Complex cSAC. Similarly, a previous historic loss of 8ha associated with previous development within the Galway Harbour Enterprise Park has resulted in combination effects associated with the development. This is considered to be a negative impact on one of the conservation objectives of the Natura 2000 site. The level of residual impact is not considered to be significant as the habitats present are extensive in the surrounding area and usage of the site by Harbour Seal was recorded but not extensive. However, given that it cannot be predicted beyond all scientific doubt that there will be no significant impact and on the basis of the precautionary principle, this impact is considered to be significant for the purposes of this assessment.

Amended Table 4.24 of NIS Addendum/Errata Document (October 2014) - Attributes and Targets to provide for Favourable Conservation Condition of Relevant Qualifying Interests of cSACs – Harbour Seal

SPA Special Conservation Interests

An amended version of Table 3.27 (Pages 140 and 141) of the NIS Addendum/Errata document dated October 2014, with regard to Common Tern is presented below. This takes into consideration comments made regarding in-combination effects associated with aquaculture developments as amended and presented above.

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
Annex I species	**Common Tern (*Sterna hirundo*) [A193]**
Level of Residual Impact	The Appropriate Assessment of aquaculture and fisheries in Inner Galway Bay (Gittings and O'Donoghue, 2014) considered potential impacts from mussel bottom culture to the fish-eating SCI species of Inner Galway Bay. In the case of the Common Tern, the GHE development could possibly have a measurable, but not significant, impact, so, the assessment in the aquaculture AA, raises the possibility for significant cumulative impacts in-combination with impacts from mussel bottom culture for this species. The aquaculture AA reviewed the biotope characteristics of the mussel bottom culture plots in Rinville Bay in relation to fish survey data from Kinvarra Bay and concluded that the plots could contain suitable benthic prey resources for terns. However, this conclusion was not informed by local knowledge of the area. More specific information on Rinville Bay indicates that, in fact, the area is not likely to provide important benthic prey resources for feeding terns: *Rinville Bay is of minor value as a feeding resource for terns as the sea bed is anoxic and benthic production is therefore low. This is due to the fact that water exchange with Galway Bay is restricted due to the narrow and shallow opening to the open sea. It behaves more like a mill pond than an open mouthed bay - the tide rises and falls quite passively giving rise to low current speeds. It also acts as a sink for suspended sediments - these fall out to the sea bed at slack high water and are not exported on the following ebb tide as bottom velocities are not high enough to re-mobilise them. However, there is no reason why juvenile fish (including sand eels) cannot enter the bay giving rise to at least some source of prey items for fish-eating birds.* The potential impact of bottom mussel culture to prey resources to terns is limited to impacts on benthic prey. Therefore, in light of the further assessment, it can be concluded that the precautionary assessment in the aquaculture AA is incorrect and that, beyond reasonable scientific doubt, there will not be any significant impact from bottom mussel culture on benthic prey resources for terns. Therefore, no potential cumulative impacts from the GHE development in-combination with impacts from mussel bottom culture arise.

Amended Table NIS(A) 3.27 (from Pages 140 and 141) of NIS Addendum/Errata Document, October 2014 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA – Common Tern

An amended version of Table 4.28 – which should have read Table 3.28 (Page 141) of the NIS Addendum/Errata document dated October 2014, with regard to SPA Wetlands is presented below.

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA		
	Attributes and targets	Comment on Potential Impact on Attribute/Target
Qualifying Interest Habitat	**Wetlands [A999]**	
	Attribute: Habitat Area **Target:** The permanent area occupied by the wetland habitat should be stable or not significantly less than the area of 13,267 ha, other than that occurring from natural patterns of variation.	Loss of 2.1 ha of intertidal habitats plus 24.8ha of subtidal habitat plus 16.27ha of legacy wetland loss has been calculated. This constitutes 0.32% of the SPA. It is considered that the walling/edge of the new reclaimed land area will (after 2-5 years) have been covered by a natural growth of invertebrates and algae and will constitute intertidal shoreline reef habitat. The area of this habitat has been calculated at 1.69 ha. This habitat will be useful foraging habitat for Curlew, Redshank, Turnstone and Grey Heron and potential resting/roosting habitat for Cormorant, Common Tern and Sandwich Tern. Loss of 0.32% of the SPA wetland habitat is not considered significant in the context of the overall area of wetland. This is especially the case given that observed counts of SCI species in the subtidal zone have generally not been greater than recorded at comparison sites and given the limited tidal exposure of the intertidal zone at the site of the proposed development. However, since it cannot be predicted beyond scientific doubt that there will be no significant impact as a result of the net loss of habitat, on the basis of the precautionary principle, this impact is considered to be significant for the purposes of this assessment.

Amended Table NIS(A) 4.28 (from Pages 141) of NIS Addendum/Errata Document, October 2014 Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA - Wetlands

CONCLUSION

Based on information as presented in the NIS submitted with the planning application, additional surveys and more detailed assessment, an amended conclusion to the overall NIS has been presented below. This supersedes the previously presented conclusion.

To conclude, the proposed Galway Harbour Extension was found to have the potential to directly impact two Natura sites *i.e.* Galway Bay cSAC and SPA. The impacts are the permanent loss of qualifying interest habitats and the potential impact on certain species arising from this loss, but the effects are not considered to be significant on either of the NATURA sites. However, adopting the precautionary principal and on the basis that it cannot be said without reasonable scientific doubt that the impacts would not be significant, for the purpose of this assessment, such habitat loss and impact on species is being treated as significant.

Legacy Issues
The historic development of the site and surrounding area has had an effect on the Natura 2000 sites – Galway Bay Complex cSAC and Inner Galway Bay SPA.

While it is considered unlikely that the effects were significant and while there were areas of the Galway Harbour Board lands that had been developed prior to designation which were not part of any EU Natura site, on the basis of the precautionary principal, for the purpose of this assessment, such habitat loss and impact on species is being treated as significant in terms of loss of Annex I cSAC habitats *i.e.* loss of 8.58 ha(3A table 3.14) of fucoid-dominated intertidal reef complex and 7.39 ha (2A table 3.14) of Atlantic Salt and Mediterranean Salt Meadows.

Galway Bay cSAC
With regard to the impact of the proposed development on the cSAC, it will reduce the fucoid-dominated intertidal reef complex by 5.93 ha (3B table 4.14) and will result in the loss of 26.93 ha of marine feeding habitat for Otter and Common Seal (Annex Habitat and Qualifying Interests of the cSAC). This loss is not considered significant with regard to Otter, due to proposed mitigation and creation of new habitat associated with the proposed development, however, significant impacts on Harbour Seal cannot be ruled out.

The proposed development will also require capital dredging of 46.48 ha of feeding habitat. This is a temporary, slight, negative impact which, based on the precautionary principal is considered significant for seal. This is a temporary slight negative impact; however, applying the precautionary principle means that the impact is indeterminate and therefore, under the precautionary principle, significant with regard to Common Seal.

Two fish species, Atlantic salmon and Sea Lamprey, which are Qualifying Interests for Lough Corrib cSAC, pass through parts of Galway Bay cSAC when migrating to and from the lake but it is not considered that the proposed Galway Harbour extension will significantly affect either of these.

0.28 ha (1A table 4.14) of perennial vegetation stony banks and annual vegetation of drift lines has been lost historically and a further 0.18 ha (1B of table 3.14) may be impacted as a result of the new development, as the area will be more sheltered as a result of the proposed development. Adopting the precautionary principal and on the basis that it cannot be said without reasonable scientific doubt that the impacts would not be significant, for the purpose of this assessment, such habitat loss and impact on species is being treated as significant.

Galway Bay SPA
This assessment has not identified any potential impacts arising from the proposed development that are likely to cause population-level consequences to any of the SCI populations of the Inner Galway Bay SPA.

This assessment has not identified any potential cumulative impacts from habitat loss due to the GHE development in combination with the historical habitat loss from the development of the Galway Harbour Enterprise Park that are likely to cause population-level consequences to any of the SCI populations of the Inner Galway Bay SPA.

Loss of 43.7ha (0.32%) of the SPA Wetland habitat is not considered significant in the context of the overall area of wetland. However, since it cannot be predicted beyond scientific doubt that there will be no significant impact as a result of the net loss of habitat, on the basis of the precautionary principle this impact is considered to be significant for the purposes of this assessment.

Lough Atalia and Renmore Lough
Lough Atalia and Renmore Lough fall under the definition of “coastal lagoons” [1150] under the EU Habitats Directive and are categorised as a priority habitat, described as being in danger of disappearing and therefore requiring protection. The conservation objectives recently published by NPWS describe the conservation status of Lough Atalia and Renmore Lough as of no conservation value as coastal lagoons. Although not in the direct footprint of the proposed development, the lagoons may be impacted during the construction and operational phase of the Galway Harbour Extension development. Mathematical modelling studies indicated that during the construction phase, sediments suspended during dredging operations could be carried into and settle in the lough on flooding tides. The potential for this impact has been mitigated by only allowing dredging operations close to the mouth of Lough Atalia during periods of ebb tide.

Modelling studies also indicated that the proposed Harbour Extension will alter the dispersion of River Corrib water in the estuary of the river. This has the potential to change the salinity regime in Lough Atalia. Although the predictions are that the range in salinity will not change *e.g*. 0 – 30 psu, the median salinity will reduce by 1.29 psu from the present value. The cumulative annual frequency of zero salinity at the southern part of Lough Atalia will increase from 7 to 18 hours over an average year. The impact of the additional temporary, seasonal and spatially restricted decreases in salinity to 0 psu within parts of the ecosystems will not affect their status or their ecological functioning.

Given the high range in natural fluctuation recorded and predicted in Lough Atalia, it is considered that this change in the median salinity will have no effect on the ecological functioning of this habitat.

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APPENDIX 1 – Additional Hydrological Information

Appendix 1 – Additional Hydrological Information

1. Capital dredge suspended sediment analysis addendum to EIS Section 8.4.2.8

1.1 Introduction

Additional sediment transport simulations are presented in this addendum to represent the proposed peak suction dredger rate of 17,000m^3 per day and the proposed mitigation measure of restricting dredging activity to the ebbing tide for capital dredge works to the proposed new navigation channel to the Docks.

1.2 Methodology

In order to evaluate the likely impact on the water column, Seven dredging locations were selected as previously used in the EIS (see Figure 1.1 for location of these representative dredging points). The dredge plume from each of these locations was modelled separately under critical conditions of Summer low Corrib flow (24.6 m^3/s) and mean Spring tides. The fine silt fractions was investigated at the full dredging capacity of 17,000 m^3 per day. These simulations were carried out for four days continuous 24hour dredging per location so as to evaluate the plume pattern, its dispersion and return over successive tides. A fine sediment fraction was selected so as to ensure conservatism in respect to predicting plume extent and suspended solids concentrations. The bed sediment sampling results (refer to Aquafact sample reference numbers 1 to 6, of Figure 1.2) showed the bed sediment to be generally classified as a fine sand, (refer to Table 1.1 below). Therefore the majority of the sediment will settle out close to the dredging location given the relatively low ambient velocities and associated bed shear stresses. Typical settling velocities for sands and silt are presented below in Table 1.2.

The simulation modelled a fine silt having a settling velocity of 0.0001 m/s and a critical bed shear for deposition of 0.08 N/m^2. For the purpose of modelling the dredging work the dredging rate is specified at 196.8 l/s based on a peak dredging rate of 17,000m^3 per day. An S-factor for the released concentration as a result of the dredging work of 6000 mg/l (based on the CIRIA Report C547 guidance document based on field measurements of losses from a trailing suction Hopper Dredgers) was specified. This represents a sediment release rate of 4,251 kg of sediment per hour into the water column at the dredge site. The sediment was released at the bottom layer and at the top layer of the TELEMAC3D model, at equal rates so as to represent potential losses/sediment disturbance at the suction head and at the surface due to overspill. It is likely that overspill / surface release from the suction dredger will be small.

The model was set-up with an immobile bed and an initial condition of a water column free of suspended solids. For this application, it is assumed that the sediment is non-cohesive, even the finer silt and the sediment settling velocity is based on the Van Rijn equation (1984) developed for non-cohesive sediments which ensures conservatism in respect to the prediction of suspended solids concentrations. In reality some degree of flocculation would happen with the finer sediments and the flocculated sediments would acquire a higher settling velocity and therefore a smaller sediment plume.

To minimise dredge sediment entering Lough Atalia on the flooding tide the proposed mitigation of confining dredging works to 6hours per tidal cycle to favour the outflowing ebbing tide was simulated for the dredge works in the navigation channel to the Docks. The simulations for sites B1 to B3 were confined to the ebbing tide period 6hour period from highwater to low water). For these simulations the daily peak rate of 17,000 m^3 per day was maintained by increasing (doubling) the dredging rate during ebbing dredge period.

1.3 Discussion of Results

The suspended solids plume plots for the dredging activities by a trailing suction hopper dredger at each of the dredging sites (A1-A4 and B1-B3) are presented in Figures 1.3 to 1.9 representing snapshots of sediment plume after four days of continuous dredging at the four principal stages of the tidal cycle (mid-ebb, Low water, mid-flood and highwater). Suspended silt concentrations down to 1 mg/l are shown in these plots which is well below natural ambient suspended solids levels for these coastal waters.

The findings from these simulations clearly show that dredging activities in the new approach channel to the old docks and Marina (as represented by B1 to B3) clearly reduces the direct impact of the concentrated dredge plume entering Lough Atalia as a result of the tidal balancing favouring the ebbing tide. The simulation results for sites A1 to A4 in the port and approach channel show no impact to Lough Atalia and generally undergo high dispersal and dilution as a result of the deeper open water at the dredge sites.

The sediment plume modelling for the seven test sites chosen to represent the capital dredge area show sediment deposition to be generally localised close to the dredging point. The simulations demonstrated that even when modelling a 100% fine silt (conservative approach), the suspended sediment concentrations are only significantly elevated in the vicinity of the dredging works with the plume enjoying reasonable dispersal thereafter. The actual monitored sediment characteristics classify the sediment as a fine sand with a fine silt/clay content varying between 4 and 40%. The coarse to fine sand fraction will deposit close to the dredge point whereas the silt will disperse with the inflowing and outflowing tides. Generally, concentrations remote from the dredging point are predicted to be less that 5 mg/l. At a concentration of 5 mg/l of silt, the depositional rate based on a settling velocity of .0001 m/s is 43.2g/m^2 per day which is considered insignificant and particularly so, given the temporary nature of the capital dredge activity being confined to only a two month period in year 1 (navigation channel to the Docks), 4month period in year 2 (Commercial Port and its navigation channel and turning circle), 3month period in year 3 (Commercial Port area) and a 1month period in year 5 (Marina and fishing pier).

Combining the sediment plume results for the seven dredge sites simulated a tidal average plume concentration plot is presented in Figure 1.10. This shows the extent of the impact are by the dredge plume with concentrations of less than 5mg/l considered low relative to ambient sediment concentrations. To convert suspended sediment concentration to potential depositional rates assuming an ability to settle based on the critical shear velocity a concentration of 5mg/l for a three month (twelve week period) represents a deposition depth of 2.2mm which is not significant.

1.4 Conclusions

The predicted suspended solids concentrations are only significant in the vicinity of the dredge works with good dispersal and dilution with the tidal flow away from the dredging site. The proposed mitigation measure of dredge works only on the ebbing tide for the proposed new navigation channel to the Docks protects Lough Atalia from potential concentrated plume impact on the flooding tide with only a relatively dilute plume entering on successive tides and primarily only dredging activities north of the proposed marina entrance.

Based on the hydrodynamic characteristics of the Harbour site a large portion of the suspended silt will widely disperse and form part of the overall sediment budget within Galway Bay. Low velocities within the Marina area and the commercial Port and Fishermans pier area will favour locally higher settlement of the suspended dredged sediment. The average concentration within Lough Atalia as a result of dredging activities at Site B3 (navigational channel north of the Marina) is less than 3mg/l which based on a 3month period (2months dredging and further 1 month for sediment conditions to return to normal) represents potentially a deposition rate of 1.3mm of sediment depth within Lough Atalia which is not significant in relation to normal annual suspended load and settlement rates.

Sediment size distribution							
Stations	**Gravel (>1.5mm)**	**Very coarse sand (1.5mm)**	**Coarse sand (0.75mm)**	**Medium sand (0.38mm)**	**Fine sand (0.19mm)**	**Very fine sand (0.09mm)**	**Silt (<0.063mm)**
1	0	0	0	17.65	75.29	2.3	4.77
2	0	20.19	0.36	5	21.01	22.09	31.35
3	0	0	0	28.98	65.87	0.6	4.54
4	0	2.27	0.99	4.19	23.19	24.73	44.62
5	0	18.38	0.07	17.92	53.05	4.34	6.24
6	0	0	0.7	32.69	63.44	0.33	3.47
Median	0	1.14	0.22	17.79	58.25	3.32	5.51
Maximum	0	20.19	0.99	32.69	65.87	24.73	44.62

Table 1.1 Sediment size distribution (percentage) at Proposed Harbour Site

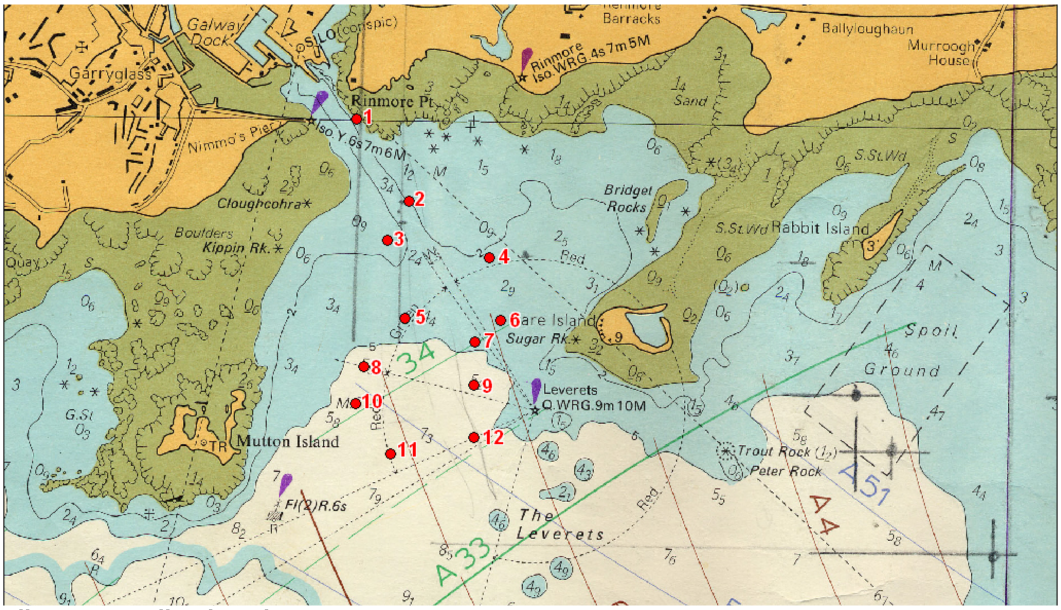


Figure 1.1 Sediment sampling locations,

Settling velocities for non-cohesive sands and silts		
Material Type	**Sediment Size (mm)**	**Settling velocity (m/s)**
Coarse sand	0.75	0.093
Medium sand	0.38	0.046
Fine sand	0.19	0.020
Very fine sand	0.09	0.0056
Coarse silt	0.047	0.0015
Very fine silt	0.01	0.00006

Table 1.2 Typical settling velocities for non-cohesive sand and silts. Note: settling velocities computed using the Van Rijn (1984) formula

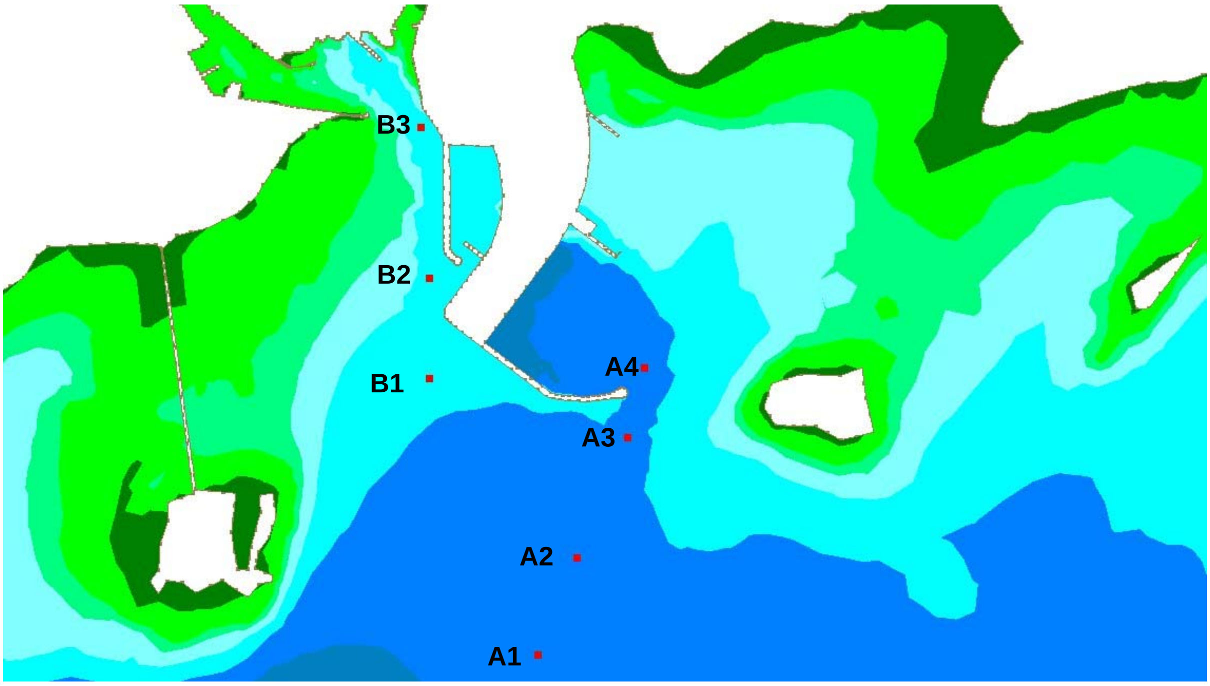


Figure 1.2 Reference locations along approach dredged channels to old Docks and proposed commercial port to assess suspended solids plume impact under capital dredge operations

