Greater Dublin Drainage Project

Irish Water

Environmental Impact Assessment Report: Volume 3 Part A of 6

Chapter 9 Biodiversity (Marine)

June 2018

Contents

9. Biodiversity (Marine)

This Chapter of the Environmental Impact Assessment provides a characterisation of the receiving environment and an assessment of the impacts of the Proposed Project on estuarine, coastal and marine ecology. The key areas of the Proposed Project boundary which may be particularly sensitive are Baldoyle Bay and Rockabill to Dalkey Island Special Areas of Conservation (SAC). In particular, the sub-littoral reefs close to the proposed outfall pipeline route (marine section) and the presence of designated marine mammals in the waters surrounding the outer end were of concern and have received a significant level of assessment.

A large number of estuarine and marine surveys were undertaken between 2012 and 2017. This included a walkover survey over the mudflats, Salicornia and Atlantic salt meadows of the Baldoyle Bay Estuary SAC beneath which the proposed outfall route (marine section) will pass using micro tunnelling. The potential for impact in this area relates to bentonite or air breakout during construction along with possible contamination from runoff from the proposed temporary construction compounds. These possible impacts can be mitigated through a Construction Environmental Management Plan, preventing discharges to the estuary and detailed control of bentonite flow and air pressures where needed.

The proposed outfall pipeline route (marine section) area was surveyed using multiple geophysical and benthic surveys between 2012 and 2017. Benthic data shows a diverse population based on sands to the west and mixed sandy gravels to the east at shelf break with no contaminants found in surface or dredge sediment depths. These habitats are not particularly sensitive to construction impacts and no significant impact is predicted.

The proposed marine diffuser will be located within Rockabill to Dalkey Island SAC (designated for Reefs at Ireland's Eye and the harbour porpoise over the greater area). The reefs were assessed in 2015 using camera and divers and these showed a diverse habitat with a naturally high silt content. The Construction Phase presents a minor risk of plume effects during dredging whilst near the proposed marine diffuser location during spring tides, but no mitigation other than monitoring and control of dredging operations is needed to keep this to a negligible impact on this feature.

Harbour porpoises were assessed by an extensive monitoring survey between 2015 and 2017 using both acoustic and observational techniques in the vicinity of the Proposed Project. Results showed some of the highest densities recorded in Ireland and moderate levels of activity throughout the year with numbers increasing in late summer. This was coincident with the presence of calves and may be due to seasonally abundant food sources such as sprat, herring and Trisopterus and gadoid species. Numbers then reduced during late spring/early summer which may be associated with an offshore movement of this species before calving. No impacts are expected for dredging operations outside the SAC, but passive acoustic monitoring and marine mammal observations will be carried out to limit proximity during high noise construction operations (i.e. piling). Operations will also be restricted to outside peak population periods to reduce a potential minor impact to a negligible impact within the SAC.

Fish surveys showed mostly nursery areas of limited importance but with a few sensitive/important fish species were present. The shellfish fishery is also important commercially but not sensitive ecologically. No impact from construction other than restriction of fishing grounds and loss of habitat at the proposed marine diffuser location are predicted.

No operational impacts of the Proposed Project and no predicted significant residual effects upon estuarine, coastal and marine ecological receptors are predicted.

9.1 Introduction

This Chapter of the Environmental Impact Assessment Report (EIAR) provides a characterisation of the receiving environment and an assessment of the ecological impacts of the Greater Dublin Drainage Project (hereafter referred to as the Proposed Project) on marine ecology.

The marine ecology impact assessment addresses the potential impacts on the benthos (animals living on or within the seafloor), marine mammals, fish, plankton and water quality. This assessment is based on the Proposed Project description set out in Chapter 4 Description of the Proposed Project in Volume 2 Part A of this EIAR (and allied construction plans appended to that Chapter), and supported as necessary by other specialist assessments of the EIAR, including inter alia, Chapter 8 Marine Water Quality, Chapter 10 Biodiversity (Marine Ornithology) and Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic) in Volume 3 Part A of this EIAR.

The Proposed Project will form a significant component of a wider strategy to meet future wastewater treatment requirements within the Greater Dublin Area as identified in a number of national, regional and local planning policy documents. The plant, equipment, buildings and systems associated with the Proposed Project will be designed, equipped, operated and maintained in such a manner to ensure a high level of energy performance and energy efficiency.

The table below includes a summary of the Proposed Project elements. A full description of the Proposed Project is detailed within Volume 2 Part A, Chapter 4 Description of the Proposed Project in Volume 2 Part A of this EIAR. Please also refer to Figure 4.1 Proposed Project Overview in Volume 5 Part A of this EIAR.

Proposed Project Element	Outline Description of Proposed Project Element
Proposed Wastewater Treatment Plant (WwTP)	• WwTP to be located on a 29.8 hectare (ha) site in the townland of Clonshagh (Clonshaugh) in Fingal. • 500,000 population equivalent wastewater treatment capacity. • Maximum building height of 18m. • Sludge Hub Centre to be co-located on the same site as the WwTP with a sludge handling and treatment capacity of 18,500 tonnes of dry solids per annum. • SHC will provide sustainable treatment of municipal wastewater sludge and domestic septic tank sludges generated in Fingal to produce a biosolid end-product. • Biogas produced during the sludge treatment process will be utilised as an energy source. • Access road from the R139 Road, approximately 400m to the southern boundary of the site. • Egress road, approximately 230m from the western boundary of the site, to Clonshaugh Road. • A proposed temporary construction compound to be located within the site boundary.
Proposed Abbotstown pumping station	• Abbotstown pumping station to be located on a 0.4ha site in the grounds of the National Sports Campus at Abbotstown. • Abbotstown pumping station will consist of a single 2-storey building with a ground level floor area of 305m^2 and maximum height of 10m and a below ground basement 17m in depth with floor area of 524m^2 incorporating the wet/dry wells. • The plan area of the above ground structure will be 305m^2 and this will have a maximum height of 10m. • A proposed temporary construction compound to be located adjacent to the Abbotstown pumping station site.
Proposed orbital sewer route	• The orbital sewer route will intercept an existing sewer at Blanchardstown and will divert it from this point to the WwTP at Clonshagh. • Constructed within the boundary of a temporary construction corridor. • 13.7km in length; 5.2km of a 1.4m diameter rising main and 8.5km of a 1.8m diameter gravity sewer. • Manholes/service shafts/vents along the route. • Odour Control Unit at the rising main/gravity sewer interface. • Proposed temporary construction compounds at Abbotstown, Cappoge, east of Silloge, Dardistown and west of Collinstown Cross to be located within the proposed construction corridor.
Proposed North Fringe Sewer (NFS) diversion sewer	• The NFS will be intercepted in the vicinity of the junction of the access road to the WwTP with the R139 Road in lands within the administrative area of Dublin City Council. • NFS diversion sewer will divert flows in the NFS upstream of the point of interception to the WwTP. • 600m in length and 1.5m in diameter. • Operate as a gravity sewer between the point of interception and the WwTP site.
Proposed outfall pipeline route (land based section)	• Outfall pipeline route (land based section) will commence from the northern boundary of the WwTP and will run to the R106 Coast Road. • 5.4km in length and 1.8m in diameter. • Pressurised gravity sewer. • Manholes/service shafts/vents along the route. • Proposed temporary construction compounds (east of R107 Malahide Road and east of Saintdoolaghs) located within the proposed construction corridor.
Proposed outfall pipeline route (marine section)	• Outfall pipeline route (marine section) will commence at the R106 Coast Road and will terminate at a discharge location approximately 1km north-east of Ireland's Eye. • 5.9km in length and 2m in diameter. • Pressurised gravity tunnel/subsea (dredged) pipeline. • Multiport marine diffuser to be located on the final section. • Proposed temporary construction compounds (west and east of Baldoyle Bay) to be located within the proposed construction corridor.
Proposed Regional Biosolids Storage Facility (RBSF)	• Located on an 11ha site at Newtown, Dublin 11. • Maximum building height of 15m. • Further details and full impact assessment are provided in Volume 4 Part A of this EIAR.

The total Construction Phase will be approximately 48 months, including a 12 month commissioning period to the Operational Phase. The Proposed Project will serve the projected wastewater treatment requirements of existing and future drainage catchments in the north and north-west of the Dublin agglomeration, up to the Proposed Project's 2050 design horizon.

Please note that there is no biodiversity (marine) assessment of the proposed Regional Biosolids Storage Facility, as the site is located inland.

This Chapter should be read with the following figures presented in Volume 5 Part A and appendices presented in Volume 3 Part B of this EIAR:

- Volume 5, Figure 9.1 Summary of Field Survey Operations for the Proposed Outfall Pipeline Route (Marine Section);
- Volume 5, Figure 9.2 Summary of Bathymetry Data for the Proposed Outfall Pipeline Route (Marine Section);
- Volume 5, Figure 9.3 Sediment Changes near the Proposed Outfall Pipeline Route (Marine Section) and Diffuser;
- Volume 5, Figure 9.4 Casual Sightings and Dedicated Surveys of the Harbour Porpoise;
- Volume 5, Figure 9.5 Inshore Shellfish Grounds along the Fingal Coast;
- Volume 5, Figure 9.6 Combined Suspended Sediment Concentrations Arising from Dredging Operations Over the Duration of the Dredging Works for the Proposed Outfall Pipeline Route (Marine Section);
- Volume 3 Part B, Appendix A9.1 Marine Ecology;
- Volume 3 Part B, Appendix A9.2 Marine Mammal Survey Investigation; and
- Volume 3 Part B, Appendix A9.3 Underwater Noise Assessment and Modelling.

9.2 Methodology

9.2.1 Desktop Study

Key literature sources used to identify features of marine ecological value within the study area and surrounding region were as follows:

- Coastal Habitats: *Ecological Study of the Coastal Habitats in County Fingal Phase IV: Intertidal Habitats* (Ecoserve 2005) and a Saltmarsh Monitoring Survey conducted in Baldoyle Estuary between 2006 and 2008 (McCorry and Ryle 2009);
- Fishing Ground and Fish Species: *Fisheries Study of Fingal Coastal Zone* (Ecoserve 2006), *Ecological Study of the Coastal Habitats in County Fingal Phase III – Estuarine Fish* (Central Fisheries Board 2004) and Commercial Fishing Assessment (Brown and May Marine Ltd 2008) along with information provided in submissions and by Inland Fisheries Ireland (IFI);
- Marine Ecology: *Intertidal and Subtidal Benthic Studies in Broadmeadow Estuary* (Aquafact 2008), *Environmental Baseline Survey of the Eirgrid Interconnector* (Fugro Survey Ltd 2008);
- Geomorphology: INFOMAR bathymetric and habitat datasets (Geological Survey of Ireland (GSI)), Regional habitat classification maps for the Irish Sea (Joint Nature Conservation Committee, United Kingdom (UK)) and Admiralty chart data for the Fingal Coastline;
- Marine Mammal data for Irish Whale and Dolphin Group (IWDG) database for sightings in the survey area. Assessments on the population of harbour porpoises including those within the Rockabill to Dalkey Island Special Area of Conservation (SAC) (Berrow et al. 2008; 2011; 2013). Uploading of sightings from IWDG web based database from 1986 to 2013;
- Fish Species: Centre for Environment, Fisheries and Aquaculture Science (Cefas) publications and International Council for the Exploration of the Sea (ICES) publications; and
- *Fisheries Sensitivity Maps in British Waters* (Coull et al. 1998), *Mapping Spawning and Nursery Areas of Species to be Considered in Marine Protected Areas (Marine Conservation Zones)* (Ellis et al. 2010), *Spawning and Nursery Grounds of Selected Fish Species in UK Waters* (Ellis et al. 2012).

9.2.2 Field Surveys

Geomorphology

A bathymetric survey was carried out along the proposed outfall pipeline route (marine section) by GSI under contract to TechWorks Marine Limited in February 2013 and March 2013. Survey work was carried out by the RV Geo, which is run by the GSI for use on the INFOMAR programme. The RV Geo is a 7.5m rigid inflatable boat (RIB) used to map very shallow/intertidal water depths and is equipped with a Systems Engineering and Analysis 468 kilohertz (kHz) Swathplus interferometric mapping system allowing for wide swath coverage in shallow water depths. The data were reviewed for both depths (bathymetry) and reflectivity (backscatter relating to seabed hardness) for this assessment, with the former dataset rendered into a digital terrain model based on a 2m grid size. The data have subsequently been used to describe the background environment for the marine ecological assessment.

The proposed outfall pipeline route (marine section) was further surveyed on two occasions in 2015 during geotechnical and archaeological ground investigations. The former was undertaken between July 2015 and October 2015 by Causeway Geotech using sidescan sonar, boreholes and vibrocores (Causeway Geotech 2015), whilst the latter was carried out by Irish Hydrodata Ltd in August 2015 using echo sounder, sidescan sonar, magnetometer and a pinger sub-bottom profiler (Irish Hydrodata 2015). Data from both surveys have been reviewed for this assessment.

Marine Benthos and Sediments

A detailed marine environmental survey was carried out along the proposed outfall pipeline route (marine section) and surrounding environments by Benthic Solutions Limited (BSL) over four survey periods as follows:

- Broad survey assessment of benthic conditions between Dublin Bay and Skerries in August 2012 (29 sampling stations). As a regional assessment, this survey covered other possible outfall locations not selected for the final route. The eight sites pertinent to the Proposed Project were targeted for further assessments in 2013 and 2017 (see bullet points below);
- The water quality component of the August 2012 survey was repeated in December 2012 (three sampling stations);
- Assessment of eight sampling stations focused along the proposed outfall pipeline route (marine section) in July 2013; and
- Repeat assessment of eight sampling stations focused along the proposed outfall pipeline route (marine section) in August 2017.