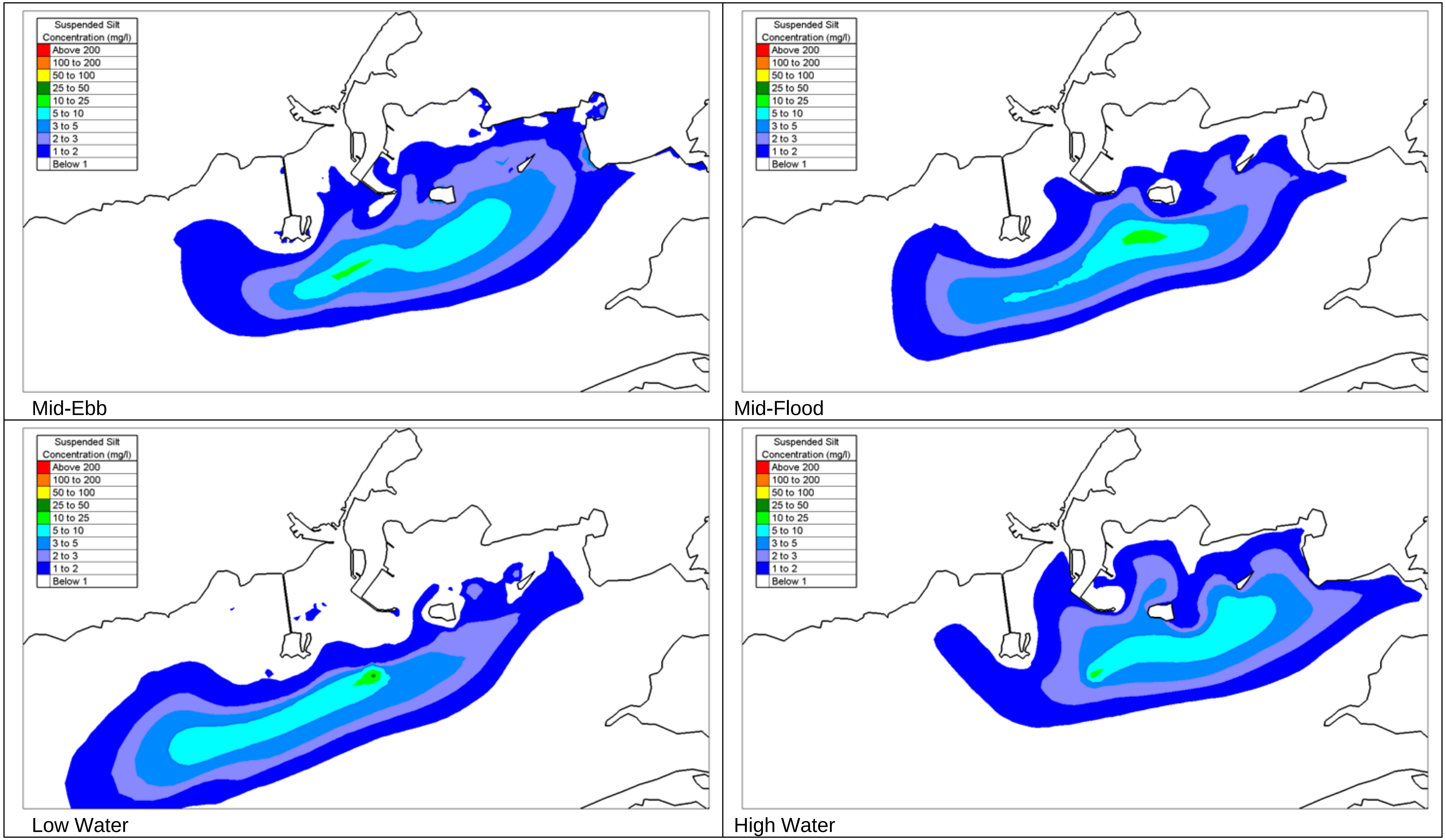


Figure 1.3 Fine silt suspended sediment plume simulation at dredge location A1 – Spring tide and Corrib Summer low flow

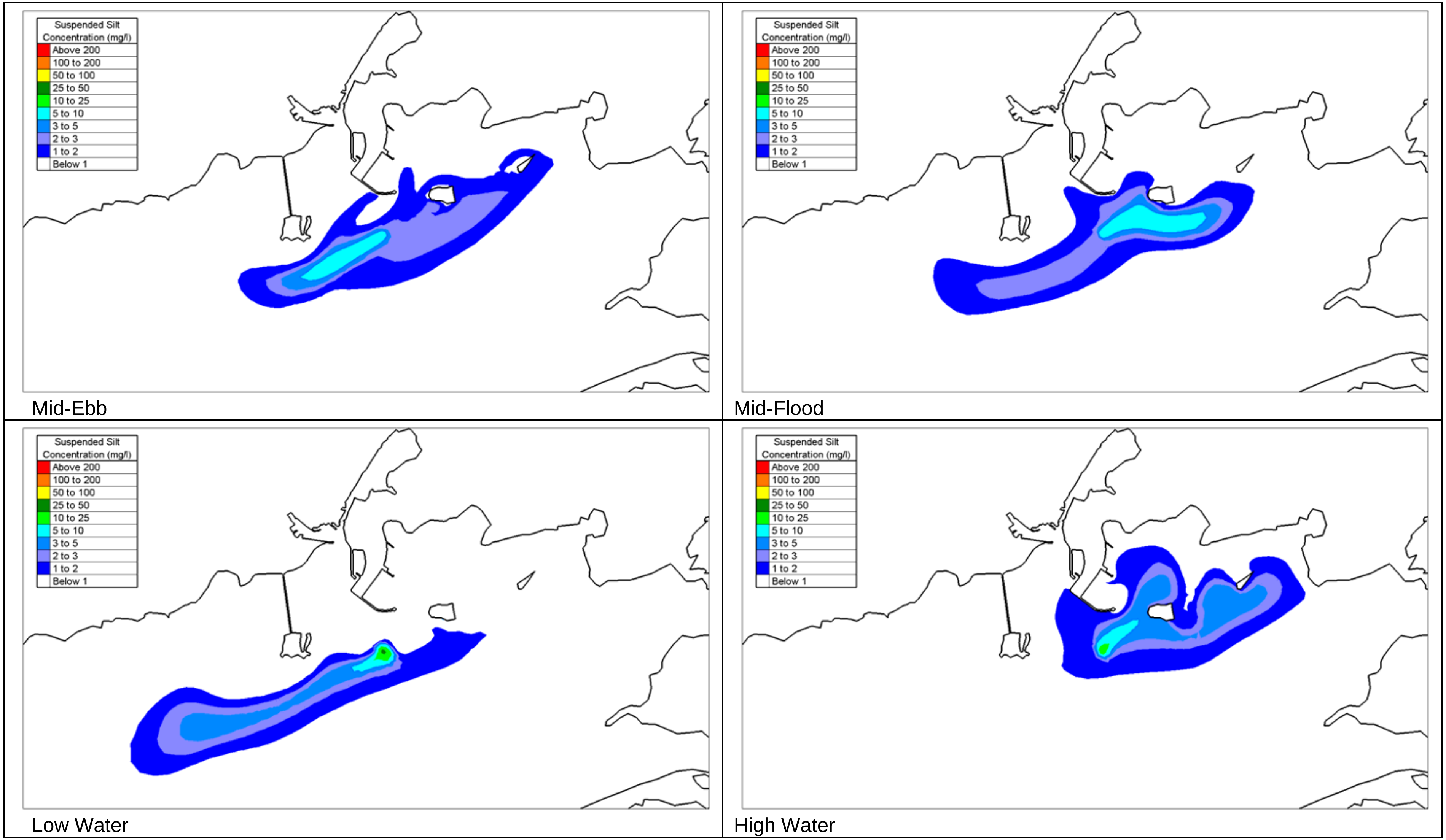


Figure 1.4 Fine silt suspended sediment plume simulation at dredge location A2 – Spring tide and Corrib Summer low flow

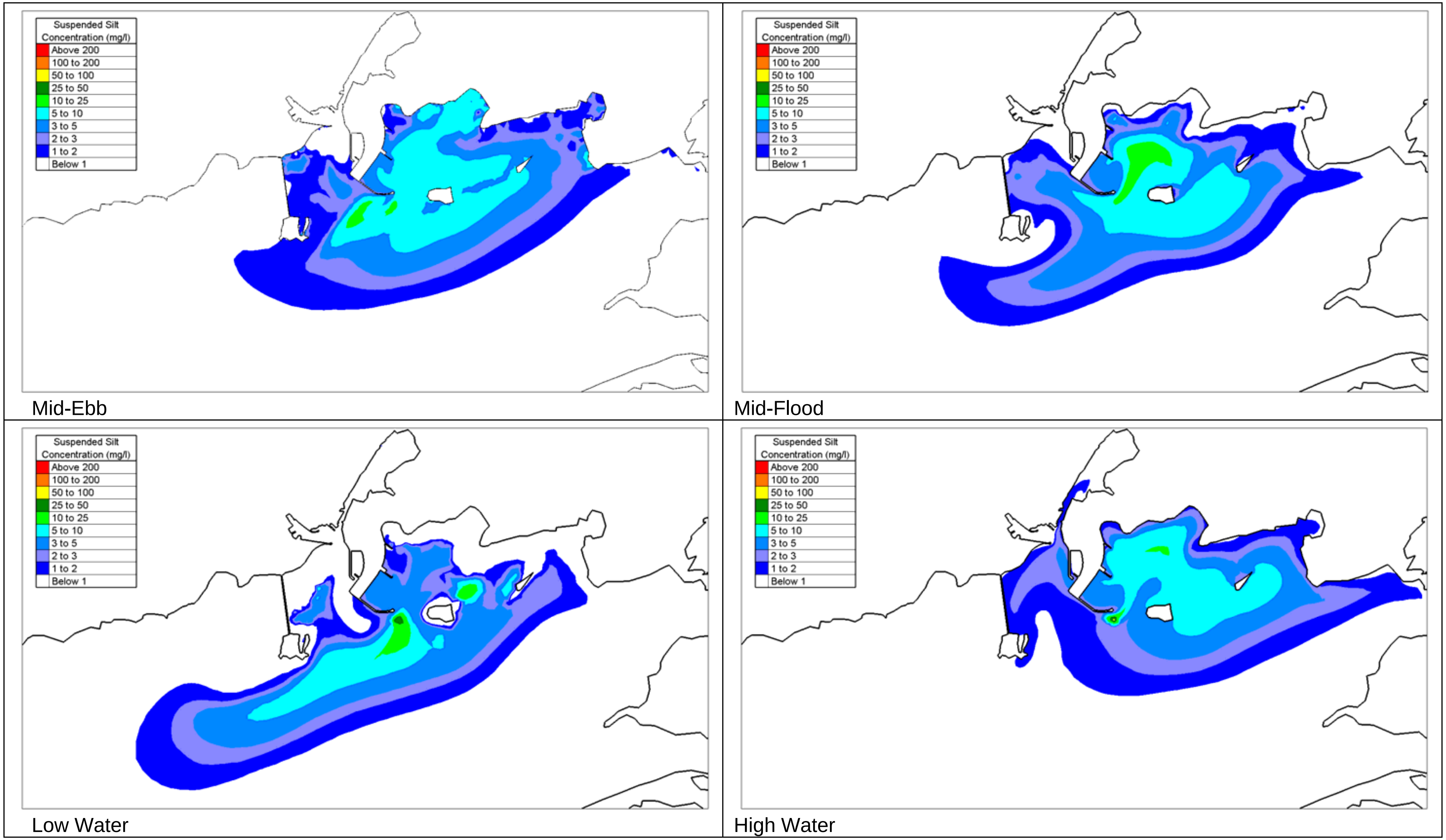


Figure 1.5 Fine silt suspended sediment plume simulation at dredge location A3 – Spring tide and Corrib Summer low flow

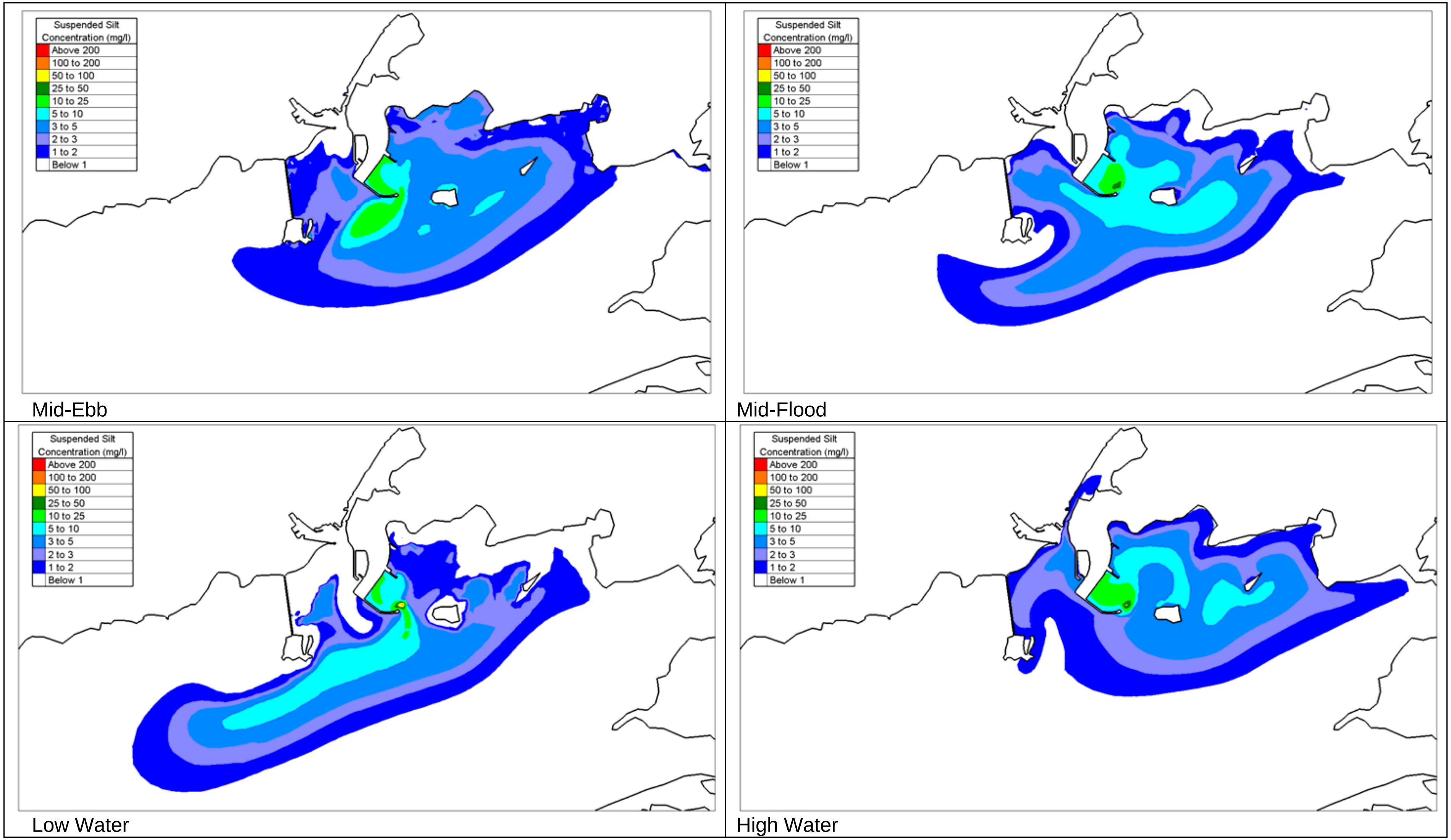


Figure 1.6 Fine silt suspended sediment plume simulation at dredge location A4 – Spring tide and Corrib Summer low flow

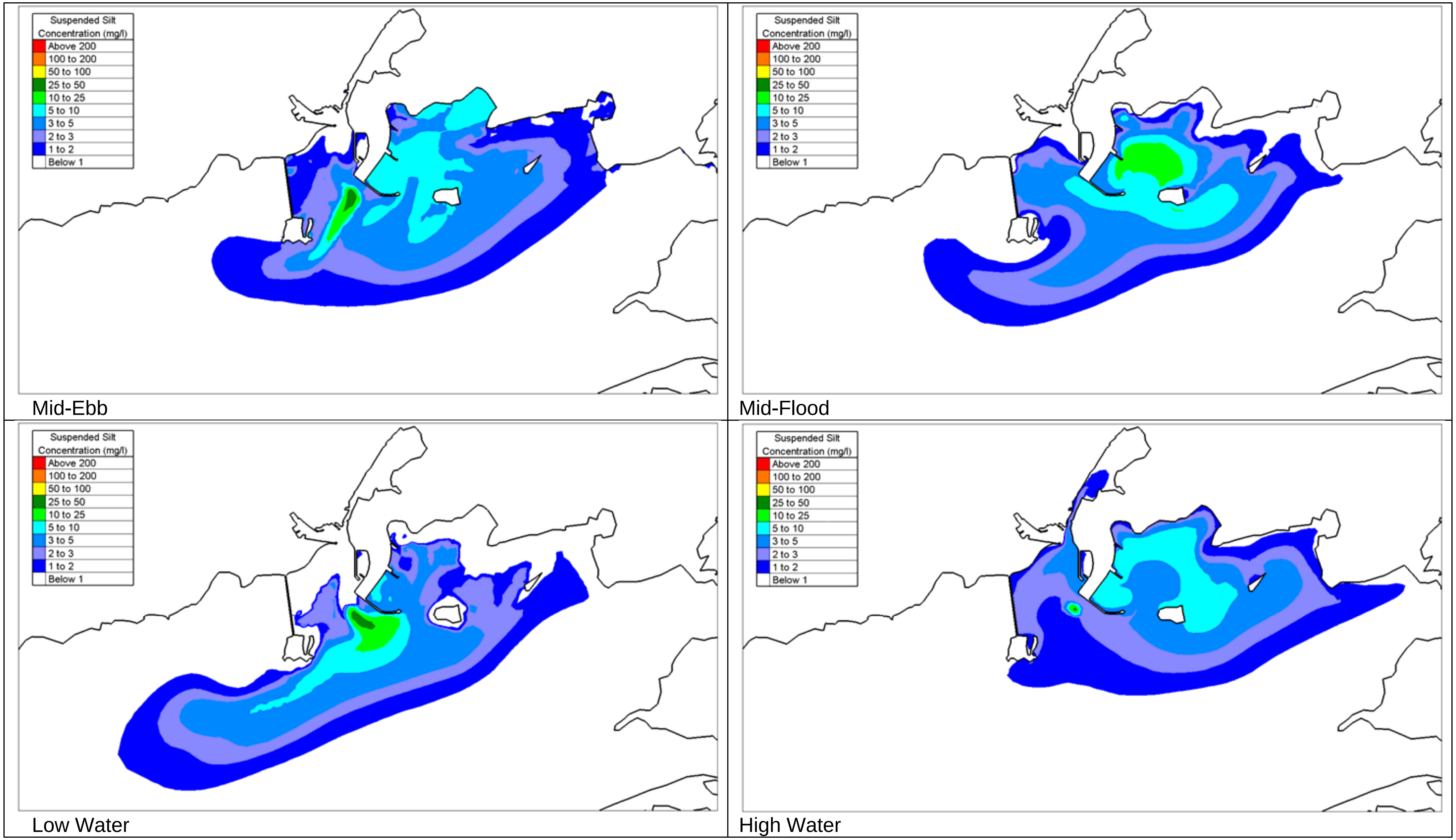


Figure 1.7 Fine silt suspended sediment plume simulation at dredge location B1 – Spring tide and Corrib Summer low flow (dredging on outgoing tides)

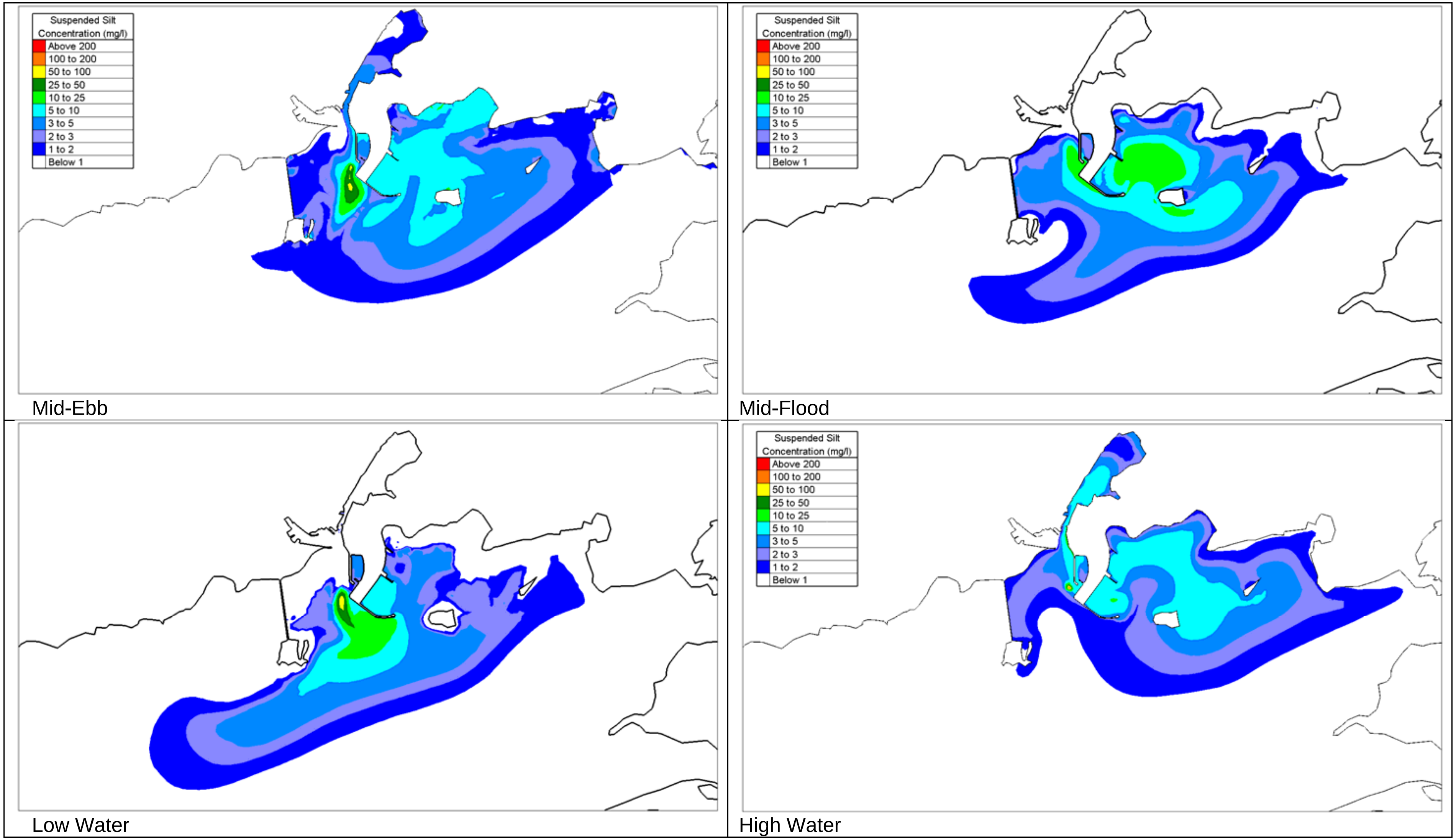


Figure 1.8 Fine silt suspended sediment plume simulation at dredge location B2 – Spring tide and Corrib Summer low flow (dredging on outgoing tides)