The timings of these studies were established to encompass the seasonal maxima for the marine benthos (i.e. both established and recently settled communities) and the seasonal extremes within the water quality. The surveys included an assessment of the macroinvertebrate communities and habitat types at all selected locations, along with some water quality profiling and sampling. Physico-chemical parameters of the shallow marine sediments were recorded during each of these surveys using grab sampling, whilst additional information of sub-surface sediments was further recorded down to a depth of 1.2m using a 3m pneumatic vibrocorer along the proposed outfall pipeline route (marine section) in the survey carried out by Causeway Geotech in 2015. Details of the benthic environmental surveys are provided in Appendix A9.1.

Results of marine survey acquisition are discussed in Section 9.3.2 to 9.3.4, with a summary plotted in Figure 9.1 Summary of Field Survey Operations for the Proposed Outfall Pipeline Route (Marine Section). Field acquisition equipment and processing method statements are included in Appendix A9.1.

Water Quality Profiling and Sampling

Field observations of water column structure and water quality sampling were acquired to provide a snapshot of ecological conditions at the proposed outfall pipeline route (marine section) over the year. The survey was carried out at three locations during August (summer) and December (winter) in 2012 (refer to Figure 9.1 Summary of Field Survey Operations for the Proposed Outfall Pipeline Route (Marine Section) and Table 9.12), with further sampling acquired at a control site and at the proposed outfall discharge point in 2013 and in 2017. A full profile of the water column was undertaken using a YSI6600 V2 Sonde, whilst discrete water samples were also acquired at the surface mid-depth and seabed using a Niskin water sampler. The sonde was equipped with sensors for measuring depth, temperature, conductivity (derived salinity), pH, dissolved oxygen and turbidity with duplicate profiles acquired at different states of the tide. Water samples were stored frozen or fixed prior to analysis at the laboratory for heavy and trace metals, total petroleum hydrocarbons (TPHs) in the first two survey years and dissolved organic carbon (DOC) along with a range of nutrients, silicon and chlorophyll for all surveys. Results are shown in Section 9.3.5.

Fish and Shellfish

A scientific 2m beam trawl survey (11mm mesh) and a beach seine net survey were conducted in September 2015 and again in September 2017 by the Aquatic Services Unit (ASU) from University College Cork (see ASU Report in Appendix A9.1) to investigate juvenile fish near the proposed outfall pipeline route (marine section). In the same month, a common whelk (*Buccinum undatum*) survey was carried out by RPS to provide catch data to support this EIAR and planning application (see RPS Report in Appendix A9.1).

The beam trawl survey consisted of four lines positioned perpendicular to the shore in the area of the proposed outfall pipeline route (marine section). Along each line, four 1km to 2km trawls were completed at a speed of 1.5 knots (see Figure 1 of the ASU Report in Appendix A9.1). One line was positioned over the proposed outfall pipeline route (marine section), two lines were located 200m to the north and south of the proposed outfall pipeline route (marine section), and the final line was for reference (control) purposes and was positioned 1km to the north. A small local fishing vessel was chartered to carry out this survey.

Four locations along the Portmarnock shore were sampled using the 45m beach seine net. As with the beam trawls, one station was positioned at the centre of the proposed outfall pipeline route (marine section), two stations were located to the north and south of the proposed outfall pipeline route (marine section), and the fourth reference station was 1km north of the proposed outfall pipeline route (marine section).

Nine stations in the area of the proposed outfall pipeline route (marine section) were sampled during the whelk survey (see Figure 5.1 of the RPS Report in Appendix A9.1), reflecting areas and methods commercially used by local fishing vessels. At each station, a string of 50 whelk pots, baited with brown crab (*Cancer pagurus*) and lesser-spotted dogfish (*Scyliorhinus canicula*), were deployed and left for a soak time of up to 24 hours before recovery and processing. In every tenth pot, the total length (mm) of each individual and the collective weight of all whelk were recorded. All other species caught were also identified and enumerated. The total weight of all whelk landed per station was recorded; this was estimated on-site, and later confirmed when the pots were landed and weighed at market. Positions for each station were recorded when the first and last pots were deployed and recovered.

Plankton

Plankton was assessed at the same time as the water quality sampling to provide a snapshot of activity and productivity in the waters surrounding the proposed outfall pipeline route (marine section) in 2012. The presence of phytoplankton was tested for during water quality sampling by analysing water samples for chlorophyll. A qualitative (and semi-quantitative) analysis for zooplankton, was also undertaken at selected locations during both summer and winter sampling campaigns using a vertical tow net trawl (250µm mesh size) technique at three locations across the proposed outfall pipeline route (marine section) and again in July 2017. The recovered material was analysed for their zooplankton content by a pelagic taxonomist at the Marine Biological Association in Plymouth.

Baldoyle Estuary Walkover

This survey was undertaken to support the earlier coastal and intertidal habitat mapping carried out by Ecoserve in 2005, and a more detailed assessment undertaken for the National Parks and Wildlife Service (NPWS) on the saltmarsh community in Baldoyle Estuary SAC (Site Code: 00199) in 2006 (McCorry and Ryle 2009). The site was visited on 13 November 2013 by a BSL botanist, and the habitat mapping prepared by McCorry and Ryle (2009) reviewed in the field in relation to the current conditions at the site and the proposed outfall pipeline route (marine section). GIS shapefiles, prepared by McCorry and Ryle (2009), were loaded onto electronic media and underlain by aerial photographs (Google Maps) to allow for an accurate assessment in the field of the extent of habitat types as previously described and mapped and to document any changes. A photographic record of the habitats recorded was also made which have been geo-referenced and provided in Appendix A9.1.

Surveys for Reefs (1170) on Ireland's Eye – Rockabill to Dalkey Island Special Area of Conservation

The Rockabill to Dalkey Island SAC (Site Code: 003000) was established in April 2013 and designated for the marine Habitats Directive Annex I qualifying interest Reefs and the Annex II species harbour porpoise (*Phocoena phocoena*). As the proposed outfall pipeline route (marine section) (including the proposed marine diffuser) is located within this SAC, additional surveys were carried out to cover both qualifying interests.

Within the Rockabill to Dalkey Island SAC, two community types are recorded within the Annex I habitat, namely intertidal reef community complex and subtidal reef community complex (Reefs 1170). Intertidal and subtidal surveys were undertaken in 2010 and 2011 (MERC 2010; 2012a; 2012b). These data were used to determine the physical and biological nature of the Annex I habitat. The area and quality of these qualifying features were based on broad interpolations from only limited drop-down video. Therefore, two additional survey campaigns were carried out to establish a greater understanding of these features within the vicinity of the proposed outfall pipeline route (marine section). The surveys were undertaken in two phases. The initial phase of the investigation was based on a detailed video inspection of features identified in the bathymetry by BSL in May 2015 (BSL 2015a). During this survey, additional bathymetry was carried out using a precision echo sounder to infill deficiencies in existing data close to the island's cliffs and rock outcrops. Detailed photography was also carried out using a MOD4 high resolution camera on nine drop-down video locations taken along the subtidal reefs around the island and at the proposed outfall pipeline route (marine section) (refer to Figure 9.1 Summary of Field Survey Operations for the Proposed Outfall Pipeline Route (Marine Section)). The results of this survey were used to identify key areas for the second phase of operations using an intertidal walk-over (three sites) and detailed subtidal transects (four sites) using scientific divers (refer to Figure 9.1 Summary of Field Survey Operations for the Proposed Outfall Pipeline Route (Marine Section)). This later phase was carried out by BSL and Aquatic Survey and Monitoring Limited in July 2015.

Surveys for the Harbour Porpoise – Rockabill to Dalkey Island Special Area of Conservation

A considerable number of surveys and sightings of the harbour porpoise have been gathered along the Irish east coast, including the area between Ireland's Eye and Skerries to the north (e.g. Pollock et al. 1997; Reid et al. 2003; Ó Cadhla et al. 2004; Small Cetaceans in the European Atlantic and North Sea (SCANS-II) 2008; Berrow et al. 2010; Berrow et al. 2011; Baines and Evans 2012; Wall et al. 2012). The boundary of the SAC was supported by targeted surveys of the harbour porpoise community conducted in 2008 (Berrow et al. 2008). Site specific information of cetacean activity in the vicinity of the proposed outfall pipeline route (marine section) and this section of the SAC was obtained over a two-year programme based on three integrated methods in line with best practice; these were land based vantage point surveys, boat based transects and Static Acoustic Monitoring. Visual surveys were only carried out in favourable weather conditions (a sea state of a Beaufort wind force of 2 or less and visibility >6km). Monthly land based surveys were conducted from sites at Loughshinny for six months and Howth Head for 24 months. Single platform line-transect boat surveys were also conducted bi-monthly following a pre-determined route and standardised design. Finally, static acoustic monitoring using C-PODs was conducted for six months at a single site off Loughshinny and for 24 months at three locations off Portmarnock. Full details of these surveys are reported in Appendix A9.1.

TechWorks Marine Limited deployed passive acoustic monitoring recorders at three mooring sites along the proposed outfall pipeline route (marine section) between March 2015 and March 2017. An additional site was located east of Loughshinny in March 2015 for six months. Each mooring was fitted with a C-POD self-contained click detector which logs the echolocation clicks of porpoises and dolphins. The recovered data were interpreted by the IWDG. All C-POD data were analysed using only high probability clicks, which reduced the possibility of false positives (i.e. recorded as present when there were in fact no dolphins or porpoise present). Harbour porpoise detections were extracted as detection positive minutes per day and were analysed statistically for temporal and geographical trends. Porpoise detections were analysed with respect to season (spring, summer, autumn and winter), diel cycle (day and night-time), tidal state (ebb, flood, slack high, slack low) and tidal phase (spring, neap) at a resolution of one hour.

IWDG further supported the Proposed Project by providing regular observations from both sea and land based surveys for cetaceans over the same survey period. Land based observation sites were located on the cliffs at Howth Head, looking directly over the proposed outfall pipeline route (marine section) for a 24-month period, as well as the Loughshinny Martello Tower, for a six-month period which recorded 20 hours of land based monitoring conducted over six survey days. The weather was favourable throughout with no swell, with a sea state of a Beaufort wind force of 2 or below and a visibility of 6km to 20km. Marine mammals were sighted on 86% of survey days. The survey effort conducted from Howth Head amounted to around 144 hours (23 surveys) between 18 March 2015 and 11 March 2017. Environmental conditions were favourable with no swell, sea state of a Beaufort wind force of 2 or below for 99% and visibility greater than 6km for 97% of survey effort. Marine mammals were sighted on 100% of survey days.

Eleven independent boat based surveys were carried out from April 2015 to January 2017 over a total of 897km of track-lines. Environmental conditions were favourable with visibility of more than 6km for 91% of the survey time and swell of less than 1m for 100% of survey effort. A sea state of a Beaufort wind force of 2 or below was recorded for 8 of the 11 surveys. However, a sea state of a Beaufort wind force of 2 or below was recorded for only 8% of the survey time carried out in April 2015, 36% of the survey time in June 2015 and 46% of the survey team during December 2016. Marine mammals were sighted on all survey days.

The software programme DISTANCE was used for calculating detection functions, which is the probability of detecting an object a certain distance from the track-line and used to calculate the density of animals on the track-line of the vessel. A detection function was calculated from each boat survey, provided that a sufficient number of sightings were made to provide a robust estimate.

All of these datasets have been integrated and are reported in Appendix A9.2.

Ambient Noise Recording

The possible impact of noise to the marine environment was further assessed based on two assessments. The first was the recording of the ambient noise level from a buoy-mounted recorder on a location close to the proposed marine diffuser location (53°24.901'N and 006°2.978'W) between 30 July 2015 and 1 September 2015 by the University of Catalonia and TechWorks Marine Limited. For the recording, a duty cycle was configured with 15 minutes on and 50 minutes off. The hydrophone sensitivity recording stored on the unit was -168dB re 1 V/ µPa and the data were sampled at 16kHz in 24 bits. The shallow nature of the site (generally <20m) was sufficient to affect the propagation of the sound in this area. The second assessment was based on modelling the propagation of sound in this area and the likely source from construction activities, and is described in Section 9.2.3.

9.2.3 Underwater Noise Modelling

Following the ambient noise assessment (previous section), the possible impact of noise to the marine environment during the Construction Phase of the Proposed Project was modelled by Quiet Oceans in 2017 (refer to Appendix A9.1). The objective of the study was to map the noise propagation of the dredging activity at one specific position for three frequencies, 125Hz, 1kHz and 8kHz, third octave as defined by international standards (ANSI S1.11, 2004; IEC. 1995) for a single environmental condition. In a similar manner to weather forecasting systems, the model produces an estimate of the spatio-temporal distribution of noise levels generated by human activities at sea, aggregating multiple sources. The production of statistical soundscapes effectively characterises the spatio-temporal emergence of anthropogenic noise from the real environmental conditions of the area.

The noise received at a particular position in the marine environment depends on the characteristics of the sound source(s) and the propagation through the marine environment. Noise propagation, and therefore noise levels, are mainly determined by the following:

- Bathymetry;
- The nature of seabed;
- Oceanographic conditions such as temperature and salinity;
- Currents;
- Sea level; and
- The weather conditions such as the wind (and consequently waves) and rainfall intensity.

The potential sound source levels used within the model were based on trailer suction hopper dredging (TSHD) and impact piling (600mm) (considered as worst case scenario for Proposed Project) based on literature sources (Parvi 2008; Robinson et al. 2011; De Jong et al. 2008; Talisman Energy et al. 2004; ITAP 2008). The outputs were shown as noise maps showing maximum 5th percentile (or exceedance level) for the full water column for the 125Hz, 1kHz and 8kHz third-octave bands.

9.2.4 Impact Assessment Methodology

The assessment process firstly requires that ecological features are valued based on their nature conservation interest. For the purposes of this assessment, ecological values will be determined using the criteria defined in Table 9.1. The criteria used is based upon Chartered Institute of Ecology and Environmental Management (CIEEM) and National Roads Authority (NRA) guidelines, which outline up to eight different geographic scales (i.e. international through to local) by which ecological value can be assigned (CIEEM 2010; NRA 2009). Here, ecological values are re-defined 'very high' through to 'negligible' as defined in Table 9.1.

In the case of internationally or nationally designated sites, assigning ecological criteria is generally straightforward, as these designated sites typically fall strictly within the relevant categories. Professional judgement is more important in assigning further values that may relate to ecological sensitivities. In assigning value to a species or habitat, it is necessary to consider its distribution and status, typically based on historical records and occurrence between geographic areas. Legal protection needs to be considered separately from value. Where a feature has value at more than one level, its highest level of value will take precedence. For example, a species designated integral to an SAC and as an Annex II species of Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) should be considered as being internationally important, even though its SAC value is considered to be of national importance. The features for which the site has been designated at each level may differ and should therefore be valued accordingly. Features of the sites that are not the reasons for its designation(s) should be assessed and valued according to their intrinsic value.

Table 9.1: Ecological Value Criteria

Ecological Value	Examples
Very high (International importance)	'European Site', including SAC, Site of Community Importance (SCI) and/or Special Protection Area (SPA). Species and/or Habitats that form the primary cited interests of SPAs and/or SACs. Proposed Special Protection Area (pSPA) and/or candidate Special Area of Conservation (SAC). Features essential to maintaining the coherence of the Natura 2000 Network. Site containing 'best examples' of the habitat types listed in Annex I of the Habitats Directive. Salmonid water designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations 1988 (S.I. No. 293 of 1988).

Ecological Value	Examples
High (National)	Species and/or habitats that contribute to the integrity of an SPA and/or SAC but which are not cited as a species for which the site is designated. Sites designated or proposed as a Natural Heritage Area. Statutory Nature Reserve or a National Park. Resident or regularly occurring populations (assessed to be important at the national level) of the following: - Species protected under the Wildlife Acts 1976-2000; and/or - Species listed on the relevant Red Data list. Sites containing 'viable areas' of the habitat types listed in Annex I of the Habitats Directive.
Medium (County)	Areas of Special Amenity. Resident or regularly occurring populations (assessed to be important at the County level) of the following: - Species of bird, listed in Annex I and/or referred to in Article 4(2) of Directive 2009/147/EC of 30 November 2009 of the European Parliament and of the Council on the conservation of wild birds (Birds Directive); - Species of animal and plants listed in Annex II and/or IV of the Habitats Directive; - Species protected under the Wildlife Acts (1976-2000); and/or - Species listed on the relevant Red Data list. Sites containing area or areas of the habitat types listed in Annex I of the Habitats Directive that do not fulfil the criteria for valuation as of international or national importance. Sites containing semi-natural habitat types with high biodiversity in a county context and a high degree of naturalness, or populations of species that are uncommon within the county. Sites containing habitats and species that are rare or are undergoing a decline in quality or extent at a national level.
Low (Local)	Locally important populations of priority species or habitats or natural heritage features identified in a local area plan (if one has been prepared). Resident or regularly occurring populations (assessed to be important at the local level) of the following: - Species of bird listed in Annex I and/or referred to in Article 4(2) of the Birds Directive; - Species of animal and plants listed in Annex II and/or IV of the Habitats Directive; - Species protected under the Wildlife Acts (1976-2000); and/or - Species listed on the relevant Red Data list. Sites containing semi-natural habitat types with high biodiversity in a local context and a high degree of naturalness, or populations of species that are uncommon in the locality. Sites or features containing common or lower value habitats, including naturalised species that are nevertheless essential in maintaining links and ecological corridors between features of higher ecological value.
Negligible (Site)	Sites containing small areas of semi-natural habitat that are of some local importance for wildlife. Sites of features containing non-native species that are of some importance in maintaining habitat links. All other features that are widespread and common and which are not present in locally, regionally or nationally important numbers which are considered to be of low or poor ecological value.

The effects on ecological features are then judged in terms of magnitude and duration. The following parameters are considered:

- Physical nature;
- Type (positive/negative, direct/indirect);
- Range of species and habitats affected;
- Population sizes of species and habitats affected;
- Spatial extent;
- Reversibility;
- Duration;
- Confidence in prediction; and
- Cumulative effects.

The magnitude of an impact is assessed using criteria set out in Table 9.2. Magnitude refers to the size of an impact, and is determined on a quantitative basis where possible (CIEEM 2016; NRA 2009). This may relate to the area of habitat lost to the development footprint or predicted loss of population of a particular species.

Table 9.2: Criteria for Determining the Magnitude of Potential Ecological Impact

Magnitude	Examples
Very high	The proposal (either on its own or with other proposals) will result in a total loss or very major alteration to key elements/features of the baseline conditions such that post-development character/composition/attributes will be fundamentally changed and may be lost from the site altogether.
High	The proposal (either on its own or with other proposals) will result in a major alteration to key elements/features of the baseline (pre-development) conditions such that post-development character/composition/attributes will be fundamentally changed.
Medium	The proposal (either on its own or with other proposals) will result in a loss or alteration to one or more key elements/features of the baseline conditions such that post-development character/composition/attributes of baseline would be partially changed.
Low	The proposal (either on its own or with other proposals) will result in a minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline conditions would be similar to pre-development circumstances/patterns.
Negligible	The proposal (either on its own or with other proposals) a very slight change from baseline condition. Change barely distinguishable approximating to the 'no change' situation.

Duration is defined as the time for which the impact is expected to last before recovery, i.e. the return to baseline conditions (refer to Table 9.3).

Table 9.3: Duration of Impact

Duration	Criteria
Permanent	Effects continuing indefinitely beyond one human generation (approx. 25 years), except where there is likely to be a substantial improvement after this period, whereby these would be described as 'very long-term effects'.
Temporary	Long-term (15 to 25 years or longer) Medium (5 to 15 years) Short-term (up to 5 years)

Determination of Significance

The significance of the impact is a correlation of the impact magnitude and ecological value. The matrix used for the assessment of significance presented in Table 9.4. The results from the impact matrix are not definitive. The overall significance of impact is determined to be a combination of the impact matrix and an evidence based approach.

Once identified, and characterised for magnitude and significance, each potential impact is assigned a confidence of prediction. IEEM guidance (IEEM 2010) outlines the following terminology for outlining the likelihood of impact occurrence:

- Certain (100%);
- Near-certain (95–100%);
- Probable (50–95%);
- Unlikely (5–50%); and
- Extremely Unlikely (0–5%).

Potential impacts described in later sections assume no specific mitigation measures. Specific mitigation measures are proposed in Section 9.7, where required, to reduce impacts identified as being of 'Moderate' and/or 'Major Adverse' significance. A statement of residual impacts is then provided.

Table 9.4: Impact Significance Matrix

Impact Significance		Ecological Value				
		Very High	**High**	**Medium**	**Low**	**Negligible**
Magnitude	**Very High**	Major	Major	Major	Moderate	Minor
	High	Major	Major	Moderate	Minor	Negligible
	Medium	Major	Moderate	Minor	Minor	Negligible
	Low	Moderate	Minor	Minor	Negligible	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible	Negligible

A summary of the generic definition of impact significance is outlined in Table 9.5. As not all impacts create an adverse effect, the definition for positive or beneficial impacts are also shown for the same impact significance.

Table 9.5: Definition of Impact Significance

Impact	Definition
Major Adverse	Considerable detrimental or negative impact to an environmental resource or receptor (by extent, duration or magnitude) of more than local significance or in breach of recognised acceptability, legislation, policy or standards.
Moderate Adverse	Limited detrimental or negative impact to an environmental resource or receptor (by extent, duration or magnitude) which may be considered significant.
Minor Adverse	Slight, very short or highly localised detrimental or negative impacts to an environmental resource or receptor.
Negligible	No significant impacts to an environmental resource or receptor.
Minor Beneficial	Slight, very short or highly localised advantageous or positive impact to an environmental resource or receptor.
Moderate Beneficial	Limited advantageous or positive impact to an environmental resource or receptor (by extent, duration or magnitude) which may be considered significant.
Major Beneficial	Considerable advantageous or positive impact to an environmental resource or receptor (by extent, duration or magnitude) of more than local significance.

Aspects of the Proposed Project That Have the Potential to Impact on the Marine Environment

Please refer to Chapter 4 Description of the Proposed Project in Volume 2 Part A of this EIAR for full details on the Construction Phase and Operational Phase methodology for the Proposed Project.

The proposed outfall pipeline route (marine section) commences in Baldoyle Estuary and runs approximately 5.9km to terminate approximately 1km north-east of Ireland's Eye, located approximately 4.5km offshore. The proposed construction method is a combination of microtunnelling and subsea pipe laying techniques within a 250m wide proposed construction corridor. The tunnelled section will run beneath Baldoyle Estuary to an approximate distance of 2km seaward of Velvet Strand to below the low water mark. The proposed outfall pipeline route (marine section) east of this point will be constructed using surface techniques involving the excavation of a trench from the tunnel termination point to the discharge location (approx. 4km). The trench (trapezoidal in shape) is envisaged to be 5m deep and 5m wide at the base, and between 20m and 40m wide at the surface subject to seabed sediment type. A proposed marine diffuser will be constructed at the end of the proposed outfall pipeline route (marine section).

At the tunnel/subsea pipeline interface, approximately 600m offshore, a temporary structure will be required consisting either of a cofferdam or a pre-excavated section of trench (filled with loose sand/granular material sourced from elsewhere along the trench alignment) to retrieve the Tunnel Boring Machine TBM from the microtunnelled section. A subsea fibre optic cable crosses the proposed outfall pipeline route (marine section) at approximately chainage 4,500m. This cable has to be protected in situ using interlocking sheet piles while the dredging and pipelaying operations progress.

On installation, the proposed outfall pipeline route (marine section) will be constructed using long length large diameter polyethylene pipes, which will be towed by sea from the pipe manufacturer to the pipe assembly area selected by the appointed contractor(s). The pipes will be towed in maximum lengths of 650m and assembled into string lengths defined by the appointed contractor(s) with the use of mechanical joints or flanged connections. The pipes will be sealed and slightly pressurised to aid floating. Concrete weight collars will be placed on the pipe string and secured in place. The pipe assembly will take place along a at Dublin port or in sheltered waters along the route of the proposed outfall pipeline (marine section).

The Construction Phase of the Proposed Project has the potential to impact on the marine environment in the following ways:

- Surface trenching has the potential to impact the benthic environment through physical disturbance and smothering during the excavation and sidecasting of the spoil and through the settlement of displaced suspended sediment over a greater area. This has the potential to impact the reef habitats found on Ireland’s Eye and the Rockabill to Dalkey Island SAC;
- All construction operations at the proposed temporary construction compounds neighbouring the estuary, or from floating plant during trenching, installation and piling has the potential to introduce pollution into the marine environment. Sensitive receptors include marine life, including nursery fish species, pinnipeds (seals) and cetaceans;
- Construction of the terrestrial elements of the Proposed Project, which could result in contaminated runoff entering the Mayne River and Tolka River catchments (see Section 11.9 to Section 11.14 of Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic) in Volume 3 Part A of this EIAR) entering the marine environment;
- The noise created during construction has the potential to impact sensitive receptors within the proposed outfall pipeline route (marine section) construction corridor through injury from noise or avoidance. Sensitive receptors include nursery fish species, pinnipeds (seals) and cetaceans, in particular the harbour porpoise. The proposed outfall pipeline route (marine section) falls within the Rockabill to Dalkey Island SAC;
- The construction of the proposed outfall pipeline route (marine section) (including the proposed marine diffuser) will result in a permanent loss of the habitat over a very small area at the proposed marine diffuser location and the introduction of a new hard substrate;
- The duration of the Construction Phase could affect the seasonal migration of important marine species, including salmonids and the harbour porpoise, nursery fish species in the area or the breeding season of seabirds nesting on Ireland’s Eye SPA;
- The use of microtunnelling techniques has the potential (albeit low risk) to release air or bentonite via a breakout into the marine environment; and
- During the Operational Phase, the treated wastewater discharged into the Irish Sea has the potential to affect water quality in the area. This can impact the quality of nearby beaches as well as neighbouring shellfish waters.

9.2.5 Non-Statutory Consultation

The issues raised as a result of non-statutory consultation on the Proposed Project are included in Table 9.6.

Table 9.6: Issues Raised During Non-Statutory Consultation on the Proposed Project.