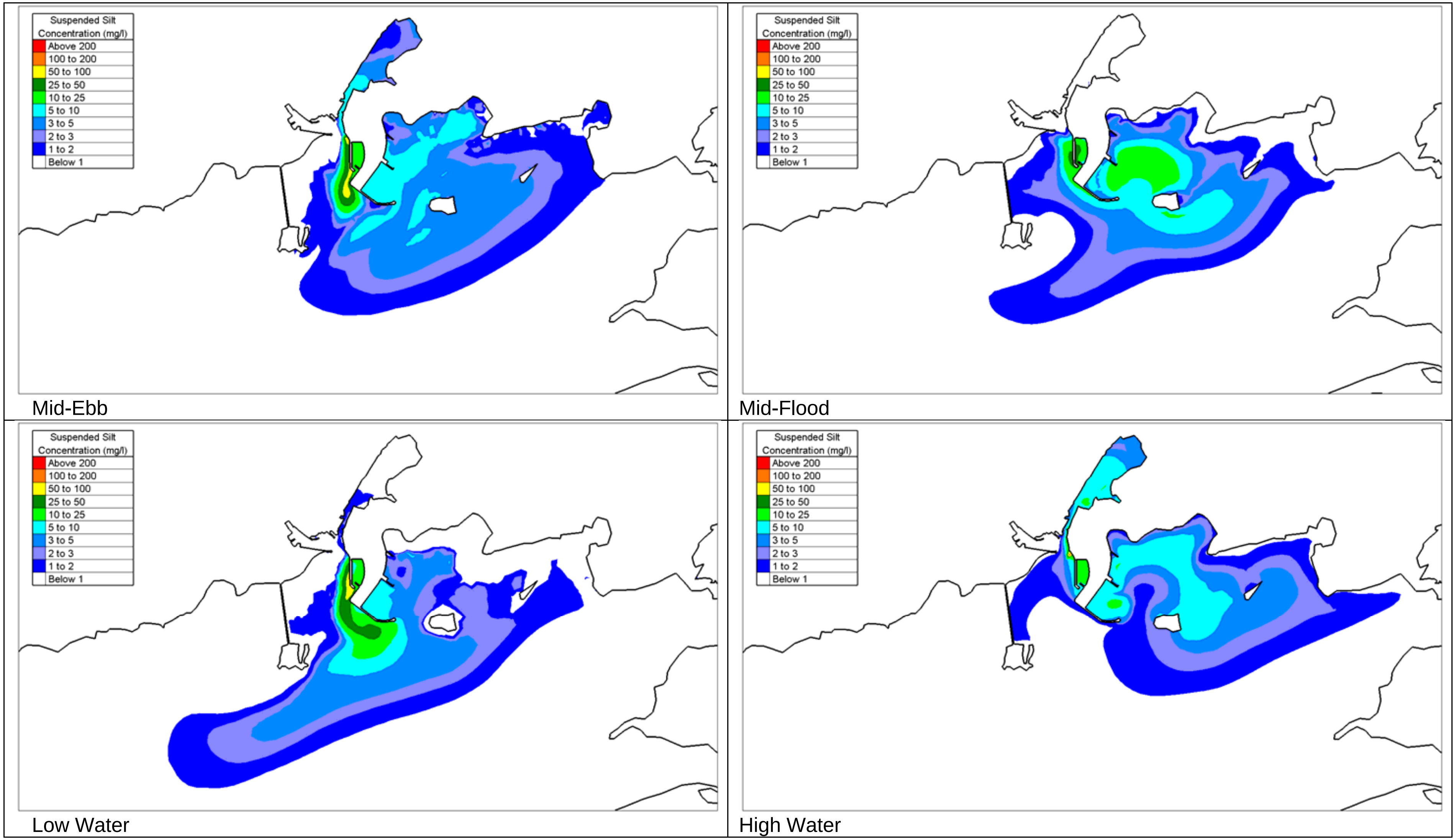


Figure 1.9 Fine silt suspended sediment plume simulation at dredge location B3 – Spring tide and Corrib Summer low flow (dredging on outgoing tides)

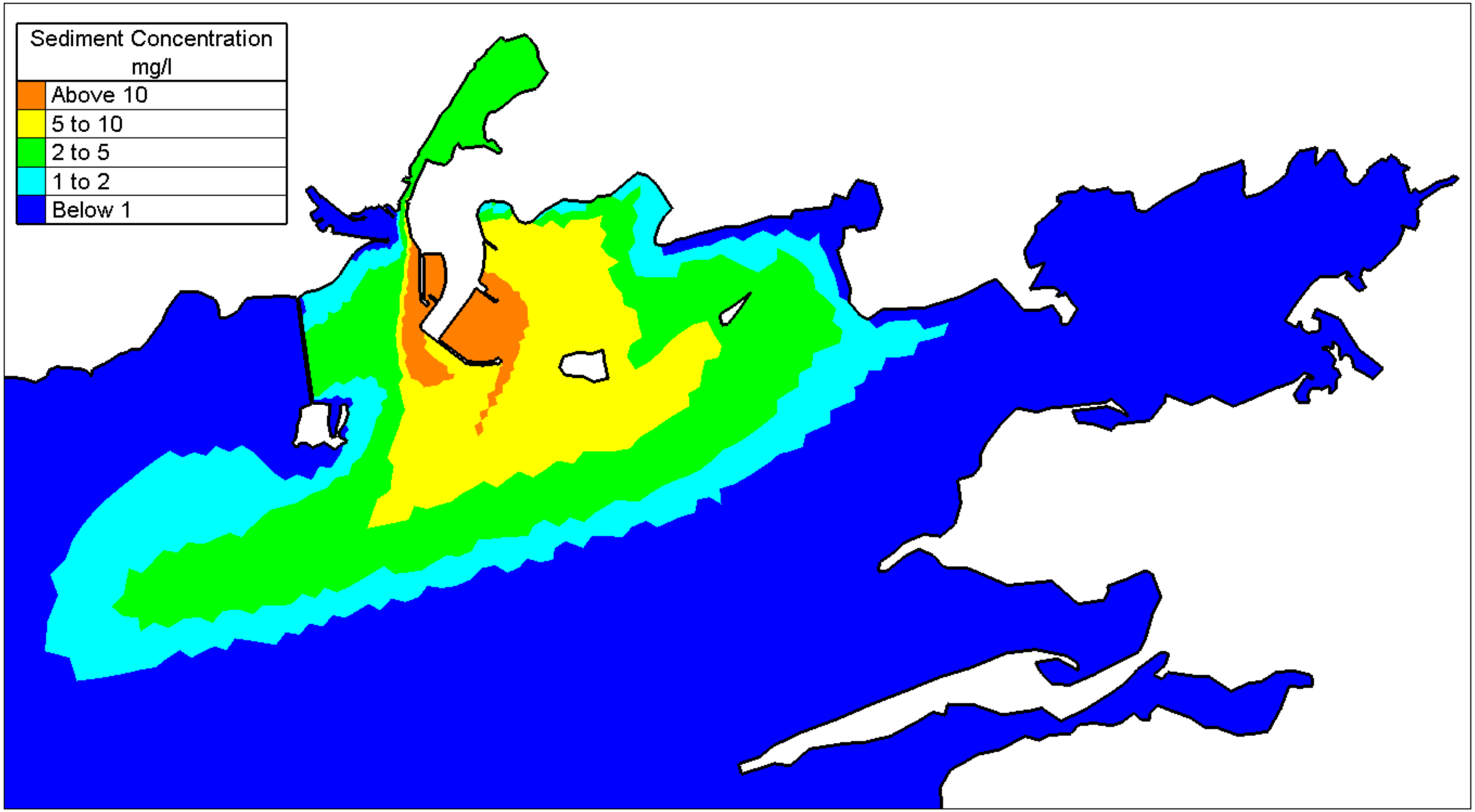


Figure 1.10 Capital Dredge tidal mean Silt Concentrations (mg/l) extrapolated from simulations of the seven dredge sites A1 – A4 and B1-B3 with mitigation for dredging of navigation channel to old Docks (Concentrations based on peak dredging rate of 17,000 m3 per day)

APPENDIX 2 – Additional Noise and Vibration Information

Appendix 2 – Additional Noise and Vibration Information

10.2.4.1 Calculation Standards

The ISO calculation method is implemented in Predictor as two separate modules. ISO 9613-1/2 industry and ISO 9613-1/2 road traffic. Predictor also includes a rail noise prediction model based on the RMR/SRM II van de Reken en Meetvoorschriften Railverkeerslawaai '96 (RMR-2006) Dutch standard. Due to the complex modelling algorithms employed in the different standards it is best practice to model each transport mode separately.

The following standards are used in the ISO industry calculation method:

1. ISO 9613-1 Acoustics – Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere;
2. ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors. Part 2: General method of calculation;

As traffic noise is dominant during the daytime the noise due to unloading bulk cargo is not considered. Oil cargos however are discharged on a 24 hour basis and night time represent the worst case scenario for modelling purposes. The Sound Power Levels of the sources used to create the model are derived from a series of measurements taken at the existing Docks area while oil tanker vessels such as the “Galway Fisher” were entering, berthing, discharging and leaving the Docks and from a database of road traffic noise measured previously by Biospheric Engineering Ltd. Due to the use of the pilot boat and the slow engine speeds used during manoeuvring the most significant noise is that generated when discharging a cargo of diesel/petrol. This is also partly due to the proximity of the ship to the dockside during discharge.

In addition to investigating the impact of shipping noise, traffic noise on the approach roads to the development and construction noise have been modelled. As a reference point the existing traffic noise and the Do Nothing port noise have also been modelled.

10.3 UNDERWATER NOISE

This section addresses the underwater noise impact of the proposed development in the inner part of Galway Bay. This evaluation was undertaken to assess potential impacts on the important Salmon and eel fisheries in Galway and the impact on marine mammals (seals and cetaceans) in the bay area. Baseline data for this section is based on monitoring carried out by Biospheric Engineering Ltd.

Salmon is a migratory species and Salmon smolts come down the river in the March/May period and go to sea for a period of one to several years. Eels are also migratory and elvers (small eels) come from the sea to begin their freshwater life around the same time. There is some scientific evidence that both species have an avoidance reaction to low frequency underwater noise (Sand, et al. (2000), Knusden, et al. (1994)). The frequency region of concern coincides with the lower end of a frequency range that can be generated by shipping and construction activities. It is important to note that these species are sensitive to particle velocity. No data exists to carry out an evaluation using particle velocity so this chapter is based on sound pressure.

During the construction phase, dredging (including rock blasting where required), pile driving and the construction of the proposed berthing area will generate significant underwater noise. This type of noise although of limited duration has the potential to cause damage to the species of concern. The potential impact needs to be assessed and in order to do so is necessary to address the issues of:

- The behaviour of noise underwater
- The hearing of fish
- The hearing of marine mammals
- The reaction of fish and marine mammals to noise
- The potential underwater noise sources generated by the proposed development

For reasons outlined later in this chapter fish species (Salmon & Eels) are the species of concern during the operational phase of this development, whereas marine mammals are of more concern during the construction phase.

10.3.1 Behaviour of Sound Underwater

In order to assess the impact of underwater noise on the species of concern it is necessary to explain the difference between the behaviour of noise in air and noise underwater. In particular it is necessary to explain the different measurement levels and the impact of these levels.

Noise propagates through a medium in the form of waves consisting of compressions and rarefactions which are detected by a receiver as changes in pressure. As with all wave motion the three basic components that define wave motion are amplitude, wavelength and frequency. All three are related but change depending on the medium in which the wave is propagating. Most receivers are sensitive to sound pressure, which is measured in micropascals (μPa). Standard atmospheric pressure is 101.3 kPa so the pressure changes due to noise in air are very small.

The range of pressure changes due to typical noise sources varies over a very wide range. The threshold of hearing in air is generally taken to be 20 μPa, whereas sonic booms and large guns can generate pressure changes of the order of 10,000 Pa. This large range of pressure changes has led to the adoption of the decibel scale using ratios of pressures to present noise measurements. Due to the logarithmic nature of the decibel scale the numbers become more manageable and generally range from 0 to 140 as outlined in section 10.1.

Unfortunately for the lay person the pressure ratio chosen for noise measurements in water is different from the noise ratio chosen for noise measurements in air. Noise measurements in water are usually expressed against a reference pressure of 1 μPa, whereas noise measurements in air are usually expressed against a reference pressure of 20 μPa. This difference in reference pressures means that it is not correct to compare underwater sound pressures with sound pressures in air.

Based on the above it should be obvious that 100 dB in air is not the same as 100 dB in water, primarily because of the differences in reference measurements. How do we make meaningful comparisons between an underwater noise and a noise in air? There are two factors to be taken into consideration (a) the difference in reference pressure, and (b) the difference in impedance in air and water (= ρc, where ρ is the density of the medium and c is the velocity of sound in it) (Sharland 1972).

In air the sound pressure level is referred to 20 μPa, while in water the sound pressure level is referenced to 1 μPa. Given the equation for dBs, the conversion factor for $dB_{air} \rightarrow dB_{water}$

$$dB = 20(p_{water}/1\ \mu Pa) = 20 \log 20 = +26\ dB$$

Therefore a pressure comparison between air and water differs by 26 dB.

The characteristic impedance of water is about 3600 times that of air; the conversation factor for a sound intensity in air vs. water is 36 dB.

$$10 \log (3600) = 36 \text{ dB}$$

The simplified conversion factor of dB in air to dB in water is therefore:

$$36 + 26 = 62 \text{ dB}$$

This simplified conversion simply relates underwater sounds to those in air. How a fish or marine mammal perceives or reacts to an underwater sound may be very different from its reaction to airborne sounds. For some fish and marine mammals, there are audiograms available, i.e. we know their hearing range. For those that we do not have audiograms for, it is generally assumed, however that animals can hear the ranges of sounds that they produce.

When evaluating the possible effects of sound pressures impinging on fish and marine mammals, it is therefore important to know the nature of the dB scale and appreciate that sound pressures in air and water should not generally be compared due to the very different properties of the two media.

Sound speed and wavelength are two related parameters which differ significantly in water and air. The speed of a wave is the rate at which vibrations propagate through the medium. Wavelength and frequency are related by:

$$\Lambda = c/f$$

Where Λ = wavelength, c = speed of sound in the medium, and f = frequency.
The speed of sound in seawater is approximately 1500 m/s while the speed of sound in air is approximately 340 m/s. Therefore a 10 Hz noise in the water has a wavelength of 150 metres whereas a 10 Hz noise in air has a wavelength of 34 metres. The importance of the increase in wavelength is apparent when we look at the propagation of noise in shallow water.

10.3.2 Propagation losses Underwater

The audibility of an underwater sound is determined by the strength of the source, the propagation efficiency, the ambient noise, and the hearing sensitivity of the subject's species. Noise levels produced by human activities in underwater environments are determined not only by the source power but by the local sound transmission conditions. A moderate level source transmitting over an efficient path may produce the same received level at a given range as our higher level source transmitting through an area where the sound is attenuated rapidly. In deep water, depth variations in water properties strongly affect sound propagation. In shallow water interactions with the surface and bottom have strong effects.

Absorption loss is another form of loss which involves a process of conversion of acoustic energy into heat and thereby represents a true loss of acoustic energy to the medium in which the propagation is taking place. The absorption losses are generally much less than the spreading losses and for distances of up to 10 kilometres in deep water can generally be ignored. It is not proposed to consider absorption losses in this study as (i) they are much less significant than spreading losses and (ii) ignoring the absorption losses will result in an additional factor of safety as the estimated received noise level will be overestimated by the extent of the absorption losses.

The zone of acoustic influence for a given source of man-made noise can vary in radius tenfold or more, depending on operating site and depth, and on seasonal with changes in water properties. Hence, sound transmission measurements, analyses, and model predictions are necessary to estimate the potential radius of acoustic influence of noisy human activities.

Etter (2013) defines shallow water as being characterized by numerous encounters with both the sea surface and the sea floor. Differences in propagation are driven by differences in the structure and composition of the seafloor. In the common shallow water bottom sediments; sand silt and mud, compressional speeds are greater than that of the overlying water column. Sound energy penetrates the bottom and losses are caused by mechanisms such as compressional wave absorption in the sediment and conversion of part of the incident energy to shear waves. Roughness of the ocean surface and bottom are perturbing effects that increase attenuation by causing more energy to be directed into the bottom.

With long range propagation in shallow water, the acoustic energy strikes the boundaries at small grazing angles leading to reflection back into the water column. At short range, the acoustic energy is reflected from the boundaries at almost normal incidence leading to multiple reflections with consequent multiple losses at the boundaries. This leads to significant attenuation close to the source which can be seen in measurements of passing vessels.

In shallow water, the propagation can be regarded as normal mode propagation where the water column is treated as a waveguide (with lossy boundaries). The solution to the wave equation is such that it consists of a finite sum of normal modes, each with a cut-off frequency below which it cannot propagate. No sound can propagate at frequencies below the cut-off frequency (fc) for the first node:

$f_c = (c_w/4D) \div \sqrt{(1-c_w^2/c_s^2)}$

Where c_w is the sound speed in water, D the water depth and c_s the sound speed of the bottom. The manifestation of the cut-off frequency is that in depths around 10m frequencies below 100 Hz will not propagate. This is an important consideration when it is known that a considerable portion of the energy associated with activities such as pile driving and blasting are at low frequencies.

The primary characteristic of acoustic signals in shallow water is the prevalence of multi-path arrivals. i.e. direct path, first surface reflection, first bottom reflection etc. The complexity of the arrival path results in constructive and destructive interference patterns arising. In order to have a full constructive addition the rays need to be perfectly reflected from the sea surface and the seabed which rarely occurs in nature. As the destructive patterns arise more frequently this results in a significant propagation loss.

The combination of these factors results in significant losses close to the source in shallow water. These losses cannot easily be modeled so the net result is that models tend to overestimate received noise levels close to the source in shallow water.

In order to calculate noise levels resulting from a particular source it is necessary to work out the transmission loss and the absorption loss. A sound wave travelling from point A to point B diminishes in amplitude or intensity, as it spreads out in space, is reflected, and is absorbed. If the source level the (at a 1 m) is 160 dB re- 1 μPa, the received level at range 1 km may be only 100 dB re-1 μPa. In this case transmission loss is 60 dB.

A major component of transmission loss is spreading loss from a point source in uniform medium (water or air), sound spreads outward as spherical waves. *Spherical* spreading implies that intensity varies inversely with the square of the distance from the source. Thus, transmission loss due to spherical spreading is given in dB by 20 (R/R_o), where Ro the reference range, normally 1 m. With spherical spreading, sound levels diminish by 6 dB when the distance is doubled and by 20 dB when distance increases by a factor of 10. Spherical spreading applies in the “free field” situation, i.e. the deep ocean.

Cylindrical spreading sometimes occurs when their medium is non-homogeneous. In shallow water, sound reflects from the surface and bottom. At some distance from the source that is long compared to water depth, various reflected waves combine to form a cylindrical wave. Such a wave may be imagined by picturing a short metal can (such as a 200 gram tin of salmon!). The top and bottom of the can correspond to the water surface and ocean bottom, and the curved outer surface is the cylindrical wave front. With cylindrical spreading, their sound intensity varies inversely with distance from the source. A simplified but useful equation for a transmission loss with cylindrical spreading is given by

$$TL = 20 \log R_1 + 10 \log (R/R_1), R > R_1$$

Where R_1 is the range at which spherical spreading stops and cylindrical spreading begins. For ranges $<R_1$, transmission loss is spherical. The preceding equation can be rewritten as

$$TL = 10 \log R_1 + 10 \log R, R < R_1$$

With cylindrical spreading, sound levels diminish by 3 dB when distance doubles and by 10 dB when distance increases tenfold. Thus, levels diminish much more slowly with increasing distance with cylindrical than with spherical spreading. Cylindrical spreading may apply in the case of shallow water, if the boundaries are highly reflective or in the case of ocean channel propagation.

When the source and receiver are close to the surface, the surface reflection of the sound interacts strongly with direct sound radiation. The reflected sound is out of phase with the direct sound. If the source has strong tonal or narrow band-width components, this phenomenon produces an interference pattern. This phenomenon, the Lloyd mirror effect is strongest with low-frequency tones and in calmer sea conditions.

A third type of spreading known as *dipole* type spreading can occur in sheltered water. When the sea surface is not too rough, it creates an interference pattern in the underwater sound field. This pattern is caused by constructive and destructive interference between the direct and surface reflected sound and is called the *Lloyd mirror* or *dipole* effect. With dipole type spreading

$$TL = 40 \log R_1$$

In general the spreading law for sound propagation in the sea is not simple, not only because of the reflection at the boundaries, but also because of the refraction that takes place due to sound gradients.

As sound travels, some power is absorbed by the medium, giving rise to absorption losses. In dB, such losses vary linearly with distance travelled, and absorption loss can be described as x dB/km. Absorption losses depend strongly and frequency, becoming greater with increasing frequency. Scattering losses also very linearly with distance, but result from different physical mechanisms. These losses are in addition to the spherical, cylindrical or other spreading losses previously mentioned.

The terms “deep” and “shallow” water are relative terms when referring to propagation losses. “Deep” water generally refers to the open ocean where spherical propagation is the norm and considerable distances are involved. “Shallow” water in the literature generally refers to the continental shelf and offshore area where depths are less than 200 metres. In the case of Galway Harbour we are dealing with extremely shallow water. The water depth at spring tides in the area of interest is typically 5 to 6 metres.