Stakeholder	Submission Details	Environmental Impact Assessment Report Chapter Reference
An Taisce (received 17 January 2014)	• Concerns raised about the potential impact on protected areas: Baldoyle Bay SAC (Site Code: 000199), Baldoyle Bay SPA (Site Code: 004016) and the Rockabill to Dalkey Island SAC (Site Code: 003000). • Environmental Impact Statement (EIS) should address potential impacts on each protected area and relevant mitigation measures. • Water quality of discharge must be tested frequently to ensure that chemical and nutrient inputs do not have a negative effect on porpoise population and reef habitat within the Rockabill to Dalkey Island SAC.	• The Natura Impact Statement (NIS) provides details on the assessment of impacts of the Proposed Project on SACs and SPAs in the Zone of Influence. • Sections 9.4 and 9.5 provide details on potential impacts, while mitigation measures are provided in Section 9.7. • See Chapter 4 Description of the Proposed Project in Volume 2 Part A of this EIAR.
BirdWatch Ireland (received 12 December 2013)	• Concerns regarding activities in the vicinity of Baldoyle Bay SPA (Site Code: 004016); • Concerns regarding the proximity of the proposed outfall pipeline route (marine section) to Ireland's Eye SPA (Site Code: 004117); • Potential impact of nutrient reduction on the estuarine environment.	• The NIS provides details on the assessment of impacts of the Proposed Project on SACs and SPAs in the Zone of Influence.
Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs/National Parks and Wildlife Service (NPWS) (Formerly Department of Arts, Heritage and the Gaeltacht) (received 10 January 2014)	• With regard to EIS, an ecological survey of the entire Proposed Project site and proposed pipeline routes should be carried out. Where ex situ impacts are possible, survey work may be required outside of the Proposed Project sites. • The impact of the Proposed Project on the flora, fauna and habitats present should be assessed. In particular, the impact of the Proposed Project should be assessed, where applicable, with regard to legislation relating to habitats and species. • The Proposed Project should be subject to Appropriate Assessment screening and, where necessary, Appropriate Assessment as per Article 6.3 of the Habitats Directive. • Consultation with the relevant Local Authorities is recommended to determine if there are any projects or plans which alone or in combination could impact on any Natura 2000 sites.	• Chapter 9 Biodiversity (Marine), Chapter 10 Biodiversity (Marine Ornithology and Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic) in Volume 3 Part A of this EIAR provide a full ecological survey of the Proposed Project including ex situ impacts and provide details on potential impacts on ecology. • An NIS has been prepared for the Proposed Project.
Inland Fisheries Ireland (IFI) (received 11 December 2013)	• EIS should include an assessment establishing the current baseline ecological conditions, detail construction and operational activities and predict the impact of future changes to the baseline. • Water quality assessment should be carried out in accordance with all relevant existing	• Chapter 9 Biodiversity (Marine), Chapter 10 Biodiversity (Marine Ornithology and Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic) provide details on the baseline ecological conditions. Chapter 4 Description of the Proposed Project in

Stakeholder	Submission Details	Environmental Impact Assessment Report Chapter Reference
	national and European legislation; • Require detailed hydraulic and water quality modelling to assess the impact on water quality at the location of the proposed outfall pipeline route (marine section). • The EIS should provide a full and detailed evaluation on the likely impacts of the Proposed Project on groundwater, freshwater, estuarine and coastal ecology. • Mitigation strategies to be developed to avoid impacts on water quality and habitat ecology. • The EIS should assess the predicted impacts of noise and vibration during the construction and operation of the Proposed Project. • All measures necessary should be taken to ensure protection of local aquatic ecological integrity, in the first place by complete impact avoidance and, as a secondary approach, through mitigation by reduction and remedy.	Volume 2 Part A of this EIAR provides details on the Proposed Project. • See Chapter 8 Marine Water Quality. Section 9.3.5 also provides details on water quality with respect to marine ecology. • Chapter 9 Biodiversity (Marine), Chapter 10 Biodiversity (Marine Ornithology and Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic) in Volume 3 Part A of this EIAR provide a full and detailed evaluation of the likely impacts of the complete project on freshwater, estuarine and coastal ecology. Chapter 17 provides details on groundwater. • Section 9.7 provides details on mitigation measures. • Section 9.4 provides an assessment of noise and vibration impacts from the Construction Phase. No significant noise impact is predicted during the Operational Phase.
Irish Whale and Dolphin Group (IWDG) (received 14 November 2013)	• Scoping document makes no provision to assess the use of the marine area influenced by the Proposed Project by harbour porpoise. • Concerns raised over the proposed outfall pipeline route (marine section) location as the area is frequently used by harbour porpoise and is adjacent to the SAC designated for harbour porpoise (Rockabill to Dalkey Island SAC) • Recommend static acoustic monitoring using C-PODS be carried out for a minimum of 12 months or 24 months as per best practice.	• Section 9.4 assesses the impact of the Proposed Project on harbour porpoise. • An NIS has been prepared for the Proposed Project. • Section 9.2.2 provides details on baseline monitoring completed.
Marine Institute (received 08 December 2013)	• EIS should address the potential impacts, particularly during the installation phase of the proposed outfall pipeline route (marine section), on inshore fishing activity. • Where any dredged/excavated materials are to be disposed of at sea, data should be provided on the physical and chemical characteristics of the materials.	• Section 9.4 addresses potential impacts on fisheries. • Section 9.3.3 provides details on sediment chemistry.

9.3 Baseline Environment

9.3.1 Designated Sites for Nature Conservation

A summary of the SACs in the marine environment is included in Table 9.7. It should be noted that potential impacts to SPAs are discussed separately in Chapter 10 Biodiversity (Marine Ornithology) while those on terrestrial designated sites for nature conservation are discussed in Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic). An NIS has also been completed for the Proposed Project.

Table 9.7: Marine Special Areas of Conservation Within the Vicinity of the Proposed Project

Site Code	Site Name	Habitat Code	Habitat Name	Distance
000199	Baldoyle Bay SAC	1140	Mudflats and sandflats not covered by seawater at low tide	Within Proposed Project area
		1310	*Salicornia* spp. and other annuals colonising mud and sand	
		1330	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	
		1410	Mediterranean salt meadows (*Juncetalia maritimi*)	
000202	Howth Head SAC	1230	Vegetated sea cliffs of the Atlantic and Baltic coasts	2.6km south
		4030	European dry heaths	
000204	Lambay Island SAC	1170	Reefs	9.3km north
		1230	Vegetated sea cliffs of the Atlantic and Baltic coasts	
000205	Malahide Estuary SAC	1140	Mudflats and sandflats not covered by seawater at low tide	2.5km north
		1310	*Salicornia* spp. and other annuals colonising mud and sand	
		1330	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	
		1410	Mediterranean salt meadows (*Juncetalia maritimi*)	
		2120	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	
		2130	Fixed coastal dunes with herbaceous vegetation (grey dunes)	
000206	North Dublin Bay SAC	1140	Mudflats and sandflats not covered by seawater at low tide	2.3km south
		1310	*Salicornia* spp. and other annuals colonising mud and sand	
		1330	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	
		1410	Mediterranean salt meadows (*Juncetalia maritimi*)	
		2120	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	
		2130	Fixed coastal dunes with herbaceous vegetation (grey dunes)	
		1210	Annual vegetation of drift lines	
		2110	Embryonic shifting dunes	
		2190	Humid dune slacks	
000208	Rogerstown Estuary SAC	1130	Estuaries	8.5km north
		1140	Mudflats and sandflats not covered by seawater at low tide	
		1310	*Salicornia* spp. and other annuals colonising mud and sand	
		1330	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	
		1410	Mediterranean salt meadows (*Juncetalia maritimi*)	
		2120	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	
		2130	Fixed coastal dunes with herbaceous vegetation (grey dunes)	
000210	South Dublin Bay SAC	1140	Mudflats and sandflats not covered by seawater at low tide	7.6km south
002193	Ireland's Eye SAC	1230	Vegetated sea cliffs of the Atlantic and Baltic coasts	0.8km south
		1220	Perennial vegetation of stony banks	
003000	Rockabill to Dalkey Island SAC	1170	Reefs	Within Proposed Project area

9.3.2 Geomorphology and Seabed Sediments

The detailed bathymetry of the proposed outfall pipeline route (marine section) is shown in Figure 9.2 Summary of Bathymetry Data for the Proposed Outfall Pipeline Route (Marine Section). The bathymetry can be separated into the three sediment types. The proposed outfall pipeline route (marine section) passes beneath the medium sands of Velvet Strand along the Portmarnock coastline, to beneath a beach break with an increased gradient of around 2°. This then passes into consistent shallow shelving fine sand (gradient <0.5°) out to a distance of 3.3km from the beach with no bedforms observed along the route. Here, the slope steepens to approximately 3° for around 150m, before returning to the shallow slope, but also becomes rougher and harder, indicative of mixed gravelly sand with some large sediments clasts (such as cobbles). At 4.8km from the beach, the seabed returns to a smoother morphology but remains at a high reflectivity to the proposed marine diffuser location. This is indicative of a thin veneer of fine sands overlying a mixed gravelly sand and shell. The proposed outfall pipeline route (marine section) was further assessed using sidescan sonar data, which confirmed the above description. A small area of increased reflectivity was recorded at the landfall end of the proposed outfall pipeline route (marine section) just below the wave break area, interpreted as an area of increased sediment compaction. No hard reef features (geogenic or biogenic) were recorded along the proposed outfall pipeline route (marine section).

During the benthic surveys, detailed sediment analysis was undertaken at nine sites near the proposed outfall pipeline route (marine section) and surrounding area between 2012 and 2017. In addition, sediments were also acquired at seven core locations along the proposed outfall pipeline route (marine section). A summary of the specific particle size results are outlined in Appendix A9.1 and presented geographically in Figure 9.3 Sediment Changes Near the Proposed Outfall Pipeline Route (Marine Section) and Marine Diffuser Location, which includes a broad interpretation of sediment habitat types recorded using seabed camera operations.

Seabed photography and sample particle size analysis indicates that the sediments surrounding the proposed outfall pipeline route (marine section) were consistent with three main sediments types, namely a fine sand along the first 3.3km of the proposed outfall pipeline route (marine section), but with the presence of a coarser sub-cropping of sandy gravels in the central section of the route and sub-cropping of a fine sand veneer at the eastern end of the proposed outfall pipeline route (marine section) near the proposed marine diffuser location. Seabed sampling along the proposed outfall pipeline route (marine section) (Stations 3 to 7) all indicated a mean Wentworth classification of fine to very fine sand (mean particle size of 127 to 168 microns) but evidence from the seabed photography and processed biological grab samples indicated the presence of patchy exposures of coarser sediments, including some cobbles, near the shelf break, approximately 1.7km west of the proposed marine diffuser. This continued east to the proposed marine diffuser location but eventually sub-cropped a veneer of mobile fine sands. Of the nearby stations sampled, stations 10 and 11 both indicated mixed gravelly sands, whilst Stations 6 and 7 (located at the proposed marine diffuser location) indicated only a fine surface layer of sands over a mixed gravelly seabed in 2012, but more exposed gravels in 2017 (Figure 9.3 Sediment Changes Near the Proposed Outfall Pipeline Route (Marine Section) and Marine Diffuser Location and Photo 9.1). This highlights the mobility of surface sediments immediately surrounding the proposed marine diffuser location.

Photo 9.1: Seabed at the Proposed Marine Diffuser Location Showing Rippled Sands in 2012, but Mixed Silty Sandy Gravels in 2017

The shallow geology of the proposed outfall pipeline route (marine section) was surveyed using sub-bottom profilers, boreholes and vibrocores (Causeway Geotech 2016). Evidence of the deeper geology recorded close to the shelf break north-west of Ireland's Eye indicated dense very sandy, fine to coarse gravels at the surface and down to a depth of 6.20m. Vibrocores along the length of the proposed outfall pipeline route (marine section) failed to penetrate the seabed east of this location due to these gravels. However, shallow sub-surface sediments west of this site indicated consistent sediments to a depth of 80cm to 120cm to those recorded at the surface, albeit with slightly reduced fines at two of the stations.

Beyond the immediate area surrounding the proposed outfall pipeline route (marine section), the seabed sediments indicated a generally sandy environment north of the proposed marine diffuser until Lambay Island, where sporadic bedrock exposures and larger areas of mixed gravelly sands (east of Lambay Island) are recorded. One station (Station 24) indicated the presence of a cobble field 2km east of the beach at Balcarrick. South of the proposed outfall pipeline route (marine section), the island of Ireland's Eye is surrounded by exposed bedrock and sublittoral reefs, with generally mixed sediment of hard ground separating the island from the mainland, at Howth. This area was surveyed and is described separately in Section 9.3.4.

Established gravel areas, cobble pavements and larger rocky areas were recorded using seabed photography and will provide a notably different habitat to that recorded at the proposed marine diffuser location and along the proposed outfall pipeline route (marine section). Here, an epifaunal component using the hard surfaces has become established, with this biological component described in greater detail below.

Both intertidal and subtidal rocky reef complexes are recorded on the northern and eastern shorelines of Ireland's Eye, south of the proposed marine diffuser location. These are classified as exposed to moderately exposed intertidal reefs and a subtidal range of flat and sloping bedrock, boulders, a mosaic of cobbles and vertical rock walls, many showing sediment scouring and occasionally a thin veneer of silt. The Ireland's Eye reef complexes are listed as a qualifying interest (Reef habitat 1170) in the Rockabill to Dalkey Island SAC (Site Code: 003000).