Sound transmission in shallow water is highly variable and site specific because it is strongly influenced by the acoustic properties of the bottom and surface as well as by variations in sound speed within the water column (Richardson et. al., 1995). With shallow water sound transmission the combination of environmental factors makes it difficult to develop accurate theoretical models. The theory must be combined with site-specific empirical data to obtain reliable propagation predictions.

When the water is very shallow (as in this case) sound propagation may be analysed using mode theory. Mode theory predicts that, if the effective water depth is less than $\lambda/4$, waves are not matched to the duct and very large propagation losses occur (λ for a 10 Hz wave in seawater is of the order of 150 metres as outlined above). The situation at Galway Harbour is further complicated by the existence of a water saturated sediment that does not act as a reflecting boundary for all the sound energy and the complex mixing zone where the fresh Corrib water meets the saline harbour water.

It is possible to make reasonable propagation predictions from simple formulas and numbers of such formulas have been developed for deep water. Urich (1983) describes the Marsh and Schulkin (1962) model which was based on a large number of measurements in "shallow" water from 100 Hz to 10,000 Hz.

With a shallow source, the source and its reflected image become a dipole source with a vertical directionality (Urich 1983). In deep water with both a shallow source and a shallow receiver, spreading loss may be as much as 40 log R, versus the 20 log R expected from spherical spreading. In shallow water, the shallow source dipole effect introduces an additional 10 log R spreading loss (Grachev 1983, quoted in Richardson et. al. (1985)), increasing the loss from ~ 15 log R to ~ 25 log R. A similar interference effect occurs when the receiving location is within ¼ wavelength of the surface, (At 6 metres depth this impacts all frequencies under 63 Hz). Thus, propagation from a shallow source to a shallow receiver in shallow water will show a spreading loss of ~35 log R.

The spreading loss is therefore a complex issue, can vary significantly in magnitude and has a significant impact on propagation losses. Under certain conditions the losses could be as high as 40 log R1 but it is likely that site conditions will reduce this rate somewhat. In order to be certain of the appropriate spreading loss to apply in each case it must be verified with site specific measurements.

10.3.3 Background Noise Levels Underwater

Ambient noise is the background noise, there is no single source, point or otherwise. In the ocean, ambient noise arises from the wind, waves, surf, ice, organisms, earthquakes, distant shipping, volcanoes, fishing boats, and more. At any one place and time, several of these sources are likely to contribute significantly to ambient noise. In this source-path-receiver model, and ambient noise is present in the medium (water or air) along the path, and it is present at any receiver location.

Ambient noise varies with season, location, time of day, and frequency it has the same attributes as other sounds, including transient and continuous components, tones, hisses, and rumbles. It is measured in the same units as other sounds. However, in measuring ambient noise, it makes no sense to use a reference distance from the source. There is no one source.

Wenz (1962) presented a graph of ambient noise spectra in the ocean attributable to many sources and spanning five decades of frequency from 1 Hz to 100 kHz. This graph shows the wind dependence of ambient sounds plus the typical contributions of many other sources. Low frequency noise (1-20 Hz) is caused largely by surface waves (especially in shallow water) and turbulent pressure fluctuations. However, biological sources, distant shipping, earthquakes, and other seismic activities are also major contributors to low frequency ambient noise. Wenz noted that shallow water noise levels are "…about 5 dB greater than corresponding deep water levels at the same frequency and same wind speed,"

The ambient noise level in Galway Harbour (as determined in this study) is consistent with the Wentz curve, albeit the shallow water noise levels are higher than deeper water levels.

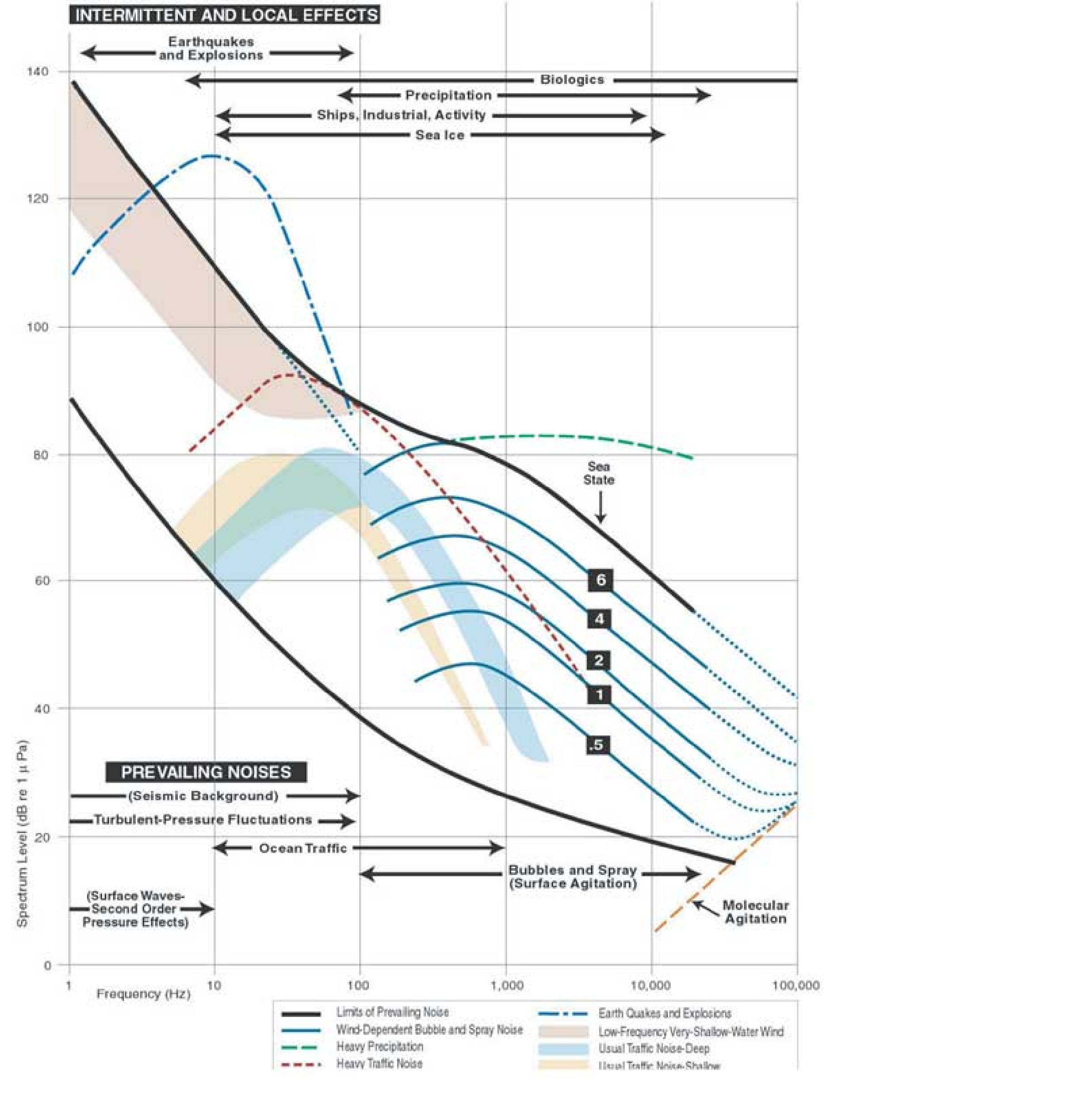


Figure 10.3.1 - Wentz Curve Background Noise in the Sea

10.3.4 Hearing of Fish

Most of the body tissues of a fish are almost the same density as water, so that, the fish will vibrate in a similar manner to the particles in the water. There will however be some differential motion between the fish and the surrounding water. This motion varies along the length of the fish depending upon the distance from the sound source, so there are differential displacements at various points on the body. Consequently, there are advantages in having a long lateral line in which the particle displacement system is subjected to differential stimulation.

Fish hearing in general is different from that of terrestrial organisms and operates in two ways. Most fish hear with a primitive version of the terrestrial inner ear (located in the skull of fish) and with the lateral line system that runs the length of each side of the fish and is often extensively branched in the area of the head. The inner ear and lateral line system are collectively called the acoustico-lateralis system. The lateral line system of fish is extremely sensitive to close range pressure changes.

The sensitivity of the lateral line system seems particularly well suited to sensing the movements of nearby fish, such as in schooling behaviour, the irregular movements of a potential prey, or the approach of a predator. The lateral line system appears to function most effectively in the near field, i.e. relatively close to the fish.

The inner ear of fish does not have a cochlea as in terrestrial vertebrates; rather there are three symmetrically paired structures with associated bony otoliths. The otoliths in both salmon and eels are hard structures composed of calcium carbonate and have a density of about 3 $kg/m^{3,}$ (Jobling 1995). Most of the fish body has the same density as the surrounding water, (varies around 1.03 $kg/m^{3,}$) (Kempe's 1991) and during the passage of a sound wave the ossicilatory particle displacements in fish tissues will be similar to those of water molecules. The mechanism for a hearing is the differential displacement of high-density otholiths relative to their low-density bodies of fish (about the same density as water), resulting in bending of sensory hair cells that line the otholiths. This mechanical stimuli is then converted to electrical stimuli in the hair cells body and sent to the brain via the auditory nerve for processing. (Jobling 1995)

The gas bladder appears to respond to sound pressure by pulsating in sympathy with the passing sound wave. The pulsations caused by the sound pressure create a secondary near-field within the body of the fish close to the inner ear. The particle displacements so produced are then re-radiated through the tissues to the inner ear where they can be detected. Thus, the gas bladder may function as a pressure transducer and sound amplifier, but there are significant differences between species as to its effectiveness.

The hearing ability of fish such as salmonoids and flatfish is limited in bandwidth and intensity threshold compared to other fish. Atlantic salmon (Salmo salar) are functionally deaf above 380 Hz (Hawkins and Johnstone 1978). These fish lack the physical connection between their swim bladder and inner ear that other fish possess (Hawkins 1986). Fish with this latter type of hearing are most sensitive to particle velocity since the otholiths essentially respond to particle displacement (Hawkins and MacLennan 1976). In fact, the swim bladder probably does little to enhance hearing in salmon (Enger 1981).

Compared to humans, salmonoids have poor hearing on the basis of perceivable frequency range and sensitivity to sound pressure. Human infants are capable of detecting sounds from 20-20,000 Hz, and at sound pressure levels much lower than that of salmonoids. For example, a human would require about 40 dB re-1 μPa sound pressure level to hear a 160 Hz pure tone, while a salmonoid would require about 100 dB. Therefore, the salmonoid requires close to a thousand fold difference in sound pressure level to hear the same 160 Hz tone.

The hearing of the European eel (Anguilla anguilla) was studied by Jerko et al. (1989) who found that the upper audible frequency limit in the eel was about 300 Hz. At low frequencies the relevant stimulus parameter was particle motion. At higher frequencies within the audible range the swim bladder conveyed an auditory advantage for stimuli with a high ratio between pressure and particle motion. An auditory function of the swim bladder in this species therefore indicates an efficient transmission channel for the swim bladder pulsations between the bladder and the ear.

As pointed out earlier the hearing ability based on particle displacement is a highly localised ability and apart form short term close range impacts is not of material interest to this study. The proposed harbour development is located over a kilometre from the entrance to the river and so near field effects are not significant.

10.3.5 Hearing of Marine Mammals

10.3.5.1 Cetaceans

Cetacean ears are similar in structure to most mammalian ears; the basic structure comprises three auditory ossicles, a tympanic membrane linked via eustacian tube to a cochlea and semi-circular canals. In cetaceans however the outer ear is equipped with circular constrictor muscles. Particular adaptations are evident to permit detection of high frequency sounds and to facilitate stereoscopic ranging in an underwater environment (Fraser et al, 1960). The fact that sounds travels much faster underwater requires rapid processing of the difference in detection times of a sound in each ear to carry this out.

It has been suggested that cetacean ears may be less vulnerable to acoustic damage than those of terrestrial mammals. However, there is no direct evidence to support this contention. The middle and inner ears of cetaceans are located outside the cranium and are enclosed in two dense bony capsules. These bones are massive by comparison to homologous structures in terrestrial mammals and may be an adaptation to withstand pressure changes during diving.

There are two main groups of cetaceans: odontocete or toothed whales and mysticete or baleen whales, the species likely to feature in Galway Bay all belong to the former group. Toothed whales communicate at moderate to high frequencies (1-20 kHz) and also have highly developed echolocation systems operating at high and very high frequencies (20-150kHz).

Although closely related to each other, the odontocetes and the mysticetes produce different calls and probably produce the calls using very different mechanisms. In general the calls produced by odontocetes tend to be high in frequency and shorter duration than those produced by mysticetes (Popper et al, 1997).

Vocalisations by odontocetes can be assigned to three types; tonal whistles, pulsed sounds and echolocation clicks. There have been no reported whistle sounds from porpoises, whereas the dolphin family have such a variety of whistles that relatively small variations in whistles may indicate behavioural states (Caldwell et al, 1990). Most whistles are produced at frequencies below 20,000 Hz.

Pulsed calls are produced by the repetition of pulses, which are broadband in their frequency content (tens to thousands of Hz in odontocetes) and of very brief duration (milliseconds). When produced in rapid succession (>20/s) the human ear cannot separate the individual pulses and the sounds are perceived as complex moans, growls, barks or screams. It is likely that odontocetes perceive the individual pulses because the species that have been tested are capable of perceiving individual echolocation pulses that are produced at much higher repetition rates (600/s) (Ridgeway, 1983, quoted in Popper above)

Odontocete species have the ability to use sound to orient in their environment and to locate food by listening for the echoes of high-frequency clicks that the animal directs at the target just as bats do (echolocation). Echolocation sounds are higher frequency and may range from 16-20 kHz to over 100kHz. The sounds are short and may include frequency-modulated sweeps. The frequency and amplitude of the echolocation click varies and apparently depends on the background noise and target distance.

Dolphins and porpoises produce their different calls using their nasal sacs, associated muscles and muscular nasal plugs. A special fatty tissue region in the melon of the head helps to concentrate acoustic energy, allowing the animal to direct the energy in a narrow beam. This is different from other mammals which utilise the larynx to produce sound.

10.3.5.2 Hearing of Pinnipeds

Harbour and Grey seals belong to the Phocidae (true seals) family and do not have an external ear. Most phocids produce only simple mate-attraction calls and mother-pup calls. Because most of their mating behaviour occurs in the water, the phocids tend to produce more underwater vocalisations than in-air vocalisations.

Phocinid seals have essentially flat audiograms from 1 kHz to 30-50 kHz, with thresholds between 60 and 80 dB re 1 μPa. Harbour Seals can detect underwater sounds up to 180 kHz if it is sufficiently loud, however their sensitivity drops off significantly above 60 kHz.

Otters spend much of their time in water, but underwater sounds have not been studied. Airborne sounds of adults include whines, whistles, growls, soft cooing sounds, chuckles and snarls. When stressed otters may utter harsh screams. The sounds produced are in the human range of audibility, with sounds in the range 3-5kHz. There is no published data on the hearing of a eurasian otter, but as they spend less time in the water than pinnipeds it can be assumed that their hearing underwater is unlikely to be as sensitive as that of a pinniped's.

The hearing ranges of the Salmon, the Eel, Cetacean species and Pinnipeds are compared on Figure 10.2. For the purposes of this study we are particularly interested in the High-Frequency Cetaceans, which include both Common and Bottlenose Dolphins and Porpoises. Low Frequency Cetaceans such as the baleen whales are less likely to appear in the inner bay area and are included in the data for completeness only.

It is immediately apparent that the frequency range of the Salmon and Eel are limited to the low frequency (less than 600 Hz) end of the spectrum. The sensitivity of the Salmon is relatively flat over the frequency range 10 Hz to 150 Hz and decreases rapidly at higher frequencies (Knudsen 1992). The sensitivity of the eel increases up to 80 Hz and decreases rapidly at higher frequencies, It is apparent from the graph that the frequencies of most interest are those below 630 Hz for the "fish" species.

Marine Mammals however have a much higher range of hearing. Bottlenose dolphins can hear sounds as low as 40 Hz. However, the sensitivity at these low frequencies is poor. In contrast, the high frequency hearing abilities of most odontocetes are exceptionally good. This is related to their use of high-frequency sound for echolocation. In the mid-frequency range where odontocetes have their best sensitivity, their hearing is very acute.

Phocinid seals have essentially flat audiograms from 1 kHz to 30-50kHz, with hearing thresholds between 60 and 85 dB re 1 μPa. Harbour seals are reported to be able to detect sound at very high frequencies, up to 180 kHz. However, above 60 kHz sensitivity is poor and different frequencies cannot be discriminated. (Richardson, et al, 1995)

A simplified interpretation of the hearing thresholds would indicate that marine mammals have "better" hearing in that they can hear over a wider range of frequencies and at lower intensities than the fish.

In the audiograms presented in Figure 10.3.2 four sound types are marked A, B, C, and D.

<u>Sound A</u>
70 dB re 1 μPa at 10 Hertz. This sound is below the threshold of all species and is not audible to either fish or marine mammals.

<u>Sound B</u>
130 dB re 1 μPa at 100 Hertz. This sound is above the threshold of all species and is audible to both fish to marine mammals.

Sound C
110 dB re 1 μPa at 1000 Hertz. This sound is above the threshold of all marine mammal species and is audible marine mammals. At 1000 Hertz the frequency is too high for Salmon or Eels to hear the sound so it is inaudible to these species.

Sound D
70 dB re 1 μPa at 100,000 Hertz. This sound is above the frequency threshold of all species except the high frequency cetaceans and is not audible to both fish or marine mammals with low frequency or mid frequency hearing ability.

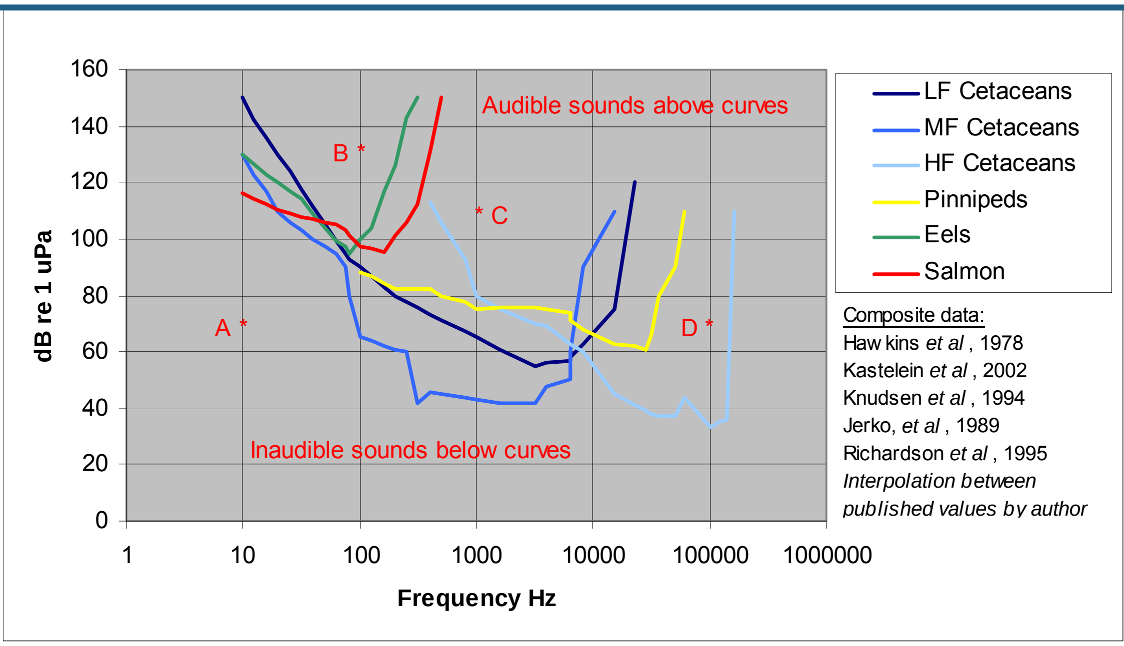


Figure 10.3.2 - Hearing Thresholds Marine Species

10.3.5.3 Avian Hearing

Birds hearing in air appears to be secondary to vision for sensing threats. Bird hearing is generally in the range 1 to 4 kHz with decreasing sensitivity to higher and lower frequencies, which is broadly similar to the human hearing range. Humans have more sensitive hearing than birds generally and birds gathering in flocks are somewhat accustomed to natural background noise. Many species live in urban environments with high levels of noise and there is both anecdotal and research evidence indicating that birds habituate to elevated noise levels.

Considerable research effort has gone into the effects of low flying military aircraft on nesting birds. Birds have a natural startle response and it is necessary to separate biologically significant disturbance from other forms. Incubating birds can be startled from a nest by a loud sound and return after an interval. If that interval is too long the eggs/young can die. Awbrey and Bowles (1990) found that startle responses by nesting raptors were short and did not result in a risk to the nest.

The noise levels associated with this project can be generally described as 'continuous' construction noise and the noise levels in air have been modeled and evaluated for impact on humans. With appropriate mitigation there will not be a significant impact and it is reasonable to infer the same applies to bird populations. Blasting noise is however a case where a startle response may result in a short term startle response. In order to minimise the risk to nesting birds in particular it is planned (other than in exceptional circumstances) to limit blasting to one blast per day.

10.3.6 Impact Thresholds for Marine Fauna

10.3.6.1 RECOVERABLE/ NON RECOVERABLE INJURY

Extreme levels of underwater noise can cause fatalities or non-recoverable injury and such noise levels occur close to very loud sources. As noise propagates out from a source, some of the energy is dissipated and the impacts are lessened. At some point, recoverable injury such as a temporary threshold shift (TTS) may be caused. This is defined as a temporary change in hearing capability which returns to normal after a period. Permanent Threshold Shift (PTS) is a permanent hearing impairment and thus a non-recoverable injury.

Further from the source, a zone may exist where the noise from the source is such that it prevents communication or detection capability for predators or prey and may directly or indirectly impact an animal. This ‘Disturbance Zone’ is one in which the animal is disturbed to an extent that it reacts in some way. Reactions can have behaviourally significant consequences, for example if breeding is interfered with.

Beyond this is a zone in which animals can hear underwater noise from the source and in some cases react to it but the consequences are not significant when viewed in the context of the conservation status of local populations.

Sound Exposure Level (SEL) is a measure of energy that incorporates both sound pressure level and duration. The spectral content can also be taken into account by an M-weighting, which is a frequency weighting to allow for the functional hearing bandwidths of different marine mammal groups.

10.3.6.2 TEMPORARY THRESHOLD SHIFT

There are limited scientific data available on underwater noise levels in general and this is particularly the case regarding injury and disturbance thresholds. For example, no data exist on the onset of Permanent Threshold Shift (PTS) in marine mammals. A review by Southall et al. (2007) proposed a PTS threshold of 6 dB above the unweighted Sound Pressure Level (SPL) and 15 dB above the M-weighted SEL.

Natural biological variations of up to 10 dB in an individual’s hearing capability can occur for many reasons. The Report of the Expert Hearing Group on Hearing Disability assessment set a minimum threshold of 20 dB (SPL) in threshold shift as the onset of disability. A threshold shift of 6 dB (SPL) in marine mammals can therefore be regarded as a conservative approach.

Some scientific data are available on recoverable injury and audibility thresholds for different species. These data was used by Southall et al. (2007) to develop metrics for potential impacts on marine mammals. Southall et al. propose SPL criteria of 230 dB re 1 µPa (peak broadband level) for PTS onset in cetaceans and 218 dB re 1 µPa for pinnipeds. TTS onset is expected at 224 dB re 1 µPa (peak broadband level) and 212 dB re 1 µPa for cetaceans and pinnipeds respectively (Finneran et al., 2002; Southall et al., 2007). The SEL criteria proposed are TTS onset at 183 dB re 1 µPa2-s for cetaceans and 171 dB re 1 µPa2-s for pinnipeds, and PTS onset is expected at 15 dB additional exposure.

The Southall criteria for High frequency cetaceans (Harbour Porpoise) were based on an extrapolation of data for Mid frequency cetaceans. Kastelein et al (2012) found that for relatively small threshold shifts (<15 dB), recovery is quick (within ~60 minutes). In most cases reduced hearing for such a short time period (if it does not occur many times per day) may have little effect on the total foraging period of a porpoise, particularly at low frequencies. With species such as Harbour Porpoise likely to move away from significant noise sources they are unlikely to repeatedly expose themselves to high noise levels in this way.

The greatest risk to bird life from this project is the risk of a diving bird being close to an underwater blast. Other activities generating noise may disturb bird life to a greater or lesser extent but are unlikely to have fatal consequences. The available evidence on the risk to diving birds during blasting indicates that unless the birds are very close to the source of the blast no injuries are likely. For this reason Terns and Gulls are not considered as being at risk from underwater noise.

Yelverton et al.l (1973) investigated far field underwater blast effects on mammals and birds and found that ducks subjected to 234 dB re 1uPa peak and 225 dB 1 uPa2-s SEL when submerged were not harmed. The corresponding levels for ducks on the surface were 230 dB re 1uPa peak and 220 dB 1 uPa2-s SEL. The explanation for the higher levels required to cause injury at the surface was based on the fact that most of the vital organs were located above the water surface. Stemp (1985) has stated that there is no evidence of high underwater sounds affecting diving birds.

There are no available data on disturbance to diving birds due to underwater noise levels. Doorling and Therrien (2012) indicate that diving birds may not hear well underwater. Startle responses and behavioural changes are therefore likely to be determined by airborne noise levels rather than underwater noise levels.

10.3.6.3 DISTURBANCE CRITERIA

Behavioural disturbance is difficult to quantify as reactions are highly variable and context specific making them less predictable Southall et al., (2007). SPL fails to account for the duration of the exposure, but it is the metric that has most often been estimated during disturbance studies (Southall et al., 2007). These values were based on those for multiple pulse sounds for all species, except for the harbour porpoise where all of the studies reviewed in Southall et al. (2007) were classified as non-pulses (intermittent or continuous sounds that can be tonal, broadband or both. Finneran and Jenkins (2012) have proposed SEL based criteria for disturbance which do take account of the duration of the exposure. These criteria are precautionary as only a small number of controlled studies have been performed, few field studies estimate received levels and a limited number of species are represented. The long-term implications of these behavioural responses have also not been determined.

Recent research on noise sensitive marine mammals indicates that disturbance/displacement is of shorter duration than previously reported, Thompson et. al (In Press) and while disturbance may take place at relatively low received levels the disturbance is context specific and distant sources may result in moderating reactions, De Ruiter et al (2013).

Hawkins and Popper (2012) have reviewed exposure metrics for fish species. The current US criteria of Peak SPL 206 decibels dB re 1 μPa, SELcum 187 dB re 1μPa2-s for fishes above 2 grams and SELcum 183 dB re 1μPa2-s for fishes below 2 grams need to be viewed in the light of more recent studies indicating that these thresholds are too conservative. Halvorsen et al. (2011) indicate the thresholds may be 20 dB below those found in better controlled studies.

In spite of the recognition that fish sense underwater noise as PV, no guidelines exist on PV exposure and very few data are available on PV levels. This significant data gap will be addressed in the forthcoming report which will set out ‘risk categories’ of High, Medium or Low within specific zones based on available studies. This categorisation of risk has been adopted for this report in relation to disturbance.

Due to historical reasons, underwater noise levels are referenced against a pressure of 1 μPa therefore noise levels in air are not directly comparable with noise levels underwater. The concept of M-weighting was introduced by Southall et al., (2007) to take into account the spectral characteristics of underwater noise and their potential impact on marine mammals in particular. Southall et al., (2007) introduced 5 categories of marine mammal thresholds, Low Frequency Cetaceans, Mid Frequency Cetaceans, High Frequency Cetaceans, Pinnipeds in Air and Pinnipeds underwater and proposed different M-weighting curves for each category.

Due to the shallow waters surrounding this development no Low Frequency Cetaceans are considered to be close enough to the proposed development to be at risk from underwater noise. In the unlikely event that any Low Frequency Cetaceans approach the risk area, mitigation measures will be implemented in a similar fashion to other Marine Mammals but the risk is not otherwise considered further in this section. In line with best international practice, Finneran & Jenkins (2012) and NOAA (2013), consideration is given to Cetaceans, Phocids and Mustelids separately rather than limiting consideration to Cetaceans and Pinnipeds as general classes of Marine Mammal.

Proposed Underwater Noise Exposure Criteria					
Species	**Single Pulse**	**Multiple Pulse**	**Nonpulse**	**Disturbance**	**Reference**
Mid Frequency Cetaceans					
Sound Pressure Level	224 dB re 1uPa (peak)(flat)	224 dB re 1uPa (peak)(flat)	224 dB re 1uPa (peak)(flat)	140 dB re 1uPa (peak)(flat)	Southall *et al*, 2007
Sound Exposure Level	183 dB re 1uPa2-s (M weight)	183 dB re 1uPa2-s (M weight)	200 dB re 1uPa2-s (M weight)		Southall et al, 2007
High Frequency Cetaceans					
Sound Pressure Level	224 dB re 1uPa (peak)(flat)	224 dB re 1uPa (peak)(flat)	224 dB re 1uPa (peak)(flat)		Southall *et al*, 2007
Sound Exposure Level	183 dB re 1uPa2-s (M weight)	183 dB re 1uPa2-s (M weight)	195 dB re 1uPa2-s (M weight)	120 dB re 1uPa2-s (M weight)	Finneran & Jenkins 2012
Phocids (in water)					
Sound Pressure Level	212 dB re 1uPa (peak)(flat)	212 dB re 1uPa (peak)(flat)	212 dB re 1uPa (peak)(flat)		Southall *et al*, 2007
Sound Exposure Level	171 dB re 1uPa2-s (M weight)	171 dB re 1uPa2-s (M weight)	188 dB re 1uPa2-s (M weight)	100 dB re 1uPa2-s (M weight)	Finneran & Jenkins 2012
Phocids (in air)					
Sound Pressure Level	143 dB re 20uPa (peak)(flat)	143 dB re 20uPa (peak)(flat)	143 dB re 20uPa (peak)(flat)		Southall *et al*, 2007
Sound Exposure Level	129 dB re 20uPa2-s (M weight)	129 dB re 20uPa2-s (M weight)	129 dB re 20uPa2-s (M weight)	100 dB re 20uPa2-s (M weight)	Finneran & Jenkins 2012

Table 10.3.1 - Proposed Underwater Noise Exposure Criteria (Part 1 of 2)

Proposed Underwater Noise Exposure Criteria					
Species	**Single Pulse**	**Multiple Pulse**	**Nonpulse**	**Disturbance**	**Reference**
Mustelids (in water)					
Sound Pressure Level	212 dB re 1uPa (peak)(flat)	212 dB re 1uPa (peak)(flat)	212 dB re 1uPa (peak)(flat)		Finneran & Jenkins 2012
Sound Exposure Level	171 dB re 1uPa2-s (M weight)	171 dB re 1uPa2-s (M weight)	188 dB re 1uPa2-s (M weight)	100 dB re 1uPa2-s (M weight)	Finneran & Jenkins 2012
Mustelids (in air)					
Sound Pressure Level	143 dB re 20uPa (peak)(flat)	143 dB re 20uPa (peak)(flat)	143 dB re 20uPa (peak)(flat)		Finneran & Jenkins 2012
Sound Exposure Level	129 dB re 20uPa2-s (M weight)	129 dB re 20uPa2-s (M weight)	129 dB re 20uPa2-s (M weight)	100 dB re 20uPa2-s (M weight)	Finneran & Jenkins 2012
Fish (0.1 kg)					
Sound Exposure Level	195 dB re 1 uPa2-s PTS onset			187 dB re 1 uPa2-s PTS onset	Popper *et al.* (1997)
Fish (1.0 kg)					
Sound Exposure Level	200 dB re 1 uPa2-s PTS onset			192 dB re 1 uPa2-s PTS onset	Popper *et al.* (1997)
Diving Birds					
No specific data is available on injury thresholds or behaviour of diving birds exposed to underwater noise					

Table 10.3.2 - Proposed Underwater Noise Exposure Criteria (Part 2 of 2)

The above criteria will be used to quantify the effect of existing and proposed noise emissions on the species of interest.

level will be lower than background during the day and equal to background levels at night. At night in a bedroom with an open window the worst case prediction is for a noise level of 30 dBA which is within the WHO guideline for no disturbance. In any other case, i.e. 2 ships unloading in port simultaneously the impact will be 3 dB less. The impact is classed as negligible at Mellows Park for this reason.

At Frenchville the background noise levels are 52 dBA by day and 35 dBA at night. There is a negligible impact during the day and as with Mellow’s Park the impact at night is classed as negligible.

Shipping Noise (Lden)		
Location	Do Nothing	With Development
Harbour Hotel	53	31
Cé na Mara Apartments	66	39
DockGate Apartments	64	36
Dún Aengus Apartments	46	43
Mellows Park	30	40
Frenchville	33	39

Table 10.4.5 - Shipping Noise (Lden)

10.4.6 Potential impact of Airborne Noise on Fauna

Airborne noise was modelled extensively in the Environmental Impact Statement. The most intense noise will arise due to impact pile driving and the airborne noise contours arising from this are shown in the figure below. Noise levels at the nesting sites on Mutton and Hare Island are in the order of 55 dBA. This represents a worst case noise level but will not arise during the nesting or pupping season as pile driving will not be carried out during the period April-July inclusive. A noise level of 55 dBA is extremely unlikely to generate a startle response at any sensitive location as traffic noise, passing boats or overhead flights by aircraft regularly generate this level of noise without adverse effect.

10.4.6.1 PHOCIDS & MUSTELIDS

The airborne noise disturbance thresholds for Phocids and Mustelids is in the order of 100 dB M weighted. The M weighting in air is almost directly equivalent to the ‘B’ weighting for human hearing. At low frequencies the difference between A weighting and B weighting is less than 30 dB so even in a worst case scenario the M weighted noise level will rise to 85 dBA, well below the threshold for disturbance.

10.4.6.2 NESTING BIRDS

Terns and other ground nesting birds show great loyalty to nesting sites. The noise levels associated with this project are below the threshold for disturbance.

For the Galway Harbour Extension, the construction will comprise a combiwall system comprising tubular ‘King’ piles of either 900mm or 1.2m in diameter with three sheet piles in between. The piles will be driven into crushed rock to a depth of 2.5 to 3.0m as indicated on drawing numbers 2139-2142 & 2139-2143.

Piling will comprise a mix of impact piling and vibratory piling (vibropiling) depending on ground conditions. The expected average rate of installation is 4 tubular piles and 12 sheetpiles per day, a quantity that will vary depending on ground and weather conditions. The estimated time to install a tubular pile is in the order of 30 minutes and each sheet pile is estimated to take 6 minutes on average to vibrate into place. A considerable amount of time each day is taken up with relocating and aligning the pile driver and handling the piles. This non-piling time serves a useful function in reducing the overall noise emissions from the activity.

Noise source level data for piling is quite complex as different parameters are often reported. One of the most widely accepted sources of information on pile driving noise levels is the Compendium of Pile Driving Sound Data compiled by Reyff (2007) . This compendium reports 10m peak sound pressure levels of 208 to 210 dB re 1 μPa for 0.9 to 1.5m diameter piles when impact driven and 175 to 182 dB re 1 μPa for sheet piles when driven by a vibratory driver. The reduction in noise level is due to the lower energy required to drive a sheet pile and the change in driver to a vibratory machine.

A report prepared by URS Consultants for construction work in Darwin Harbour indicates a spectrum level in the range 185-210 dB re 1 μPa for a 1.5m impact pile driver with a peak frequency in the 200 to 500 Hz region.

10.5.6 Shallow Water Noise Model

As outlined above, noise propagation in shallow water is complex in particular close to the source. The use of source level data indicates a high noise level close to the source which does not actually arise. Until better models are developed, the concept of all noise sources being reduced to a single point in space requires this to happen. The noise levels predicted close to the source are therefore considerably overestimating the actual received noise levels.

It is difficult to model underwater noise in shallow water in a simplified manner due to the number of variables involved. Marsh and Schulkin (1962) validated a shallow water model with about 100,000 measurements. Greatest errors are likely close to the source as the model was optimised for long range transmission (Urick et al. 1968). The model is based on water depths of up to 200m and surface bottom interactions are seriously underestimated in very shallow (<20m) water due to (a) cut-off frequency and (b) higher grazing angles close to the source resulting in greater absorption in the sediments.

Schlulkin and Mercer (1985) reviewed the model and proposed some revisions and the near field anomaly term has been adjusted for propagation over mud in the model used as the basis of the calculations for this project.

The model for this project takes account of each of the sources on a case by case basis with frequency dependence built into the propagation model. The received level for each receiver type is corrected as appropriate using a type specific weighting. In order to simplify the discussion the sources are considered in three groups; impulsive sounds from blasting and pile driving, continuous noise from construction activities and noise from shipping.

10.5.6.1 Noise Model Results

Noise Model Results are presented in Appendix 10.2, with the category of impact indicated on the figure for each impacted species, i.e. Piling Noise levels impacting on Pinnipeds indicating the zones in which Permanent Injury, Temporary Injury and Disturbance are likely to occur.

Appendix 10.3 comprises impact radii plots illustrating the radius in which the various impacts occur for different sources.

These figures indicate that for pile driving an exclusion zone of 64m is required, for dredging a zone of up to 128m for dredging and 1 km for blasting activities in order to avoid any possibility of temporary injury to marine fauna. The limiting factor being the impact on Pinnipeds in all cases. The following tables show the relevant information.

Underwater Noise Impacts – Blasting and Impulsive Piledriving impact range (m)								
Activity	**PTS Onset Non-recoverable**	**TTS Onset Recoverable**	**Disturbance <100m**		**Disturbance <1000m**		**Disturbance >1000m**	
			Animal	**Population**	**Animal**	**Population**	**Animal**	**Population**
Cetaceans								
Dolphin	19	100	H	L	M	L	L	L
Harbour Porpoise	16	90	H	L	M	L	L	L
Phocids								
Common Seal	100	500	H	L	M	L	L	L
Grey Seal	100	500	H	L	M	L	L	L
Mustelids								
Otter	90	500	H	M	M	L	L	L
Fish								
Salmon	18	no data	H	L	M	L	L	L
Lamprey	18	no data	H	L	M	L	L	L
Eel	18	no data	H	L	M	L	L	L
Diving Birds								
Cormorant	no data	no data	H	L	M	L	L	L
Great Northern Diver	no data	no data	H	M	M	L	L	L
Red-Breasted Merganser	no data	no data	H	M	M	L	L	L

Table 10.5.3 - Underwater Noise Impacts – Blasting and Impulsive Piledriving impact range (m)

Underwater Noise Impacts – Construction Activities impact range (m)								
Activity	**PTS Onset Non-recoverable**	**TTS Onset Recoverable**	**Disturbance <100m**		**Disturbance <1000m**		**Disturbance >1000m**	
			Animal	**Population**	**Animal**	**Population**	**Animal**	**Population**
Cetaceans								
Dolphin	13	75	H	L	L	L	L	L
Harbour Porpoise	55	300	H	M	M	L	L	L
Phocids								
Common Seal	60	350	H	M	M	L	L	L
Grey Seal	60	350	H	M	M	L	L	L
Mustelids								
Otter	55	100	H	M	M	L	L	L
Fish								
Salmon	95	no data	H	L	M	L	L	L
Lamprey	95	no data	H	L	M	L	L	L
Eel	95	no data	H	L	M	L	L	L
Diving Birds								
Cormorant	no data	no data	H	L	M	L	L	L
Great Northern Diver	no data	no data	H	M	M	L	L	L
Red-Breasted Merganser	no data	no data	H	M	M	L	L	L

Table 10.5.4 - Underwater Noise Impacts – Construction Activities impact range (m)

Underwater Noise Impacts – Shipping Traffic impact range (m)								
Activity	**PTS Onset Non-recoverable**	**TTS Onset Recoverable**	**Disturbance <100m**		**Disturbance <1000m**		**Disturbance >1000m**	
'dno' indicates does not occur			**Animal**	**Population**	**Animal**	**Population**	**Animal**	**Population**
Cetaceans								
Dolphin	dno	dno	H	L	L	L	L	L
Harbour Porpoise	dno	dno	H	L	L	L	L	L
Phocids								
Common Seal	dno	<2	H	L	L	L	L	L
Grey Seal	dno	<2	H	L	L	L	L	L
Mustelids								
Otter	dno	<2	H	L	L	L	L	L
Fish								
Salmon	2	no data	H	L	L	L	L	L
Lamprey	2	no data	H	L	L	L	L	L
Eel	2	no data	H	L	L	L	L	L
Diving Birds								
Cormorant	no data	no data	M	L	L	L	L	L
Great Northern Diver	no data	no data	M	L	L	L	L	L
Red-Breasted Merganser	no data	no data	M	L	L	L	L	L

Table 10.5.5 - Underwater Noise Impacts – Shipping Traffic impact range (m)

10.6 VIBRATION

10.6.1 Introduction

This development has the potential to cause vibration from 2 sources; underwater blasting and construction traffic. The impact from construction traffic is likely to be of the order of less than 2 mm/s peak particle velocity in close proximity to operating heavy construction machinery. Levels from blasting could be higher than this if uncontrolled.

10.6.2 Vibration Sensitive Locations

There are no residential areas close enough to the proposed development to warrant any concern regarding vibration. Due to the isolated nature of the site there is no significant issue regarding vibration from construction machinery or traffic. There are 3 areas of potential concern regarding underwater blasting vibration.

- Sensitive structures on the Galway Harbour Enterprise Park
- Ground nesting birds (in season)
- Commercial Shelfish areas in Galway Bay

10.6.3 Vibration Design Criteria

Blasting can give rise to vibration, audible noise, and flyrock. The levels of vibration caused by blasting are well below those which can cause structural damage to properties. Nonetheless, vibration transmitted through the ground can 'shake' buildings and people and may cause nuisance.

Professional control of drilling and blasting operations can ensure through the design of the layout of the workings, that blasts are designed to minimise impact on sensitive areas. Use of the "delayed detonation" blasting technique, whereby the blast takes place in a series of timed small explosions rather than a single large blast, helps to minimise the vibration levels.

The EPA recommends that to avoid any risk of structural damage to properties in the vicinity of the blast, the vibration levels from blasting should not exceed a peak particle velocity of 12 millimetres per second as measured at a receiving location when blasting occurs at a frequency of once per week or less. In the event of more frequent blasting, the peak particle velocity should not exceed 8 mm/second.

10.6.4 Sensitive Structures in the Harbour Area

The Galway Harbour Enterprise Park has both bitumen and a fuel storage tank farms located in close proximity to the proposed development. Both sites are fully bunded, but because any spillage is regarded as having a major impact the sites are regarded as particularly vibration sensitive and appropriate mitigation measures will be applied.

10.6.5 Ground nesting birds

Vibration levels from underwater blasting are of very short duration and can be controlled to low levels. There will however be a short period each year where if blasting is required to be carried out some mitigation may be required.

10.6.6 Commercial shell-fishing

Commercial fishing in Galway Bay comprises fishing for prawns and commercial oyster rearing. In both cases the animals habitat is the bottom of the water column. The separation distance between the site and the oyster farming in particular indicates that any impact will be negligible. There is the potential however for some disturbance to prawns in the area between Mutton Island and Hare Island. The disturbance due to vibration levels is however likely to be less than that resulting from changes to water flow which are dealt with in Chapter 7.

10.7 MITIGATION

10.7.1 Introduction

The approach taken to mitigation on this project is based on the best practice hierarchical approach. This approach can be summarised as follows:

10.7.1.1 Prevention

Where possible the final design has engineered low noise and vibration solutions into the design. In the initial design stages a significant quantity of rock was to be removed by blasting and excavation. By re-designing the location and orientation of the proposed development to take maximum advantage of the sediment thickness, the quantity of rock to be excavated has been minimised.

Once the final layout was determined the staging of the construction works were examined. In the event of pile driving and blasting (to key in the piles) taking place close to Nimmo's Pier significant noise levels could arise in the lower parts of the River Corrib.

In order to minimize impact on migrating fish and the seal pupping season, no blasting or pile driving will take place from April until July inclusive.

10.7.1.2 Reduction

Where it has not been possible to prevent impacts, steps have been taken to reduce the impact through minimisation of cause of impact at source, abatement at source or abatement at the receptor. An example of this type of measure is the imposition of a limit on the maximum instantaneous charge in any underwater blast to minimise underwater noise and vibration impacts. A comprehensive environmental monitoring and management programme is proposed as part of the project development.

10.7.1.3 Remedy/Offset

Where residual impacts remain, that cannot be prevented or reduced, remedial or compensatory action is taken.