9.3.3 Sediment Chemistry

Details of sediment chemistry levels were recorded along the proposed outfall pipeline route (marine section) from surface sediments in 2012 and 2013 and from sub-surface vibrocores (to approximately 80cm to 120cm) in 2015. Changes to the levels of chemistry within the sediments are not expected to have altered significantly since these surveys due to the absence of any industrial activities near the site. A standard array of tests was carried out based on the array of naturally occurring and potentially anthropogenic contaminants. Results of detectable components are summarised in Table 9.8.

For heavy and trace metals, elements of the greater potential for toxicity have been compared with Ecotoxicological Assessment Criteria (EAC) proposed by OSPAR (1997). EACs are defined as concentration levels of a substance above which concern is indicated. Table 9.8 shows a summary of metal results for sites surveyed during the marine surveys. These have been compared with the EAC limits where relevant. For the proposed outfall pipeline route (marine section), all metals were recorded in low concentrations below or between the two OSPAR EAC limits. Exceptions to this were recorded during the surveys but outside the area of the proposed outfall pipeline route (marine section). These were for arsenic within Dublin Bay, which recorded a slightly elevated concentration of 20.3 milligrams / kilogram (mg/kg), and for cadmium at a station north of Rush harbour, with a 1.2mg/kg level recorded. Overall, there appears to be no significant pattern of distribution, with the levels of metals remaining relatively consistent across the survey area with variations generally limited to sediment changes (i.e. the proportion of finer sediments) rather than from contamination sources. Comparisons with sub-surface sediments taken using the vibrocorer show that buried sediments within the dredge depth indicate similar or slightly lower levels of most metals.

Other chemical indicators tested for during the marine survey were organotins (dibutyltin and tributyltin) and polychlorinated biphenyls (PCBs). The level of tributyltin was below detectable limits at all stations surveyed. This pollutant is of great environmental interest because it directly enters the aquatic ecosystems due to industrial application of organotin biocides and because of its high toxicity to non-target aqueous organisms (Horiguchi et al. 1997). Of far less toxicity is dibutyltin which is used as a stabiliser in plastics. Although this can have detrimental effects in higher concentrations (Bulten and Meinema 1991), it is generally found in low concentrations in coastal areas and can accumulate in the tissues of marine organisms such as fish (Kannan et al. 1996). Similar tests in buried sediments indicated undetectable concentrations of both compounds.

Sediments were also tested for seven congeners of PCBs which were widely used as dielectric and coolant fluids in transformers, capacitors, and electric motors. PCBs remained undetectable during all surveys. Due to their environmental toxicity and classification as a persistent organic pollutant, the production of PCBs was banned in the United States in 1979 and by the Stockholm Convention on Persistent Organic Pollutants in 2001 (Porta and Zumeta 2002).

For organic chemistry, the concentrations of TPH in the surface sediments were detectable in most surface samples analysed, ranging from below 10mg/kg to 29mg/kg (refer to Table 9.8). Analysis of material below the surface indicated undetectable concentrations below 10mg/kg. All sediments sampled fell below the level of 100mg/kg, an action level for possible harmful environmental effects used by regulatory authorities in the UK (i.e. Cefas). Aromatic compounds were also tested. These were split into BTEX and two- to six-ring polycyclic aromatic hydrocarbon compounds (PAHs). BTEX is an acronym that stands for ‘benzene, toluene, ethylbenzene and xylenes’, and was undetectable in all samples. These compounds are some of the more volatile organic compounds found in petroleum derivatives such as petrol and can contaminate river and marine sediments near urban centres. Toluene, ethylbenzene and xylenes have harmful effects on the central nervous system and can accumulate in the tissues of some marine life.

Table 9.8: Summary of Sediment Chemistry (Surface Grab Samples 2012 and 2013, Subsurface Vibrocore Samples 2015)

Parameter	Unit	2012 Survey (Four Sites)		2013 Survey (Eight Sites)		2015 Survey (Six Sites) 0.8m to 1.2m depth		Ecotoxicological Assessment Criteria	
		Range	Mean	Range	Mean	Range	Mean	Lower Limit	Upper Limit
Arsenic	mg/kg	4.5–6.3	5.2	4.1–7	5.8	4.73–6.66	5.9	1	10
Copper	mg/kg	11.1–14	12.9	9.2–14.5	11.7	3.76–5.79	4.3	5	50
Lead	mg/kg	11.7–17.1	14.0	11.8–20.2	15.4	7.95–14.2	9.8	5	50
Tin	mg/kg	1.2–3.6	2.3	1.3–3.5	2.2	-	-	-	-
Aluminium	g/kg	14.6–19.1	17.0	15.2–21.4	18.4	14.0–18.3	15.7	-	-
Barium	mg/kg	149–178	161.8	143–177	158.4	-	-	-	-
Iron	g/kg	9.0–14.2	11.8	1.5–14,400	10.4	-	-	-	-
Cadmium	mg/kg	0.2–1	0.5	0–0.6	0.3	0.11–0.17	0.1	0.1	1
Chromium	mg/kg	27.4–37.2	32.1	23.4–36.5	29.8	27.2–44.2	33.3	10	100
Nickel	mg/kg	8.7–14.1	11.0	9–17.6	12.0	7.4–11.1	9.4	5	50
Vanadium	mg/kg	30.6–48.6	40.1	36.6–56.3	46.3	-	-	-	-
Zinc	mg/kg	28.6–41.2	35.8	31.1–47.5	39.7	33.1–51.6	37.4	50	500
Mercury	mg/kg	0.02–0.04	0.0	0.02–0.03	0.0	0.01–0.02	0.02	0.05	0.5
Dibutyltin	µg/kg	24–160	76.3	20–110	67.1	<5	<5	-	-
Tributyltin	µg/kg	<5	<5	<20	<20	<2	<2	0.005	0.05
Total Hydrocarbons	mg/kg	11–44	29.0	18–29	22.3	<10	<10	-	-
PCB (7 congeners)	µg/kg	<5	<5	<5	<5	<0.2	<0.2	1	10
Toluene	µg/kg	<5	<5	<5	<5	-	-	-	-
Benzene	µg/kg	<1	<1	<1	<1	-	-	-	-
Ethylbenzene	µg/kg	<2	<2	<2	<2	-	-	-	-
Xylenes	µg/kg	<6	<6	<6	<6	-	-	-	-
m/p Xylenes	µg/kg	<4	<4	<4	<4	-	-	-	-
o Xylene	µg/kg	<2	<2	<2	<2	-	-	-	-

Parameter	Unit	2012 Survey (Four Sites)		2013 Survey (Eight Sites)		2015 Survey (Six Sites) 0.8m to 1.2m depth		Ecotoxicological Assessment Criteria	
		Range	Mean	Range	Mean	Range	Mean	Lower Limit	Upper Limit
PAH 16 USEPA/compound	µg/kg	<80	<80	<80	<80	4.2–14.3	7.4	50	500
Total PAHs	µg/kg	<1.,280	<1,280	<1,280	<1,280	94–155	117		

Quantitative two- to six-ring PAHs were analysed at each station using Gas Chromatography-Mass Spectrometry. The PAHs listed under the United States Environmental Protection Agency (USEPA) for the 16 priority pollutants for air, water and sediment quality are summarised in Table 9.8. Results indicated undetectable total concentrations (<1.28mg/kg) at all sites and for all individually speciated PAH compounds (<0.08mg/kg). Sub-surface sediments were all tested in 2015 using a methodology producing a lower detection limit. This recorded the presence of individual PAHs at a low mean concentration of 7.4µg/kg and a total PAH concentration of 117µg/kg. PAHs and their alkyl derivatives have been recorded in a wide range of marine sediments (Laflamme and Hites 1978) with the majority of compounds produced from what is thought to be pyrolytic sources. These are the combustion of organic material such as forest fires (Youngblood and Blumer 1975) and the burning of fossil fuels. The resulting PAHs, rich in the heavier weight four- to six-ring aromatics, are normally transported to the sediments via atmospheric fallout or river runoff. Another PAH source is petroleum hydrocarbon, often associated with contamination from urban centres and shipping fuels. These are rich in the lighter, more volatile, two- and three-ring PAHs (naphthalenes, phenanthrene and anthracene) with their alkyl derivatives. The PAHs recorded during the vibrocoring survey indicated no petroleum influences and are therefore expected to reflect a ubiquitous mixed or pyrolytic origin. PAHs recorded by all surveys indicated natural low concentrations well below the level of environmental concern.

9.3.4 Marine Benthos

Macroinvertebrate Community

A macroinvertebrate analysis was carried out on replicates over a large area benthic programme with 24 stations surveyed in 2012 and a further eight stations repeated around the proposed outfall pipeline route (marine section) in 2013 and again in 2017 (Appendix A9.1). The survey was carried out during the summer months to convey a maximum population after the established annual recruitment by recently settled juveniles to adults. Sites represented the proposed outfall pipeline route (marine section), as well as sediment changes near the Proposed Project and within a full tidal excursion (or maximum distance travelled by surface water over a full tidal cycle) from the proposed marine diffuser location. Macrofaunal samples were processed in the field using a 500µm mesh size.

For all three benthic survey campaigns, the macrofaunal taxonomy of all recovered fauna identified almost 16,000 individuals from the 63 grab samples analysed. A matrix of faunal data for each sample is listed in Appendix A9.1. For ease of presentation and comparison, the survey sites were rationalised to a dataset within close proximity of the proposed outfall pipeline route (marine section), a total of 57 samples. Here, over 11,000 individuals were recorded from 245 different species. Of the species recorded, 92 were classified as epifaunal in nature, with 199 infaunal species consisting of 67 annelids accounting for 47.5% of the total individuals. The molluscs were represented by 46 species (27.8% of individuals), the crustaceans by 52 species (but only 12.2% of individuals) whilst echinoderms were represented by 14 species (8.7% of individuals). All other groups (i.e. Turbellaria, Nematoda, Nemertea, Cnidaria, Chelicerata, Porifera and Chaetognatha) accounted for the remaining 3%, or 11 species.

The population along the proposed outfall pipeline route (marine section) indicated a number of community changes relative to the change in sediment type, with sands providing the dominant habitat to the west, becoming mixed with gravelly muddy sands and sandy gravels dominating the seabed at the shelf break and towards the east. A distribution of these different taxa are presented for Station 4 (sands) to the west and Station 11 (gravelly muddy sands) to the east, in Diagram 9.1, with a separation of the data by survey year.

Other species of interest in the area were recorded at Station 27, located south of Ireland's Eye in 2012. This recorded a seed mussel bed (*Modiolus modiolus*), with very high numbers of recently settled individuals. Other mussel beds (in particular those of the blue mussel (*Mytilus edulis*)) have been recorded in areas to the west of Ireland's Eye and can be considered a potentially sensitive habitat to impacts from smothering. When found in dense aggregations, this biotope creates an important biogenic reef habitat encouraging high biodiversity. These can be designated as an Annex I habitat under the Habitats Directive. No Annex I habitats were recorded within the proposed outfall pipeline route (marine section).

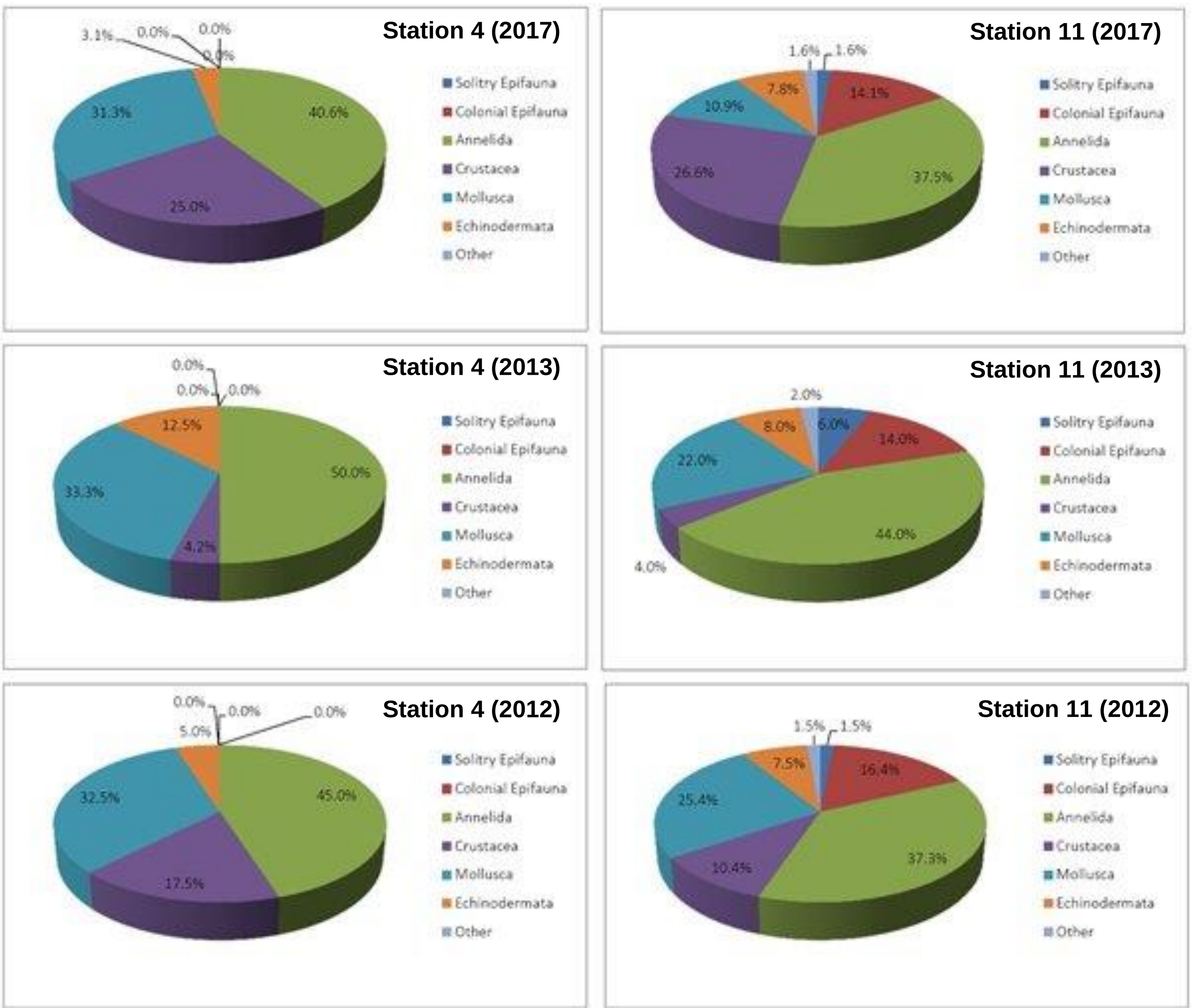

Diagram 9.1: Macro-Invertebrate Distribution by Phylum (Stations 4 and 11, Between Surveys in 2012 and 2017)