10.7.2 Construction Phase

The primary concern during the construction phase are the blasting and pile driving processes. Mitigation measures will be driven by the principle of reduction at source. In this regard trial blasting will be carried out prior to the commencement of production blasting to confirm the optimum blast ratio for the process, to test the effectiveness of the proposed mitigation measures and to provide initial monitoring data for the blasting events.

The mitigation measures proposed are based on international best practice in particular that adopted by the Canadian authorities (Anon), and the American authorities (Anon 1991), (Anon

2006) and British Standard 5607 *Code of practice for the safe use of explosives in the construction industry.*

- A test programme to develop from small charges to the maximum charge weight per delay interval for production will be carried out and reported to the planning authority prior to the commencement of production blasting.

- Details of volume and length of all blasting agents, detonation cord, and explosives will be limited to the minimum necessary to conduct the work in a manner that is efficient, safe for workers and protective of aquatic and marine organisms. Initiation of explosive charges should be conducted with the minimum length of detonation cord possible but will preferably utilise shock tube detonation where possible.

- The charge weight per delay, location, diameter, spacing and burden between borings, placement of explosives within borings, stemming, maximum length of stemming and the location of the detonator within the boring will be recorded for each blast and reported to the planning authority. A full blast report including climatic and sea conditions and any incidents occurring during blasting (including misfires) will be reported to the planning authority on a quarterly basis.

- All drilling and blasting will require the preparation of a detailed method statement outlining:
    - The location and route of any submerged cables, power or service lines
    - The effect of climatic and sea conditions on the operation
    - Shipping both commercial and leisure
    - Site geological conditions
    - Environmental conditions including the protection of marine life
    - Proximity of structures and residential areas
    - Proposed exclusion zones
    - Explosive type, detonation method, transport, storage, charging and dealing with misfires
    - The removal of material pre and post blasting.
    - Monitoring and reporting measures to be implemented during the course of the works

- All blasting will take place in daylight hours and sea state 0 to sea state 3. Where possible blasting will take place at low tide conditions.

- All explosives used will be detonated using a delayed detonation technique with a minimum delay of 25 milliseconds between detonations.

- The maximum instantaneous charge permitted in any blast will be 10 kg of explosive.

- The timing of all blasting operations will be such as to minimise the impact on marine animals, including smolt migration, seal pupping etc.

- Details of the policing of the exclusion zone for blasting, a detailed Marine Mammal Watch Plan including the provision of Marine Mammal Observers for the blasting programme will be submitted to the Parks & Wildlife Service for agreement prior to the commencement of blasting

- All shock tubes and detonation cord or electric wires will be recovered and removed after each blast.

- After loading a charge in a hole, the hole will be backfilled (stemmed) with clean imported angular stemming material. The stemming material shall be uniform, crushed, angular stone. The stemming material shall be within the range 1/20 to 1/8 of the borehole diameter being confined. The stemming material shall not be acceptable if it contains more than 10% fines. Stemming material shall be placed a minimum vertical length of three borehole diameters above the placed charge within sound rock. A standard procedure of logging the hole and placing the explosives shall be established to resolve and verify the proper placement of stemming material. Records of the above shall be held on site for inspection until the conclusion of the blasting operations.

- Due to the complex nature of the inner bay and the significant flow of fresh water from the Corrib it is not likely that mitigation measures such as the use of air-curtains will be effective due to the currents involved.

Underwater noise levels to be monitored in accordance with the proposals in the EMF and to be agreed with the National Parks and Wildlife Service prior to the construction period with particular emphasis on the smolt and eel migration period.

Vibration levels during underwater blasting to be recorded at the following locations:

Galway Harbour Enterprise Park at a location to be agreed with the operators of the storage tanks

Mutton Island at a location to be agreed with Galway City Council.

Dredging works will be carried on a round the clock basis. TSHD operations will not give rise to any significant noise levels. The operation of the backhoe dredger needs to be carefully controlled to avoid operation at night close inshore. The full extent of operation will not be clear until the TSHD dredging is complete and the dredge management plan must be revised to take account of night time noise levels.

Pile driving noise is such that it cannot be permitted during nigh time hours, i.e. 11pm to 7 am. The pile driving equipment can however operate on a round the clock basis provided no pile driving is carried out during night hours.

10.7.3 Residual Impacts

The mitigating effect of relocating the port to the New Harbour cannot be overstated. The noise levels, particularly at night time, will reduce considerably in the existing docks area. The provision and use of shoreside electricity could significantly reduce ship noise emissions in the future.

10.7.3.1 Noise Levels at the Existing Docks

Beneficial

Noise levels at the existing docks area will remain at current levels due to traffic and city centre noise sources. Noise levels due to shipping will reduce significantly and in particular night time shipping noise levels will in effect be eliminated.

10.7.3.2 Noise levels at residential areas at Renmore & Southpark

Minor Adverse

Minimal increase in noise levels which will generally mean that the New Harbour activity will be inaudible based on current noise levels at these locations. It is possible that on a very calm night, with no traffic noise the port will be audible out of doors at these locations. This impact is unlikely to occur other than on a few occasions during the year.

10.7.3.3 Underwater Noise Levels at the New Port

Localised minor adverse impacts but not on a biologically significant scale.

Noise levels due to shipping at the new port will be limited in time and geographical extent. The operational noise levels due to shipping will not cause any level of disturbance at any sensitive sites.

10.8 CONCLUSIONS

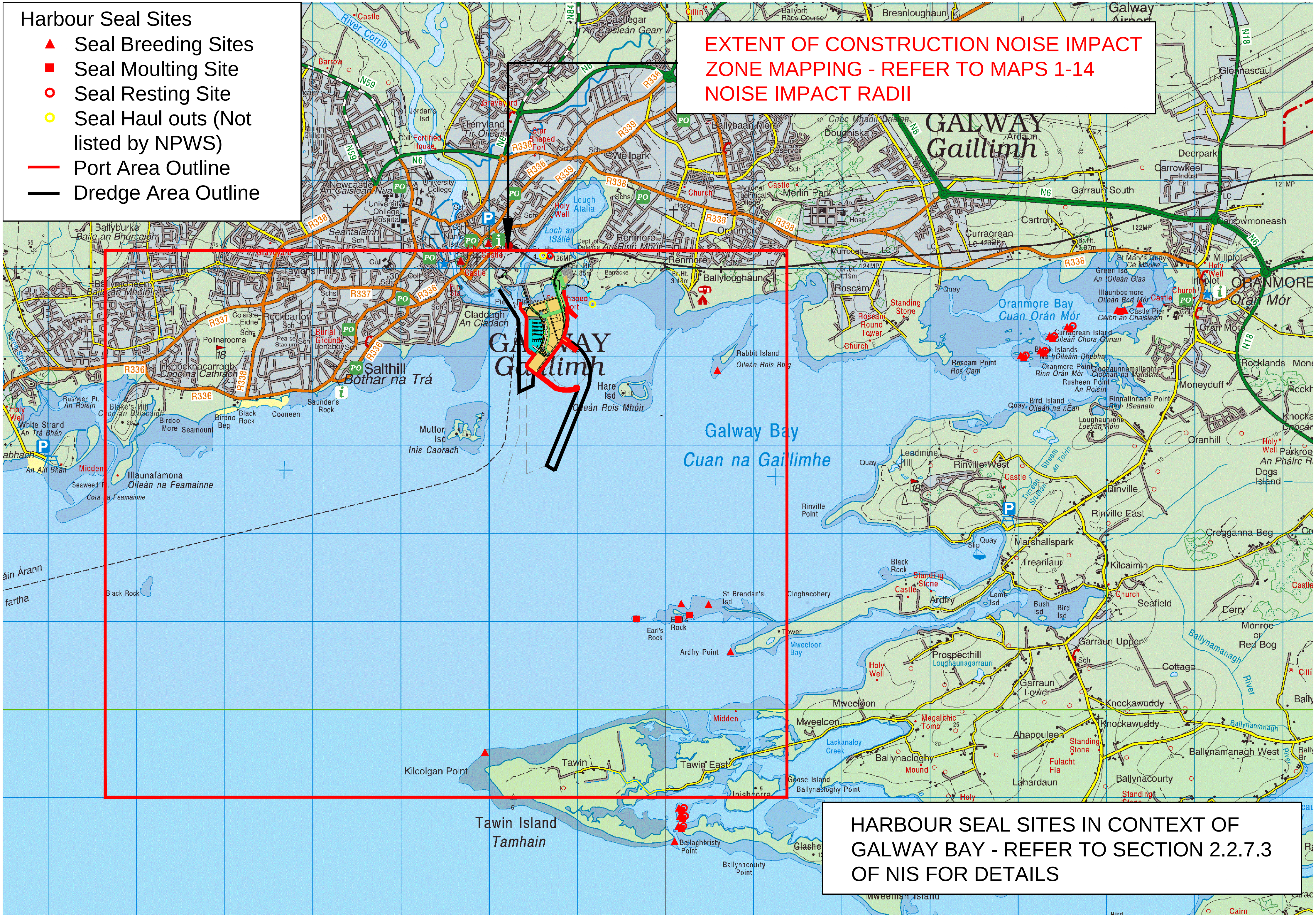
The overall impact of the proposal will be to reduce the underwater noise levels in the existing harbour area. There will be an increase in the intensity of the underwater noise levels at the new harbour area due to larger vessels. The impact of these increased intensity levels is mitigated by the fact that the elevated levels will be of shorter duration as docking, entering and leaving the port will be quicker and less vessels will be required for an equivalent throughput of cargo.

Operating noise levels due to the proposed development are below the level that has the potential to cause any hearing damage to fish or marine mammal species in the long term. Significant mitigation measures will be employed during the construction phase to avoid potential impacts on these species.

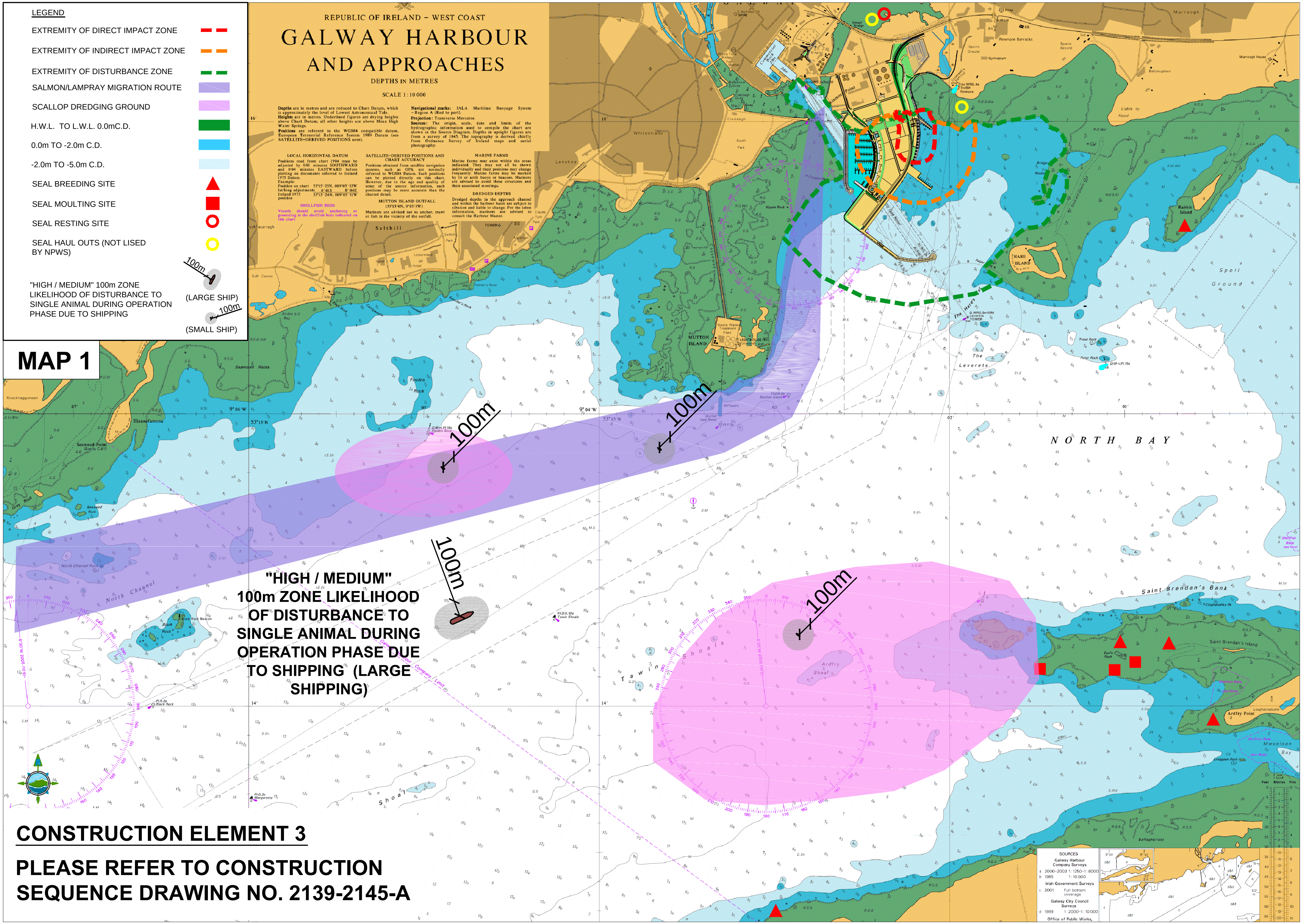
The proposed noise level due to larger vessels using the new port facility will be comparable with existing noise levels at the head of Nimmo's pier in both intensity and temporal effect. It is possible that shipping noise could create an avoidance response in both fish and marine mammal species for a short time while a vessel is berthing. The impact of this avoidance response will be short term (minutes) and of no critical significance.

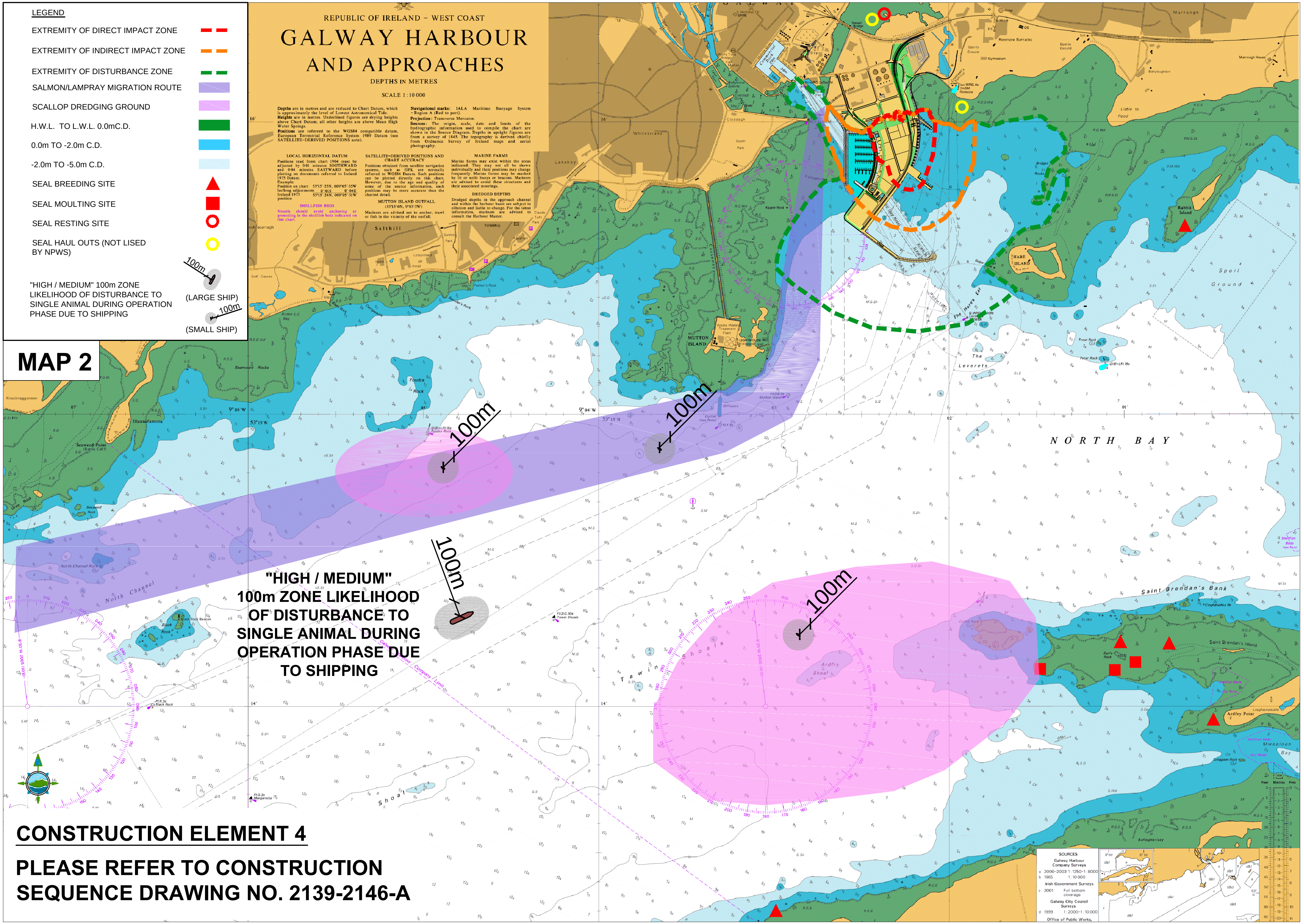
With the proposed noise and vibration mitigation measures in place no significant long term impact on marine life in the bay is expected.

APPENDIX 3 – Noise Radii Map

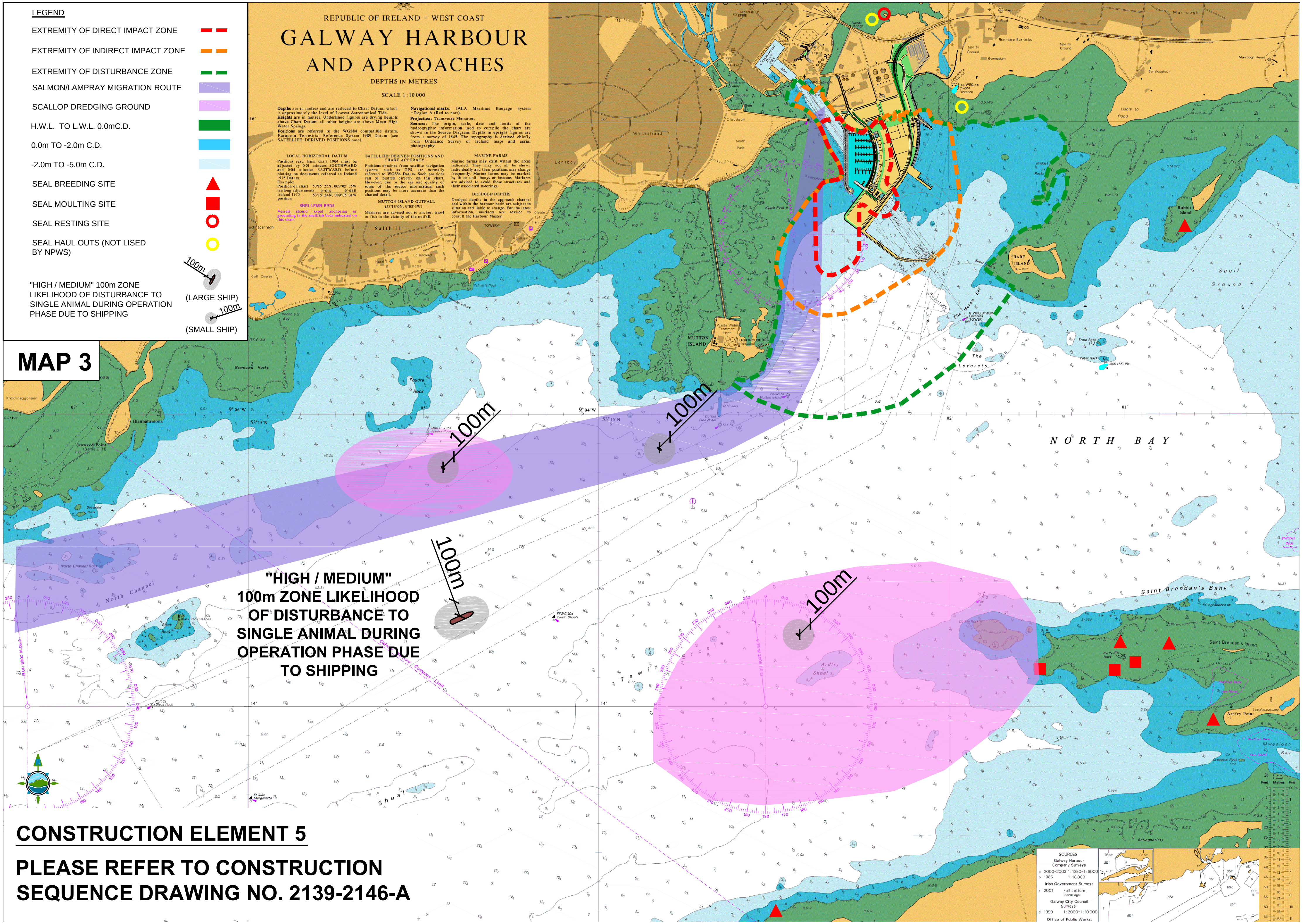


Harbour Seal Sites
Seal Breeding Sites
Seal Moulting Site
Seal Resting Site
Seal Haul outs (Not listed by NPWS)
Port Area Outline
Dredge Area Outline
EXTENT OF CONSTRUCTION NOISE IMPACT ZONE MAPPING - REFER TO MAPS 1-14 NOISE IMPACT RADII
HARBOUR SEAL SITES IN CONTEXT OF GALWAY BAY - REFER TO SECTION 2.2.7.3 OF NIS FOR DETAILS
GALWAY
Gaillimh
Galway Bay
Cuan na Gaillimhe
Oranmore Bay
Cuan Orán Mór
ORANMORE
Orán Mór
Salthill
Bothar na Trá
Mutton Isd
Inis Caorach
Hare Isd
Oileán Rois Mhóir
Rabbit Island
Illaunafamona
Oileán na Feamainne
St Brendan's Isd
Earl's Rock
Ardfry Point
Kilcolgan Point
Tawin
Tawin Island
Tamhain
Mweeloon
Rinville West
Ballyloughaun
Renmore
Claddagh
An Cladach

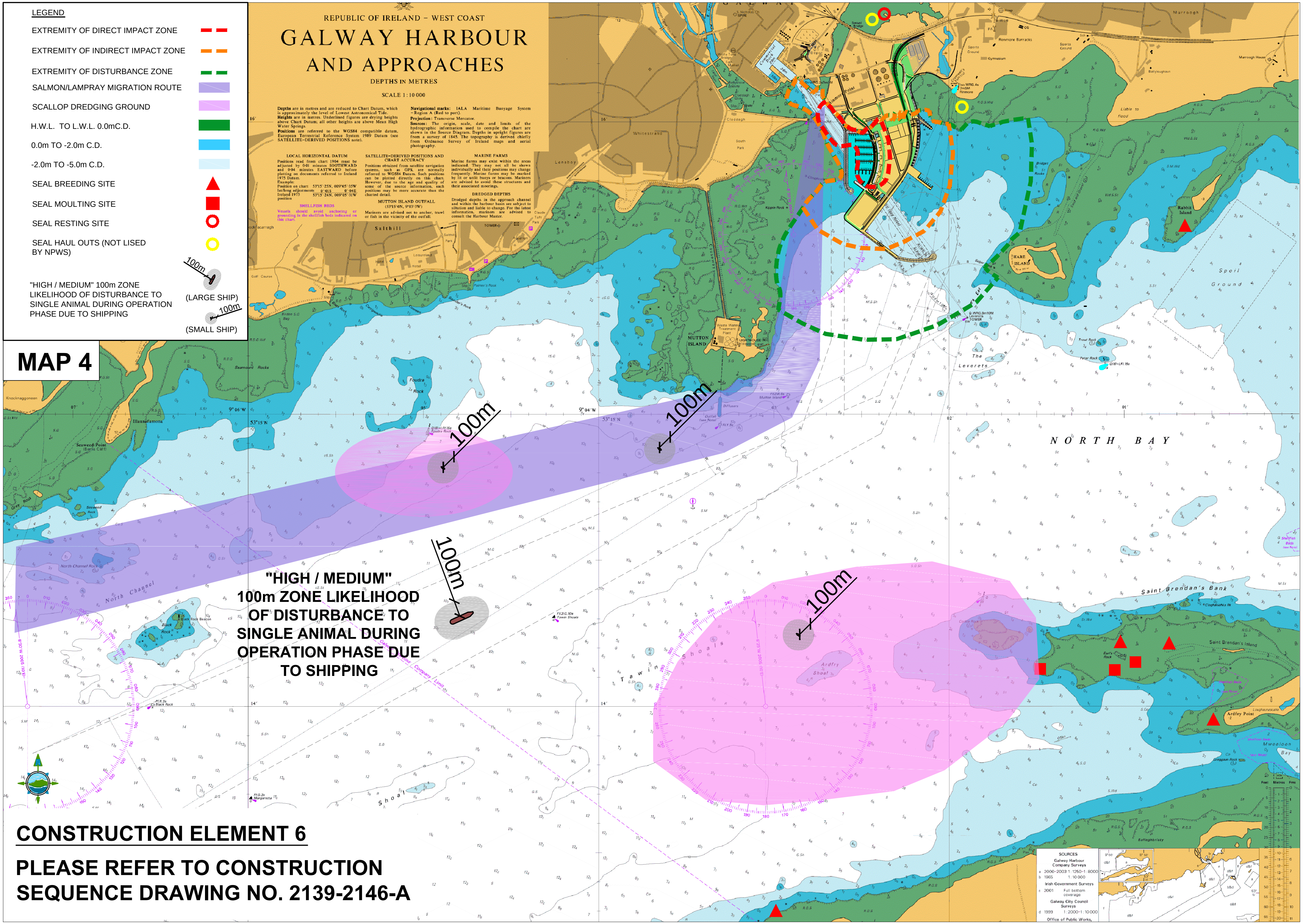

LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 1
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
100m
100m
100m
100m
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING (LARGE SHIPPING)
NORTH BAY
MUTTON ISLAND
HARE ISLAND
Rabbit Island
Saint Brendan's Bank
North Channel
Salthill
CONSTRUCTION ELEMENT 3
PLEASE REFER TO CONSTRUCTION SEQUENCE DRAWING NO. 2139-2145-A

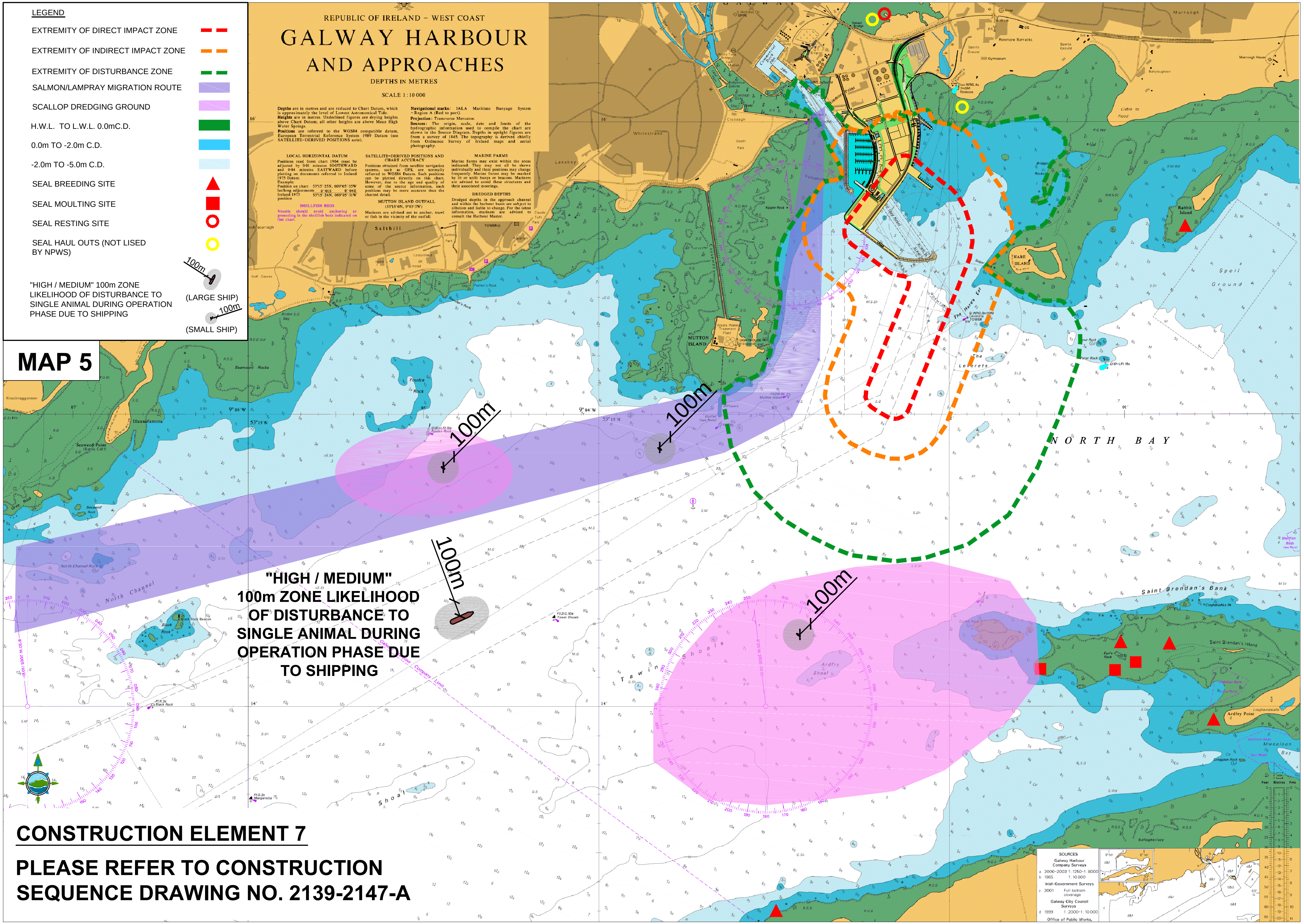


LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 2
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
LOCAL HORIZONTAL DATUM
SATELLITE-DERIVED POSITIONS AND CHART ACCURACY
MARINE FARMS
SHELLFISH BEDS
MUTTON ISLAND OUTFALL
DREDGED DEPTHS
Salthill
MUTTON ISLAND
HARE ISLAND
Rabbit Island
NORTH BAY
North Channel
Saint Brendan's Bank
Saint Brendan's Island
Ardfry Point
Tawin Shoals
Ardfry Shoal
Foudra Rock
The Leverets
Spoil Ground
Mweeloon Bay
100m
100m
100m
100m
"HIGH / MEDIUM"
100m ZONE LIKELIHOOD
OF DISTURBANCE TO
SINGLE ANIMAL DURING
OPERATION PHASE DUE
TO SHIPPING
SOURCES
CONSTRUCTION ELEMENT 4
PLEASE REFER TO CONSTRUCTION
SEQUENCE DRAWING NO. 2139-2146-A

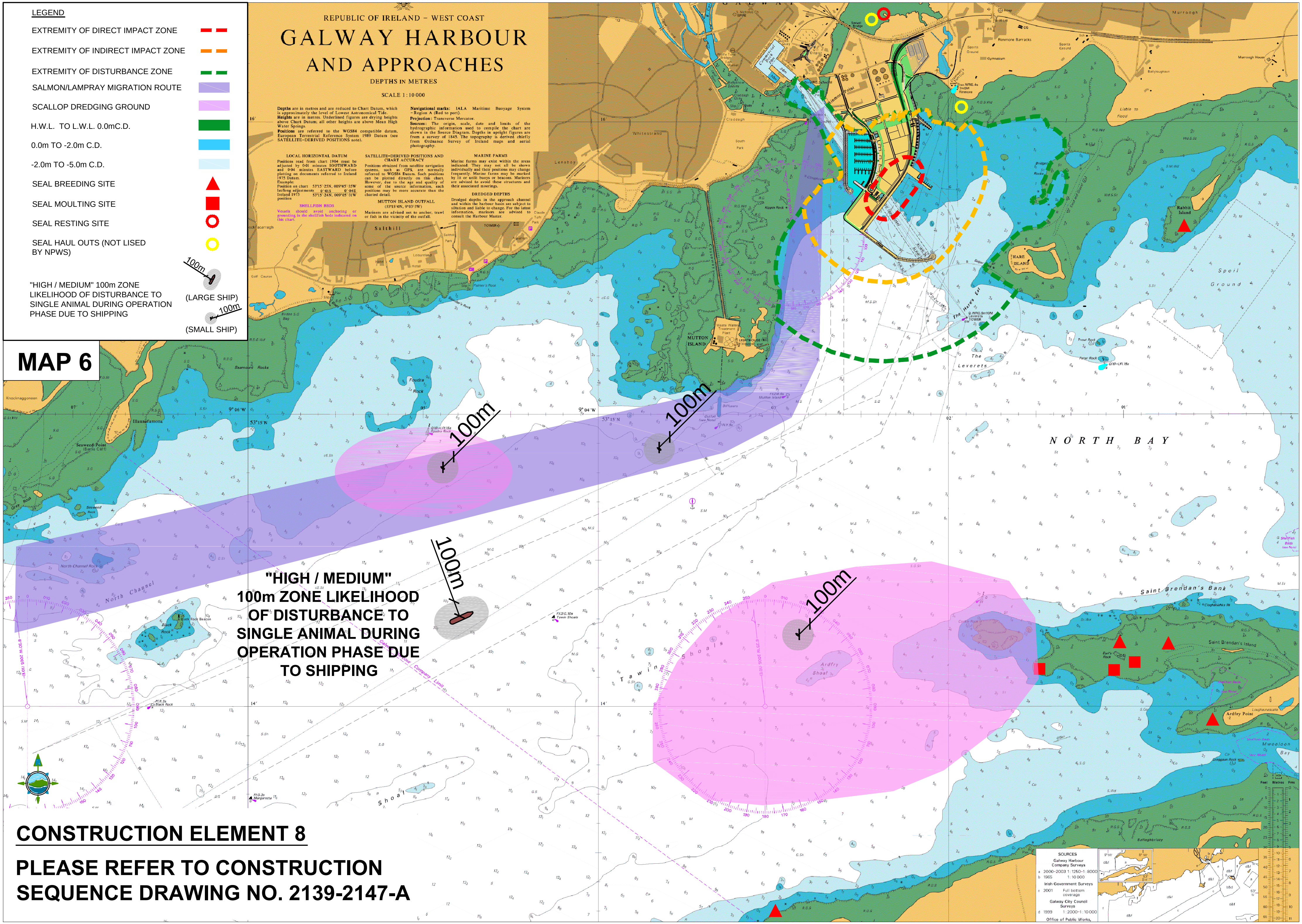


LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 3
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
MUTTON ISLAND
HARE ISLAND
Rabbit Island
NORTH BAY
North Channel
Saint Brendan's Bank
Saint Brendan's Island
Ardfry Point
Tawin Shoals
Ardfry Shoal
Spoil Ground
Salthill
100m
100m
100m
100m
"HIGH / MEDIUM"
100m ZONE LIKELIHOOD
OF DISTURBANCE TO
SINGLE ANIMAL DURING
OPERATION PHASE DUE
TO SHIPPING
CONSTRUCTION ELEMENT 5
PLEASE REFER TO CONSTRUCTION
SEQUENCE DRAWING NO. 2139-2146-A

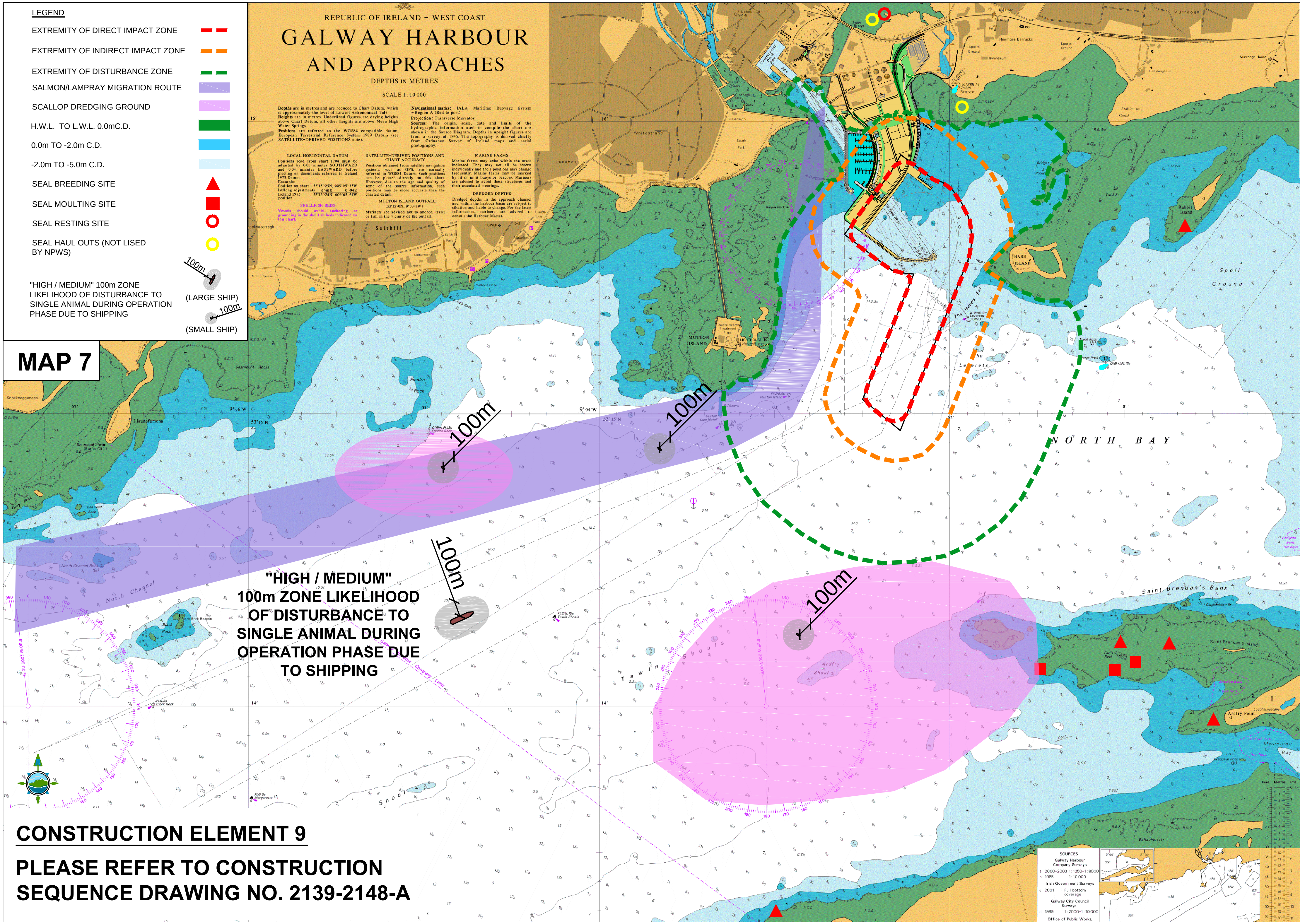

LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 4
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
NORTH BAY
100m
100m
100m
100m
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
MUTTON ISLAND
HARE ISLAND
Rabbit Island
Saint Brendan's Bank
Saint Brendan's Island
Ardfry Point
North Channel
CONSTRUCTION ELEMENT 6
PLEASE REFER TO CONSTRUCTION SEQUENCE DRAWING NO. 2139-2146-A



LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 5
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
100m
100m
100m
100m
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
MUTTON ISLAND
HARE ISLAND
NORTH BAY
Rabbit Island
Saint Brendan's Bank
Saint Brendan's Island
Ardfry Point
Ardfry Shoal
North Channel
Salthill
Foudra Rock
CONSTRUCTION ELEMENT 7
PLEASE REFER TO CONSTRUCTION SEQUENCE DRAWING NO. 2139-2147-A

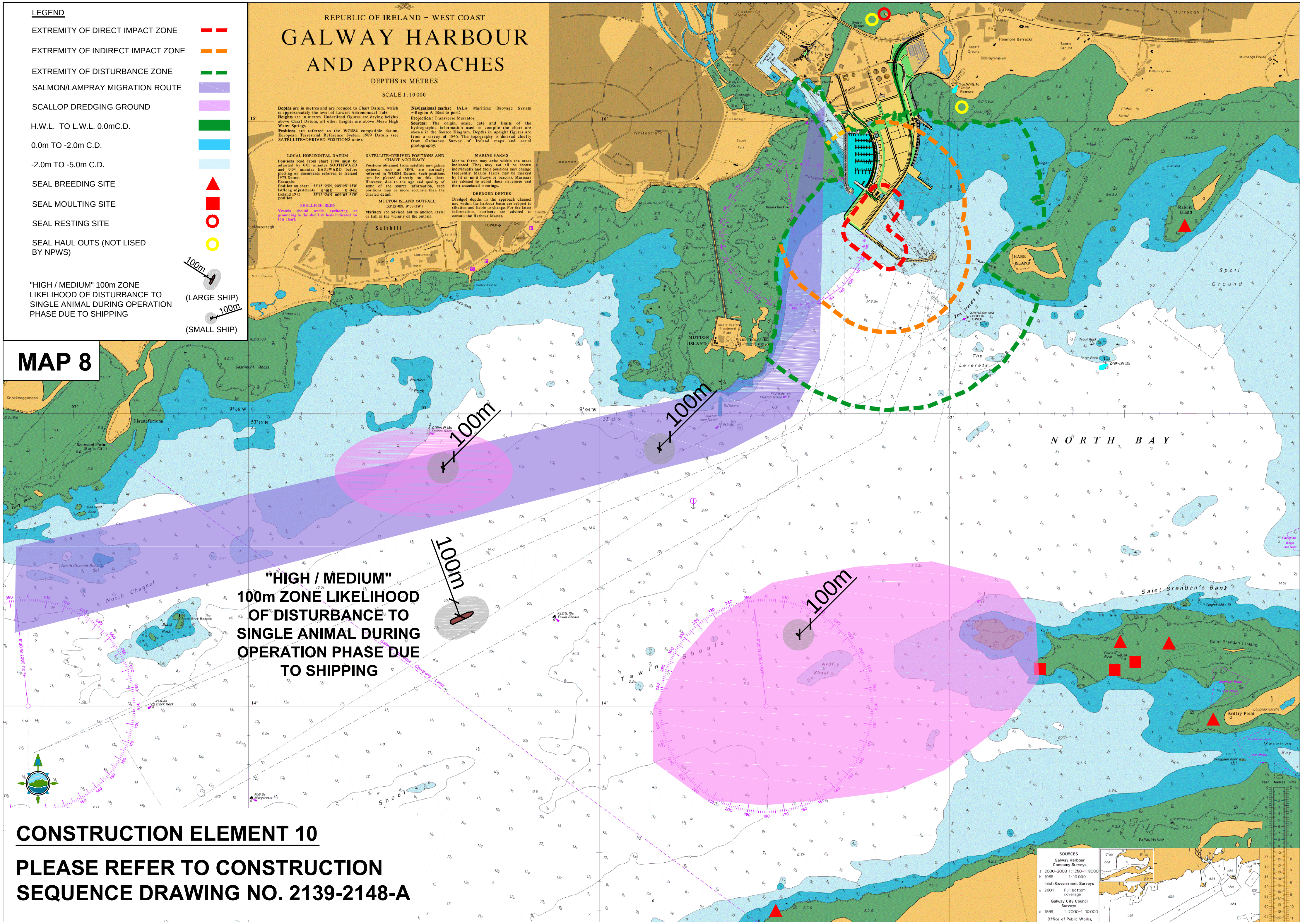

LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 6
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
100m
100m
100m
100m
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
NORTH BAY
MUTTON ISLAND
HARE ISLAND
Saint Brendan's Bank
North Channel
Tawin Shoals
CONSTRUCTION ELEMENT 8
PLEASE REFER TO CONSTRUCTION SEQUENCE DRAWING NO. 2139-2147-A