The benthic community recorded in this area was diverse and typical for a mixed inshore sediment environment, with both infaunal deposit feeders and surface living epifaunal species both well represented. When the surveys were combined, the overall population was dominated by polychaete worm (a segmented annelid), closely followed by the molluscs, in particular the bivalves. The molluscs represented four of the top 10 numerically dominant species present, whilst annelids (polychaete worms) were also represented by a further four species, whilst the remaining species were represented by a brittle star *Amphiura filiformis* and the crustacean *Pseudocuma longirostris*. Polychaetes were dominated by *Capitomastus minimus* (particularly in 2017), *Owenia fusiformis, Lagis koreni* and *Cirratulus cirratus*, whilst the molluscs were *Kurtiella bidentata, Fabulina fabula, Thracia phaseolina* and *Abra alba*.

When combined surveys were ordered into rank dominance, the main distribution of these species altered slightly, although seven of the top 10 numerically dominant species are included within the top 10 ranked species. Here, the mollusc *F. fabula* is the most consistent species with two other molluscs (*A. alba, K. bidentata and T. phaseolina*) recorded in the top six behind the polychaete *C. minimus*. This species community is very similar to communities recorded in the early 1970s (Walker and Rees 1980). A close resemblance to the shallow Venus or Boreal offshore sand association and the Boreal offshore muddy sand association (Jones 1950; Thorson 1957) indicates that a significant stability within the marine sediments has been maintained in this area over several decades.

The primary and univariate parameters are listed for all stations in Appendix A9.1. The number of individuals recorded during this study was quite consistent within the survey area, although the medium sands of Station 1, in Dublin Bay, indicated a low number of both species and individuals in 2012. A median for the survey was 47 species and 1,860 individuals per square metre. The median diversity was at a moderate level overall (at 4.10), although this parameter varied by station, ranging from a low diversity of 2.92 recorded in Dublin Bay (Station 1 in 2012), to a very high diversity of 5.37 in the same year recorded on the mixed gravely sands at Station 10, due south of the proposed marine diffuser location. This reflects the varying sediments and biological niches available in these two quite different sediment types. Other indices (Pielou's evenness and Margalef's species richness) both indicated relatively low species dominance within the population and only slight variability, indicative of some community separation by some sites and between survey years. Overall, these stations reflect a relatively consistent community with a moderate diversity and abundance, but with a subtle change between 2012, 2013 and 2017. Benthic environments are naturally dynamic with the biological population constantly varying between years due to the different success rates by some species during larval recruitment. This affects the relative dominance of key species between survey years and would be expected to continue to change constantly in the survey area.

The moderate diversity reflects a high number of species for the relatively high numbers of individuals overall, although the numbers of individuals varied between sites and slightly between years. The most dominant individual species by site was the polychaete *C. minimus* which had a mean abundance of 2,000 individuals per m^2 (ind/m^2), although this was recorded at maximum density of 2,300ind/m^2 (for Station 11 in 2017). Only 16% of the 247 species recorded were represented, on average, by more than one specimen per grab sample (i.e. >10ind/m^2), whilst 16% of species were represented by only a single specimen over all three surveys (a cumulative sample area of 5.7m^2).

A more thorough examination of the macrofaunal community was carried out using a multivariate analyses technique on the datasets from all three survey years. The results showed minor variations but with significant similarities in faunal compositions between the three survey years. However, the communities fundamentally remained the same throughout. Changes in the biological community from 2012 to 2013 were attributed to higher abundances of the more dominant species recorded in 2012. In 2017, the population altered further with a change in the top five species.

The distribution of key phylogenetic groups between survey years is shown in Diagram 9.1. This separates the surveys into two stations, which represent sands to the west of the proposed outfall pipeline route (marine section) (Station 4) and muddy sandy gravels (Station 11) just north of the proposed marine diffuser location. Results show that, whilst some variations exist between survey years, shown above, the greatest variations in species richness between stations is predominantly a result in habitat change across the area. At both sites, annelids were the dominant fauna type followed by molluscs, crustaceans and then echinoderms, by both richness and abundance. The greater variation was recorded at Station 11, having a notably higher epifaunal component owing to the gravel substrate. Furthermore, the numbers of Crustacea appeared to fall in 2013, but recovered again in the later survey. Comparison of survey years showed that the richness of crustacea decreased significantly in 2013 for both sandy and gravelly substrates, whilst the richness of echinoderms dropped significantly in the sandy substrate but remained consistent on the coarser sediments over all three years. As all three surveys were conducted in the same season (summer), these observed inter-annual differences demonstrate the natural temporal shift in community structure with changes in the dominance of certain species.

Multivariate analysis was also used to compare the distribution and repetition of biological communities by sediment type. The results indicated consistent clustering of sites into communities dominated by sediment types, despite the survey year in which the samples were acquired. Muddy sandy gravel, found at the proposed diffuser location, varied from the other sediment types due to higher counts of the brittlestar *Amphiura filiformis* and polychaete *Scalibregma inflatum*. Muddy sand was separated out due to relatively high counts of the polychaetes *Lagis koreni* and *Owenia fusiformis*. Stations with the sand classifications found predominantly along the shallower part of the proposed outfall pipeline route (marine section) differed due to lower species dominance but high numbers of the polychaete *Magelona mirabilis*. The edible mussel (*Mytilus edulis*) and swimming crab (*Liocarcinus depurator*) were responsible for most of the differences recorded in the maerl gravel found on the southern side of Ireland's Eye, surveyed in 2012.

Epifaunal Community

Observations made during the taxonomy and via seabed photography have identified a significant epifaunal community within many of the stations surveyed, particularly those to the east of the proposed outfall pipeline route (marine section) relating to the coarser gravels. Taxonomic records showed that both solitary and colonial species of epifauna were recorded during the benthic survey, with as many as 23 different species recorded at Station 10, located within the mixed gravelly sediments. Diagram 9.2 shows the numbers of species recorded relative to the infaunal biology, with epifaunal species represented in all sites surveyed over the three periods.

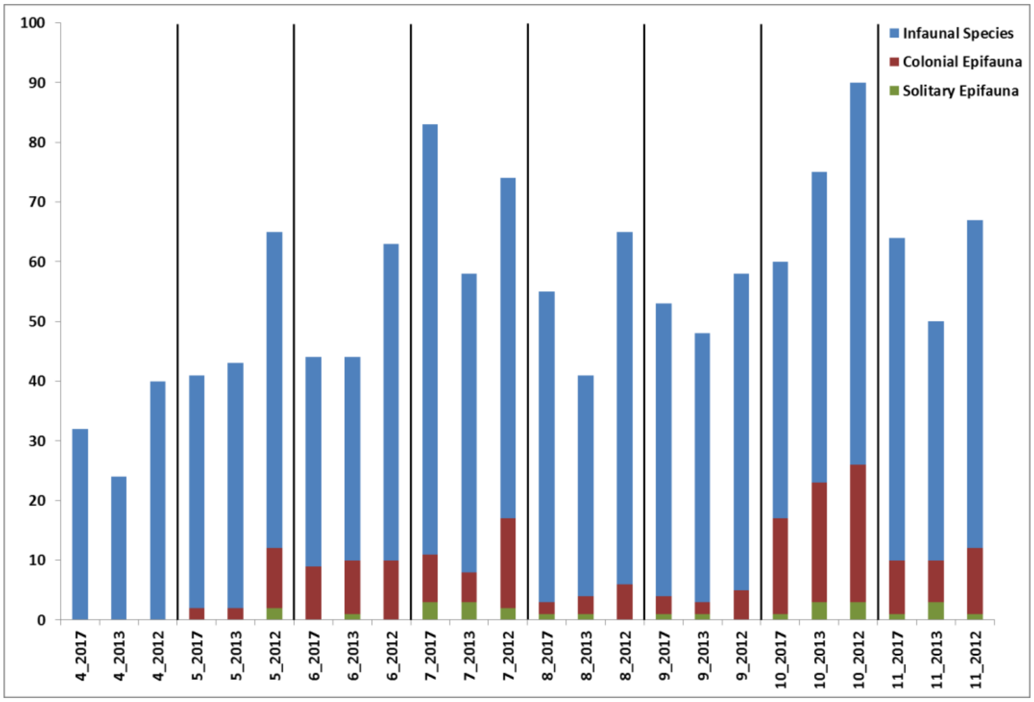

Diagram 9.2: Distribution of Epifaunal Species

From all surveys, these samples recorded a large number of epifaunal species dominated by 24 species of bryozoan, 27 species of Cnideria, six species of sponge and an entroproct. One of the most dominant groups were bryozoans, with *Conopeum reticulum* the most common, but none were recorded in large numbers. Most of the bryozoans were upright branching or 'turf' forming species, e.g. *Bugula* spp., *Crisia* spp., *Alcyonidium diaphanum, Flustra foliacea, Vesicularia spinosa* and *Scrupocellaria scruposa*. The sponge fauna was relatively sparse. *Cliona celata* was found boring within shells, whilst *Dysidea fragilis* is a ubiquitous species around the Irish coast and can range from small crusts to large massive specimens. *Scypha ciliata* often settles on other epibenthic species, and none of the species were commonly found due to the generally sandy substrate at most sites sampled.

The densest coverage by epifauna was by the hydroids, which were relatively well developed, especially *Laomedea flexuosa* and *Sertularia cupressina* which were recorded at over half of the sites. Some larger species, such as *Hydrallmania falcata* and *Halecium* spp., acted as settlement surface for smaller creeping species such as *Campanularia hincksii* and *Clytia hemisphaerica*. Many of the hydroids were heavily settled along with juvenile *Mytilus* and *Modiolus* mussels.

Another species found present during the initial benthic survey was biogenic maerl sands in isolated patches at Station 27, south of Ireland's Eye. This is coralline red algae which can create a diverse biological community at the seabed through sediment modification and habitat creation, although only isolated pockets of mostly dead debris were recorded during the survey using seabed photography at this station (in 2012). The presence of maerl has been previously recorded by the GSI as part of the INFOMAR project in this area of Dublin Bay. As this was on the opposite side of Ireland's Eye to the proposed outfall pipeline route (marine section), this was not surveyed again in 2013 or 2017 (as no impacts are expected).

In addition to coarse sediments recorded along the proposed outfall pipeline route (marine section) itself, the intertidal and subtidal reefs of the Ireland's Eye SAC are recorded approximately 1.6km to the south. These features have been surveyed separately and are described in detail in the next Section.

Littoral and Sublittoral Reefs Around Ireland's Eye

The conservation objectives of the Annex I Reefs (1170) of the Rockabill to Dalkey Island SAC are to maintain a favourable conservation status within the SAC. The NPWS has confirmed that the habitat is stable or increasing subject to natural processes and that the community structure of the intertidal and subtidal reef community complex is to be maintained as a conservation objective. The SAC is based on an estimated habitat area of 182ha using the 2010 and 2011 intertidal and subtidal reef survey data (MERC 2010; 2012a; 2012b), INFOMAR bathymetry and the Arklow to Skerries Islands Admiralty Chart (1468_0).

Within the Rockabill to Dalkey Island SAC, the designations for intertidal and subtidal reefs were based on surveys undertaken in 2010 and 2011 (MERC 2010; 2012a; 2012b). These data were used to determine the physical and biological nature of the Annex I habitat, on all of the islands within the SAC. Estimated areas of each community type within the Annex I habitat were based on interpolations for the island of Ireland's Eye.

The development of a community complex target arises when an area possesses similar abiotic features but records a number of biological communities that are not regarded as being sufficiently stable and/or distinct temporally or spatially to become the focus of conservation efforts. In this case, examination of the available data from Rockabill to Dalkey Island SAC identified a number of biological communities whose species composition overlapped significantly. Such biological communities are grouped together into what experts consider are sufficiently stable units (i.e. a complex) for conservation targets.

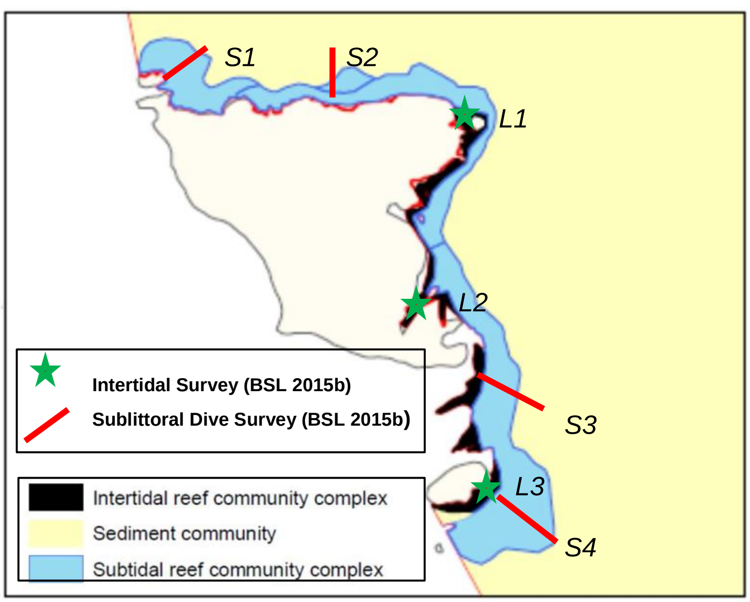

Diagram 9.3: Ireland's Eye Marine Community Types designated by Rockabill to Dalkey Island SAC

Intertidal Reef Community Complex

This reef community complex is recorded on the eastern and southern shores of Ireland's Eye immediately south of the proposed outfall pipeline route (marine section) (including the proposed marine diffuser). The exposure regime of the complex ranges from exposed to moderately exposed reef for Ireland's Eye. The substrate here is that of flat and sloping bedrock, cobbles and boulders. Vertical cliff faces are found on the north and north-east shores of the island.

A detailed walkover survey was carried out in 2015 at three locations (see Diagram 9.3) along the eastern edge of the island, relating to the northern, central and southern extreme of the eastern shoreline (BSL 2015b). Survey operations were conducted in June/July 2015. Sites were selected from aerial photography to present different exposures and the vertical profiles completed along all of the lower, middle and upper shorelines at these locations. Each biological zone was photographed and surveyed.

This survey has collected semi-quantitative data from two moderately exposed littoral stations (L1 and L3) and a sheltered station (L2). L1 was slightly modified by shading, wave surge and nitrogenous enrichment and the L3 upper shore biotope was similarly enriched by roosting seabirds. The positions of these sites are shown in Diagram 9.3. In the littoral zone, the biotopes '*Corallina officinalis* on exposed to moderately exposed lower eulittoral rock/*Laminaria digitata* on moderately exposed sublittoral fringe rock' (LR.HLR.FR.Coff/IR.MIR.KR.Ldig) usually emerged from the sublittoral, followed by a zone covered by seaweeds to a faunally dominated shore consisting of limpets, barnacles and littorinids. The littoral zone was separated into vertical zones up the shoreline, with six bands recorded at L1 and L3 (exposed shorelines) and five at L2 (within a sheltered gulley) as described in Table 9.9.

Table 9.9: Summary of Intertidal Reef Community Complex

Littoral Site	L1	L2	L3
General description	Gully sheltered by north-east stack. Typical exposed shore to wave action amplified by the effect of surge through the gully. Shading with reduced algal component.	Sheltered inlet protected from wave action.	South-east tip of the island partially separated from the main island by a connecting intertidal reef
Zone (i) supralittoral	Nitrate enriched LR.FLR.Lic.Pra	A typical lichen zone dominated by the nitrophilous yellow lichen *Xanthoria parietina* and the green algae *Prasiola stipitata* LR.FLR.Lic.Pra	Nitrate enriched LR.FLR.Lic.Pra *Prasiola stipitata*
Zone (ii) Upper shore	LR.HLR.MusB	Limpets, barnacles and littorinids found amongst the algae spiral wrack and channel wrack mixed to form an LR.MLR.BF.FspiB	Limpets and *Semibalanus balanoides* barnacles. LR.HLR.MusB
Zone (iii) Middle upper shore (barnacle zone)	Barnacles LR.HLR.MusB.Cht	*Ascophyllum nodosum* and *Fucus vesiculosus* LR.LLR.F.Asc.FS	Patchy canopy of the bladderless 'Bladder wrack' *Fucus vesiculosus*. LR.HLR.MusB.Cht
Zone (iv) Upper middle shore	Faunally dominated LR.HLR.MusB.Sem	Typical *Fucus serratus* and red seaweeds LR.MLR.BF.Fser.R	Faunally dominated LR.HLR.MusB.Sem
Zone (v) Lower middle shore	LR.HLR.FR.Mas		*Laminaria hyperborea* forest (with occasional *L. hyperborea*) with frequent patches of red algae dominated by coralline crusts. *Fucus serratus*, *Osmundea pinnatifida* and *Mastocarpus stellatus* LR.HLR.FR.Mas (v)
Zone (vi) Lower shore	Algae dominated LR.HLR.FR.Coff/IR.MIR.KR.Ldig	Algae dominated LR.HLR.FR.Coff/IR.MIR.KR.Ldig	Algae dominated LR.HLR.FR.Coff/IR.MIR.KR.Ldig

An example summary of the vertical habitat changes recorded in the littoral zones is listed in Table 9.10. Overall, intertidal habitat indicated faunal populations that were well represented and moderately diverse habitats containing many of the common species found along the Irish Sea coastline.

Table 9.10: Summary of Intertidal Reef Community Complex (L3) (BSL 2015b)

Littoral Zonation	Example Image
South-east tip of the island partially separated from the main island by a connecting intertidal reef	
Zone (i) Supralittoral upper shore LR.FLR.Lic.Pra *Prasiola stipitata* on nitrate-enriched supralittoral or littoral fringe rock.	
Zone (ii) Eulittoral upper shore LR.HLR.MusB Mussel and/or barnacle communities.	
Zone (iii) Eulittoral middle upper shore (barnacle zone) LR.HLR.MusB.Cht *Chthamalus* spp. on exposed upper eulittoral rock. Patchy canopy of the bladderless 'Bladder wrack' *Fucus vesiculosus*.	
Zone (iv) Eulittoral Upper middle shore LR.HLR.MusB.Sem *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock. Faunally dominated.	
Zone (v) Eulittoral lower shore LR.HLR.FR.Mas *Mastocarpus stellatus* and *Chondrus crispus* on very exposed to moderately exposed lower eulittoral rock. *Fucus serratus*, *Osmundea pinnatifida* and *Mastocarpus stellatus.*	

Littoral Zonation	Example Image
Zone (vi) Sublittoral fringe LR.HLR.FR.Coff/IR.MIR.KR.Ldig *Corallina officinalis* on exposed to moderately exposed lower eulittoral rock/*Laminaria digitata* on moderately exposed sublittoral fringe bedrock. Algae dominated *Laminaria digitata* forest (with occasional *L. hyperborea*) with frequent patches of red algae dominated by coralline crusts.	

Subtidal Reef Community Complex

This reef community complex is recorded off the northern, eastern and southern shores of Ireland's Eye immediately south of the proposed outfall pipeline route (marine section) and the proposed marine diffuser location. The substrate ranges from that of flat and sloping bedrock, to bedrock with boulders and also a mosaic of cobbles and boulders. Vertical rock walls occur on the north and east of Ireland's Eye, whilst the northern reaches of the island show both sediment scouring and a thin veneer of silt covering the reef. In general, previous surveys (MERC 2010; 2012a; 2012b) noted that where the reef was subjected to the effects of sediment, either through scouring or settlement of silt, low numbers of species and individuals occurred, although these observations were based on extremely limited site investigation works with only a couple of drop-down video sites acquired.

As with the intertidal surveys noted above, a detailed assessment of the subtidal reefs was carried out in 2015, although this operation was carried out in two separate phases. In May 2015, Ireland's Eye was surveyed at nine locations using a specialist drop-down camera system (BSL 2015a). The positions of these sites are shown in Diagram 9.3. This survey infilled some missing bathymetry close to Ireland's Eye cliffs and provided targeting information for representative areas for a second, more detailed, survey. This more detailed assessment was carried out using a scientific dive team at four locations on the northern and eastern sides of the island in June/July 2015 (BSL 2015b). Sites were selected using the earlier video system looking for representative examples based on transects at the base of the reef structure up to the eulittoral zone. Each biological zone was photographed and surveyed. The floral and faunal taxa were identified and abundance scale values allocated using the SACFOR protocol on all the conspicuous species in each biotope encountered. As recorded by the earlier MERC projects, the sublittoral reefs were all found to be heavily silted, but were moderately diverse.

This survey collected semi-quantitative data from four dive locations, with two sites located beneath the steep cliff face of the northern coast (S1 and S2), and two located adjacent to the rocky shorelines in the south-east of the island (S3 and S4). The sublittoral stations were characterised by *Laminaria digitata* forests in the shallower part (IR.MIR.KR.Ldig.Ldig) and were usually replaced by the biotope 'Foliose red seaweeds with dense *Dictyota dichotoma* and/or *Dictyopteris membranacea* on exposed lower infralittoral rock' (IR.HIR.KFaR.FoR.Dic). The deeper extent was dominated by a 'Mixed turf of bryozoans and erect sponges with *Sagartia elegans* on tide-swept circalittoral rock' (CR.HCR.XFa.ByErSp.Sag) or, in the case of Sublittoral S2, 'Flustra foliacea and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock' (CR.HCR.XFa.FluCoAs). The deeper biotope at Sublittoral S4 was categorised as a possible '*Polyclinum aurantium* and *Flustra foliacea* on sand scoured tide-swept moderately wave-exposed circalittoral rock' (HCR.XFa.FluCoAs.Paur), probably due to the increased sedimentation noted at these stations. The maximum depths surveyed for each site was between 10.5m and 14m below mean sea level. An example summary of the vertical habitat changes recorded in the sublittoral zones is listed in Table 9.11.

Table 9.11: Summary of Subtidal Reef Community Complex (S2) (BSL 2015b)

Sublittoral Zonation	Example Image	
These stations were situated along the north coast of the island and showed significant evidence of a heavy silt burden. The deeper sediment plains gave way to a steeply inclined reef at a depth of approximately 15.5m Ordnance Datum Malin (ODM). The reef was initially broken, with deposits of muddy gravel lying between boulders and outcrops of sloping bedrock.		
Zone (i) Infralittoral upper shore IR.MIR.KR.Ldig.Ldig *Laminaria digitata* on moderately exposed sublittoral fringe bedrock Stunted *Laminaria digitata* kelp plants, with several other foliose red algae, such as *Palmaria palmata* and *Delesseria sanguinea*. Beneath these algae, crusts of mussels and barnacles predated by the common starfish *Asterias rubens*.		
Zone (ii) Infralittoral rock approx. 6m to 8.5m IR.HIR.KFaR.FoR.Dic Foliose red seaweeds with dense *Dictyota dichotoma* and/or *Dictyopteris membranacea* on exposed lower infralittoral rock Algal species were *Rhodymenia holmesii, Sphondylothamnion multifidum* and *Apoglossum ruscifolium* amongst the sward. Fish observed were ling (*Molva molva*), the black goby (*Gobius niger*) and greater pipefish (*Syngnathus acus*).		
Zone (iii) Circalittoral ca. 10-15.5 m **CR.HCR.XFa.FluCoAs** *Flustra foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock**.** The biotope on these outcrops was dominated by the bryozoans *Flustra foliacea, Scrupocellaria* sp. and *Bugula flabellata* **CR.HCR.XFa.ByErSp.Sag** Mixed turf of bryozoans and erect sponges with *Sagartia elegans* on tide-swept circalittoral rock Other sub-dominant taxa were feather-star *Antedon bifida*; plumose anemone *Metridium dianthus* and *Sagartia elegans* and *Urticina feline*; barnacle *Balanus crenatus*; soft coral *Alcyonium digitatum*; frequent erect sponges *Hymeniacidon perlevis, Amphilectus fucorum* and *Haliclona simulans*; the hydroids *Nemertesia antennina* and *Obelia dichotoma*; as well as the tunicate *Clavelina lepadiformis*.	 	 

Univariate analyses showed clear differences between the littoral and sublittoral stations in terms of species richness, with twice as many species recorded from the sublittoral area (88.3±19.2SD as opposed to 44.7±11.6SD). Both littoral and sublittoral environments indicated moderately high species diversity. Multivariate analyses revealed statistical separation of biotopes with the vertical zonation of the fauna (by water depth or height on the foreshore) constituting the dominant community patterns observed. A comparison of the species composition for both littoral and sublittoral stations around Ireland's Eye indicates the consistency of the flora and fauna at the different survey sites (Diagram 9.4).