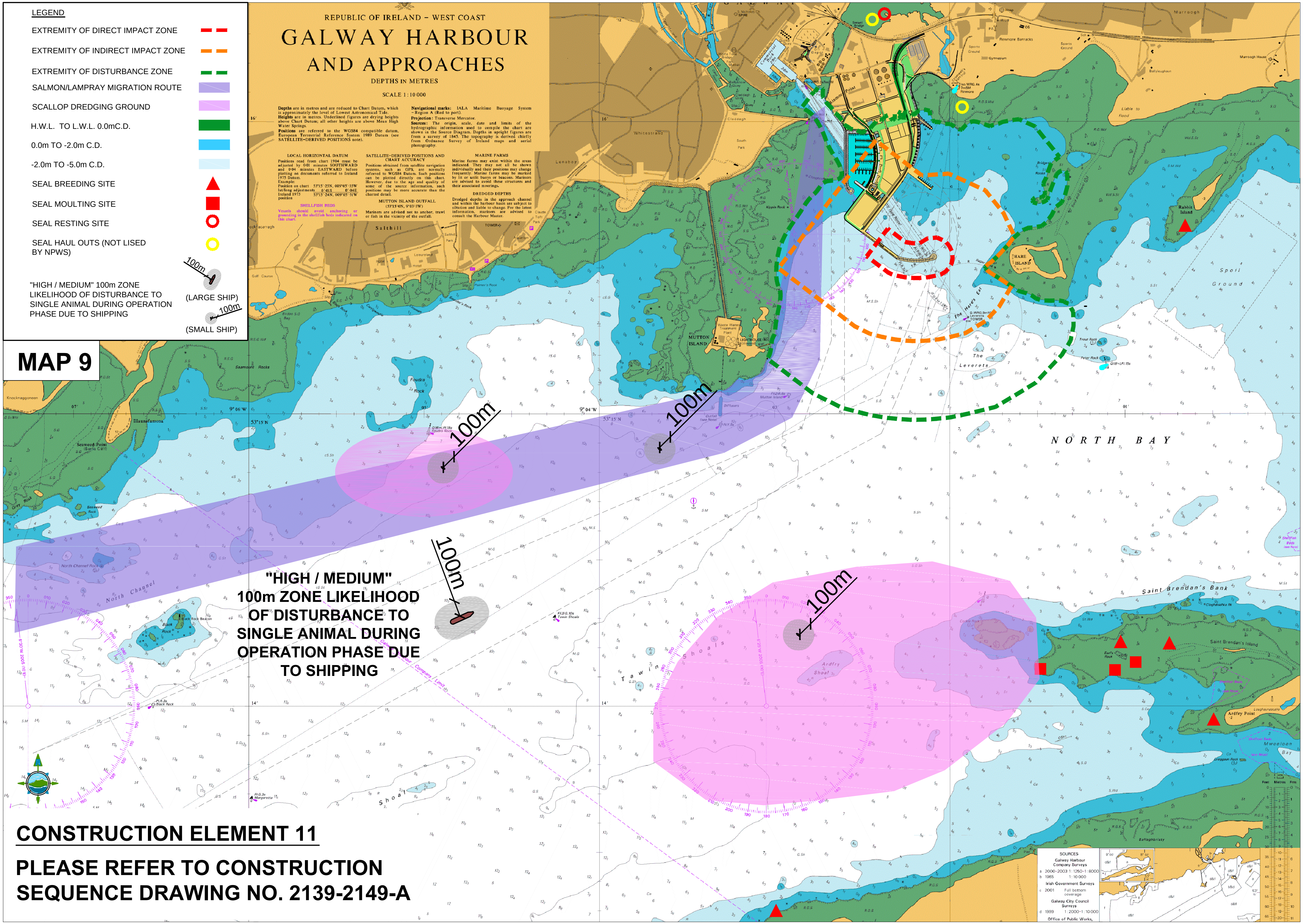
MAP 7

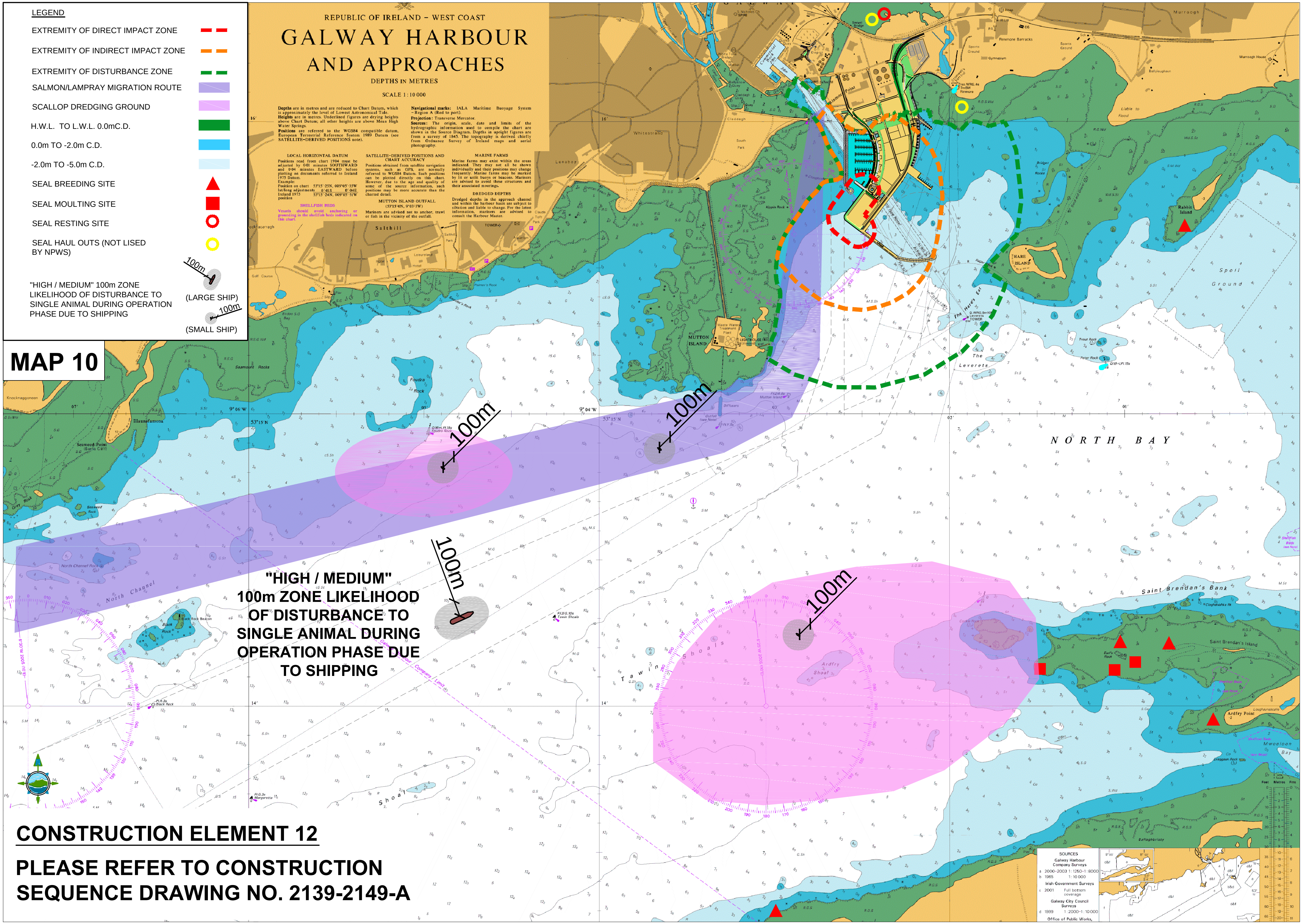


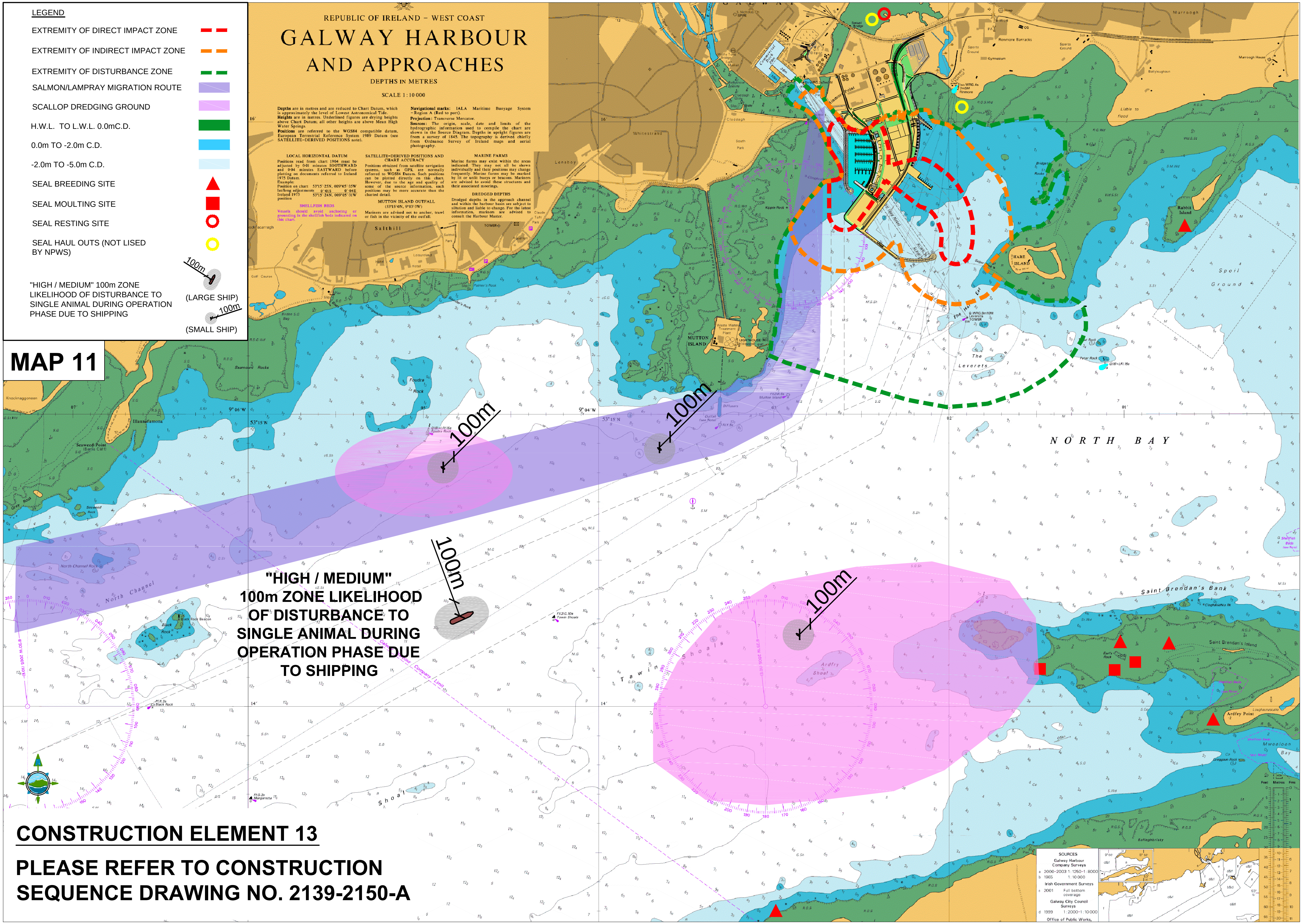
CONSTRUCTION ELEMENT 9

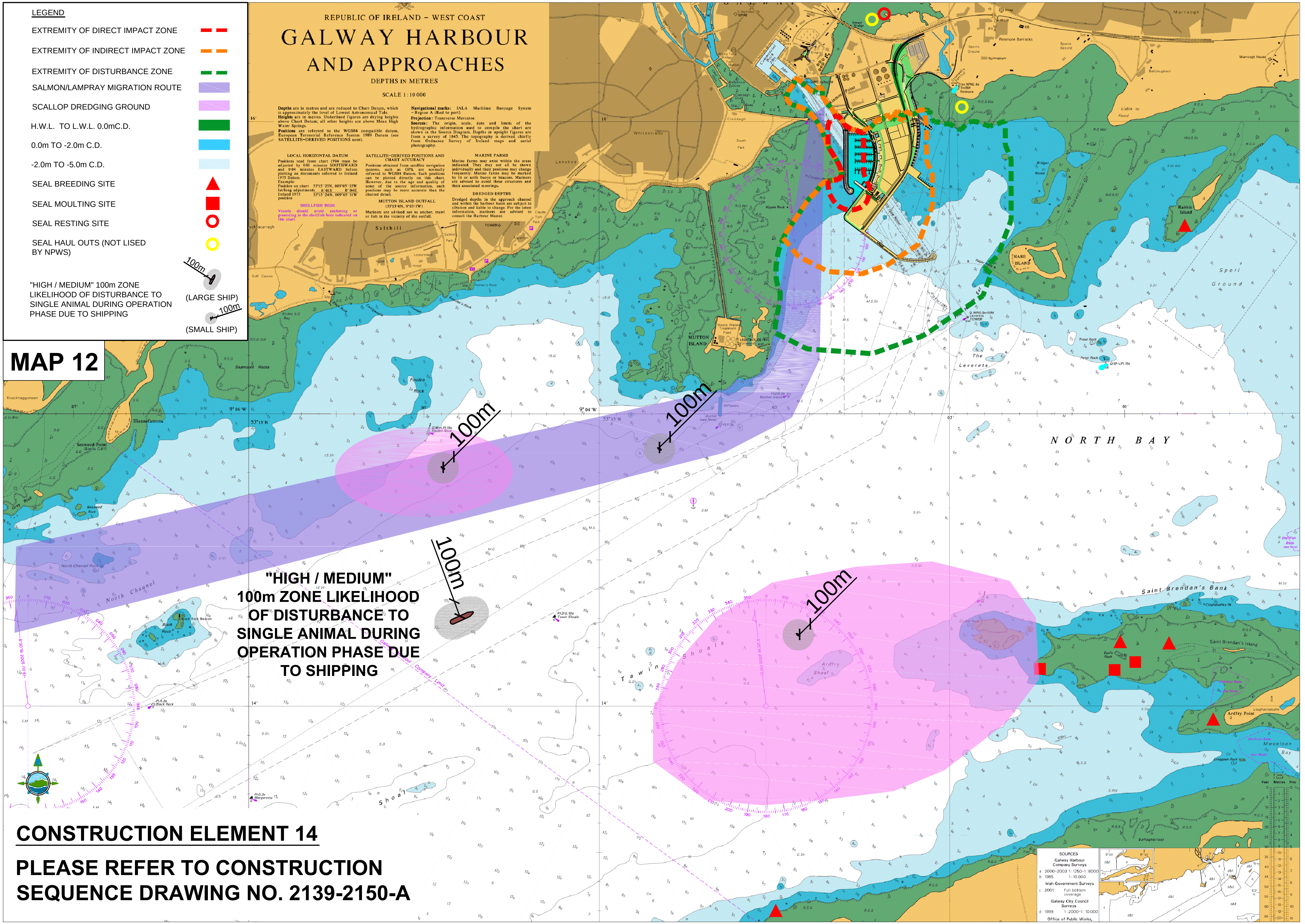
PLEASE REFER TO CONSTRUCTION SEQUENCE DRAWING NO. 2139-2148-A

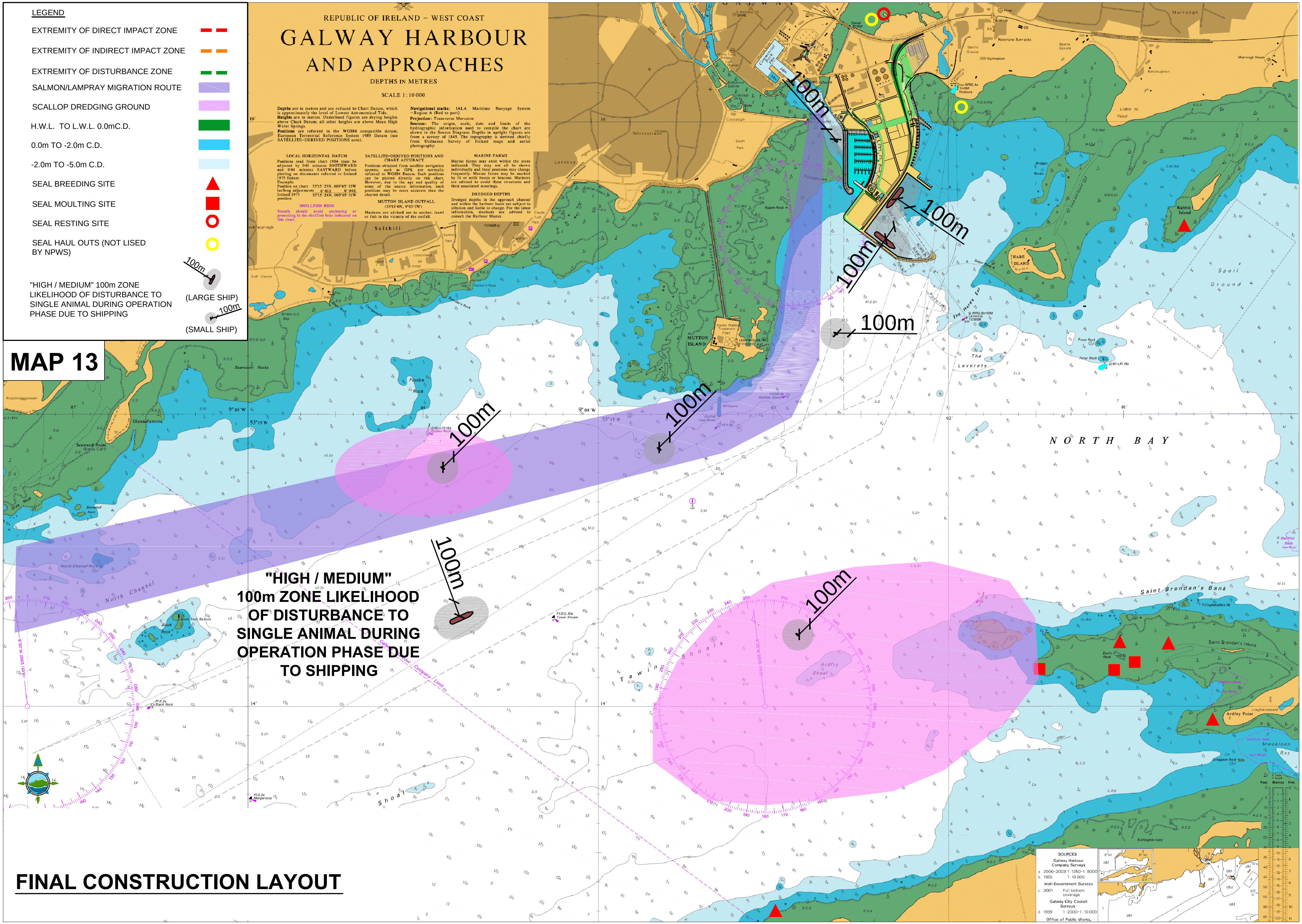

LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 8
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
NORTH BAY
MUTTON ISLAND
HARE ISLAND
Rabbit Island
Saint Brendan's Bank
Saint Brendan's Island
Ardfry Point
Ardfry Shoal
Tawin Shoals
North Channel
Black Rock
Foudra Rock
Salthill
100m
100m
100m
100m
"HIGH / MEDIUM"
100m ZONE LIKELIHOOD
OF DISTURBANCE TO
SINGLE ANIMAL DURING
OPERATION PHASE DUE
TO SHIPPING
CONSTRUCTION ELEMENT 10
PLEASE REFER TO CONSTRUCTION
SEQUENCE DRAWING NO. 2139-2148-A


LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 9
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR
AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
NORTH BAY
100m
100m
100m
100m
"HIGH / MEDIUM"
100m ZONE LIKELIHOOD
OF DISTURBANCE TO
SINGLE ANIMAL DURING
OPERATION PHASE DUE
TO SHIPPING
CONSTRUCTION ELEMENT 11
PLEASE REFER TO CONSTRUCTION
SEQUENCE DRAWING NO. 2139-2149-A


LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 10
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
100m
100m
100m
100m
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
NORTH BAY
MUTTON ISLAND
HARE ISLAND
Rabbit Island
Saint Brendan's Bank
North Channel
CONSTRUCTION ELEMENT 12
PLEASE REFER TO CONSTRUCTION SEQUENCE DRAWING NO. 2139-2149-A


LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 11
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
MUTTON ISLAND
HARE ISLAND
Rabbit Island
NORTH BAY
North Channel
Saint Brendan's Bank
Saint Brendan's Island
Ardfry Point
Ardfry Shoal
Tawin Shoals
The Leverets
Spoil Ground
Salthill
100m
100m
100m
100m
"HIGH / MEDIUM"
100m ZONE LIKELIHOOD
OF DISTURBANCE TO
SINGLE ANIMAL DURING
OPERATION PHASE DUE
TO SHIPPING
CONSTRUCTION ELEMENT 13
PLEASE REFER TO CONSTRUCTION
SEQUENCE DRAWING NO. 2139-2150-A
SOURCES


LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 12
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR
AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
100m
100m
100m
100m
"HIGH / MEDIUM"
100m ZONE LIKELIHOOD
OF DISTURBANCE TO
SINGLE ANIMAL DURING
OPERATION PHASE DUE
TO SHIPPING
N O R T H   B A Y
Saint Brendan's Bank
MUTTON ISLAND
HARE ISLAND
Rabbit Island
Salthill
North Channel
Tawin Shoals
Ardfry Point
CONSTRUCTION ELEMENT 14
PLEASE REFER TO CONSTRUCTION
SEQUENCE DRAWING NO. 2139-2150-A



LEGEND
EXTREMITY OF DIRECT IMPACT ZONE
EXTREMITY OF INDIRECT IMPACT ZONE
EXTREMITY OF DISTURBANCE ZONE
SALMON/LAMPRAY MIGRATION ROUTE
SCALLOP DREDGING GROUND
H.W.L. TO L.W.L. 0.0mC.D.
0.0m TO -2.0m C.D.
-2.0m TO -5.0m C.D.
SEAL BREEDING SITE
SEAL MOULTING SITE
SEAL RESTING SITE
SEAL HAUL OUTS (NOT LISED BY NPWS)
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
100m
(LARGE SHIP)
100m
(SMALL SHIP)
MAP 13
REPUBLIC OF IRELAND – WEST COAST
GALWAY HARBOUR AND APPROACHES
DEPTHS IN METRES
SCALE 1:10 000
100m
"HIGH / MEDIUM" 100m ZONE LIKELIHOOD OF DISTURBANCE TO SINGLE ANIMAL DURING OPERATION PHASE DUE TO SHIPPING
NORTH BAY
MUTTON ISLAND
HARE ISLAND
Rabbit Island
Saint Brendan's Bank
Saint Brendan's Island
Ardfry Point
Mweeloon Bay
Spoil Ground
North Channel
Foudra Rock
Salthill
Tawin Shoals
Ardfry Shoal
FINAL CONSTRUCTION LAYOUT