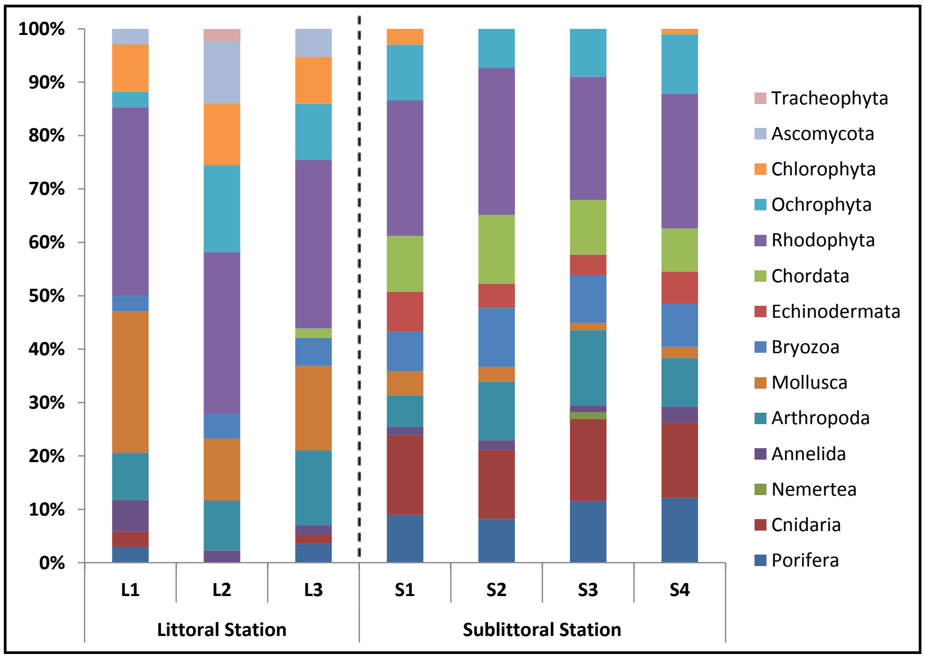

Diagram 9.4: Distribution of Species per Phyla and Station on Ireland's Eye (BSL 2015b)

No species of particular nature conservation interest were noted during any of the surveys and no rare or particularly fragile biotopes were recorded. However, natural siltation levels were high in the sublittoral environment, a fact that has not appeared to have had a significant impact on the biological diversity in this area.

9.3.5 Water Quality Profiling, Sampling and Plankton

Water Quality Profiling (Vertical Profile)

A detailed discussion on water quality for the area, along with the impact from the Proposed Project, is covered in Chapter 8 Marine Water Quality. A summary of key water quality aspects has, however, been discussed below to place this into the context of the marine ecology and the parameters recorded during the benthic surveys.

The status of coastal waters is assessed using the EPA Trophic Status Assessment Scheme. This assessment is required for Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment (Urban Waste Water Treatment Directive) and Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (Nitrates Directive). The scheme compares the compliance of individual parameters against a set of criteria indicative of trophic status. Currently, the EPA reports that the north-western Irish Sea and Dublin Bay (HA 09) are unpolluted whilst Malahide Bay has a potentially eutrophic status based from 2007–2012 monitoring. Potentially eutrophic water bodies are those in which criteria in two of the categories are breached and the third falls within 15% of the relevant threshold value.

Rogerstown and Baldoyle estuaries were both categorised as eutrophic between 2010 and 2012. Whilst Baldoyle was not surveyed between 2007 and 2009, Rogerstown was recorded as intermediate during the earlier surveys and has shown a slight deterioration. Malahide Bay has improved in water quality from potentially eutrophic to unpolluted since an earlier failure to comply with the environmental quality standard for dissolved inorganic nitrogen (DIN). Previously, the deterioration in status in Malahide Bay was due to the presence of green opportunistic macroalgae, which were previously observed in these areas during earlier assessments but had not been formally assessed (EPA 2010).

In addition to nutrient enrichment, other pressures such as hazardous substances and morphological alterations can also impact on the quality of aquatic systems (EPA 2015). Under Directive 2000/60/EC of 23 October 2000 of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (Water Framework Directive), these additional pressures, along with nutrient enrichment, must be addressed. In the Directive, biological indicators are used to assess the ecological status of transitional and coastal waters. Classification schemes have been developed that use the characteristics of different biological communities, together with information on the physico-chemical environment to define ecological status.

According to the EPA's (2017) Water Quality in Ireland, the ecological status of the transitional waters of the north-western Irish Sea is good and Malahide Bay moderate, whilst the proposed outfall pipeline route (marine section) location is classified as undetermined (but previously recorded as good (EPA 2015)). Ecological status is assessed on a 'one-out-all-out' basis. Overall ecological status of a water body is based on the biological quality element or physico-chemical standard with the lowest status. For example, if all the elements in a particular water body are at or near reference conditions, then the status of the water body is considered to be high. However, if any single biological quality element or chemical parameter is of lesser status, then classification is based on that element. Malahide Bay was one of 102 transitional and coastal areas assessed by the EPA, Marine Institute and IFI between 2007 and 2012 for Water Framework Directive status classification, using the biological quality and physico-chemical elements listed above.

Water quality measurements were undertaken at four locations within the bay as part of the benthic survey operations in the summer of 2012 and repeated again in the winter of the same year. Further sampling was carried out at the proposed outfall in 2017. The position of these sites is shown in Figure 9.1 Summary of Field Survey Operations for the Proposed Outfall Pipeline Route (Marine Section). A summary of the profiled results is outlined in Table 9.12.

Four locations were chosen for profiling deployments within the regional survey area, namely the proposed marine diffuser location (Station 7), the offshore reference (Station 1), the southern extremes based on a full tidal excursion from the proposed outfall pipeline route (marine section) location and a site located at the mouth of Malahide Estuary (Station 24). The proposed outfall pipeline route (marine section) was sampled twice in each seasonal period with a separation of approximately six hours between deployments so as to sample different tidal states. Overall, data showed very little variation between sites. Most data extremes were recorded at the reference location 11km offshore from the mainland (4km from Lambay Island) and in approximately 35m of water. These data showed that a small thermocline of approximately 1.5°C and around 15m depth was apparent at this site: warmer during the summer, cooler during winter. There was also a corresponding increase in salinity with depth at the same point. Water quality at the proposed marine diffuser location was repeated for high and low water tide periods in 2017.

Table 9.12: Water Profiling Results Summer and Winter (2012 and 2017) (Red Denotes Highest Value, Whilst Blue Denotes the Lowest)

Summer (2 August to 5 August 2012)		Temp (°C)		Salinity (PSU)		Turbidity (NTU)		pH		O² (%Sat)	
Location	Tide (HW)	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
ENV_007	+1.5hrs	14.88	14.98	33.96	33.98	-0.1	2.1	8.05	8.07	99.1	101.4
ENV_007	+6.5hrs	14.88	15.01	33.93	33.96	-0.1	0.2	8	8.01	99.7	101.4
ENV_001	+5hrs	15.09	15.15	33.92	33.96	0.1	5	8.02	8.03	98.7	100.5
ENV_024	-4hrs	15.15	15.16	33.81	33.83	2	4.3	8.05	8.05	98.1	98.9
REF_001	+1.75hr	13.87	15.27	33.97	34.34	-0.4	3.5	7.95	8.02	97.5	104.2
Mean		**14.8**	**15.1**	**33.9**	**34.0**	**0.3**	**3.0**	**8.0**	**8.0**	**98.6**	**101.3**
Winter (11 December 2012)		**Temp (°C)**		**Salinity (PSU)**		**Turbidity (NTU)**		**pH**		**O² (%Sat)**	
Location	**Tide (HW)**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
ENV_007	HW	7.59	7.61	34.52	34.55	2	8.3	7.88	7.89	99.1	102.8
ENV_007	+7hrs	7.29	7.34	34.51	34.54	2.6	10.3	7.96	7.98	98.5	102.4
ENV_001	-1hr	7.69	7.72	34.23	34.27	2.2	7.2	7.70	7.82	99.1	103.7
ENV_024	+6hrs	6.73	7.4	34.04	34.5	2.0	3.0	7.95	7.98	99.4	102.2
REF_001	+2.5hrs	7.74	9.14	34.53	35.07	-0.6	0.1	7.95	7.98	98.6	103.5
Mean		**7.41**	**7.84**	**34.37**	**34.59**	**1.64**	**5.78**	**7.89**	**7.93**	**98.94**	**102.9**
Summer (9 August 2017)		**Temp (°C)**		**Salinity (PSU)**		**Turbidity (NTU)**		**pH**		**O² (%Sat)**	
Location	**Tide (HW)**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
ENV_007	HW	15.28	15.46	34.25	34.32	0.0	2.6	7.09	7.22	99.0	101.9
ENV_007	LW	14.41	15.01	34.28	34.41	0.0	1.3	7.06	7.28	97.7	99.7
Mean		**14.85**	**15.24**	**34.27**	**34.37**	**0**	**1.95**	**7.075**	**7.25**	**98.35**	**100.8**

Water Quality Sampling

In addition to water quality profiling, discrete samples of water were sampled at three depths and at two locations at the proposed marine diffuser and a control site east of Lambay Island in 2012 and again over the proposed marine diffuser location in 2017. These were analysed for the range of parameters, including nutrients, heavy metals and hydrocarbons and are summarised in Table 9.13.

Results showed that a number of parameters were undetectable within the samples, including the metals cadmium, mercury and barium, the nutrients nitrite and phosphorus, TPH or chlorophyll A. For the remainder of the results, total and dissolved organic carbons (TOC and DOC) recorded significantly higher concentrations in the summer, whilst the reverse was recorded for total silicon and nitrates. Metals indicated no pattern of distribution, although an inexplicably high concentration was recorded for chromium and nickel at the reference stations for the summer sample at 20m.

Table 9.13: Water Quality Variations in 2012 and 2017(µg/l)

Station	Ref1 (2012)			Station 7 (2012)			Station 7 (2017)		
Depth (m)	0	20	40	1	7	20	1	7	20
Ni (Total)	2–3	4–58	3	3	2–3	3	-	-	-
Cr (Total)	<1–1	<1–153	<1–1	1	1	1	-	-	-
Cd (Total)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-
Cu (Total)	4	5–8	5-6	6–7	5	5–7	-	-	-
Pb (Total)	<1	<1	<1–2	<1–1	<1	<1	-	-	-
Zn (Total)	9	10–16	11–13	18–19	11–12	11–13	-	-	-
As (Total)	10–17	11–26	12–28	<0.112	12	11–18	-	-	-
Hg (Total)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-
Ba (Total)	<10	<10	<10	<10–10	<10	<10	-	-	-
*SO4 (Dissolved)	2,840–3,100	2,910–3,250	2,990–3,250	2,760–2,770	2,740–2,990	2,720–2,820	2,170–2,500	2,190–2,550	2,080–2,160
Nitrite as N	<10	<10	<10	<10	<10	<10	<10	<10	<10
Nitrate as N	300–400	<200–400	<200	<200–200	<200–200	<200	<200	<200	<200
Si (Total)	100–600	<100–400	300–400	200–600	200–800	300–900	-	-	-
Phosphorus	<100	<100	<100	<100	<100	<100	<10–10	<10–10	<10
TOC	200–580	<200–540	<200–520	<200–530	<200–540	<200–610	<200	<200–220	<200
TPH Gas Chromotography	<10	<10	<10	<10	<10–10	<10	-	-	-
DOC	290–520	240–530	220–500	230–520	250–500	220–450			
Chlorophyll A	<10	-	-	<10	-	-	<10	<10	<10

*milligrams/litre (mg/l)

Zooplankton

Semi-quantitative samples of large zooplankton were taken during the benthic sampling campaign in 2012, both summer and winter (>250µm) and again in 2017 over high and low water periods. Samples were acquired using a vertical tow technique where a trawl net is hauled vertically from the seabed to the surface and the complete water sample rinsed and fixed in 4% formalin prior to the taxonomy and enumeration in the laboratory. Samples here were processed at Plymouth Marine Laboratory. The results are given in Appendix A9.1.

Sample results showed the presence of zooplankton all year round, although the major contributors (such as the decapods and copepods) were more abundant in the summer months. The reference station indicated much greater numbers in the summer (at 681 individuals per m^3) than recorded at the proposed outfall pipeline route (marine section) location (maximum of 57ind/m^3 in the summer and 99.8ind/m^3 in the winter 2012). This is interpreted as a result of the deeper water-depth recorded at the reference site, with the majority of zooplankton species recorded in deeper waters during daylight hours where they are less prone to predation. Data from 2017 at the proposed marine diffuser location indicated a higher abundance than the same site in 2012, increasing from

365 to 408ind/m^3 between high and low water periods. The most dominant species were consistently the copepods *Acartia clausi*, *Centropages hamatus* and *Temora longicornis* between survey years, although up to 27 different species were recorded in each of the samples overall.

9.3.6 Baldoyle Estuary Walkover

Previous Survey Data

Fingal County Council commissioned a survey of coastal habitats in the county in 2004 (Ecoserve 2005). Phase I of the study involved the mapping of all coastal habitats within the county. Phase II of the survey involved a study of the coastal vegetation communities within the county boundaries. Rare, threatened or legally protected flora were also recorded. The Baldoyle Estuary was surveyed as part of the Portmarnock area.

The Baldoyle Estuary was further surveyed over several days in June 2006 as part of a national saltmarsh monitoring project commissioned by NPWS. The survey developed a monitoring methodology based on the Joint Nature Conservation Committee guidelines for saltmarshes, which was based on vegetation surveys and assessments of threats and management practices and adapted for Irish saltmarsh habitats.

A detailed habitat map for the site and descriptions of the Annex I habitats present were outlined in the NPWS Saltmarsh Monitoring Project report (McCorry and Ryle 2009). The habitat map showing the distribution and extent of Annex I habitats produced are presented below in Diagram 9.5.

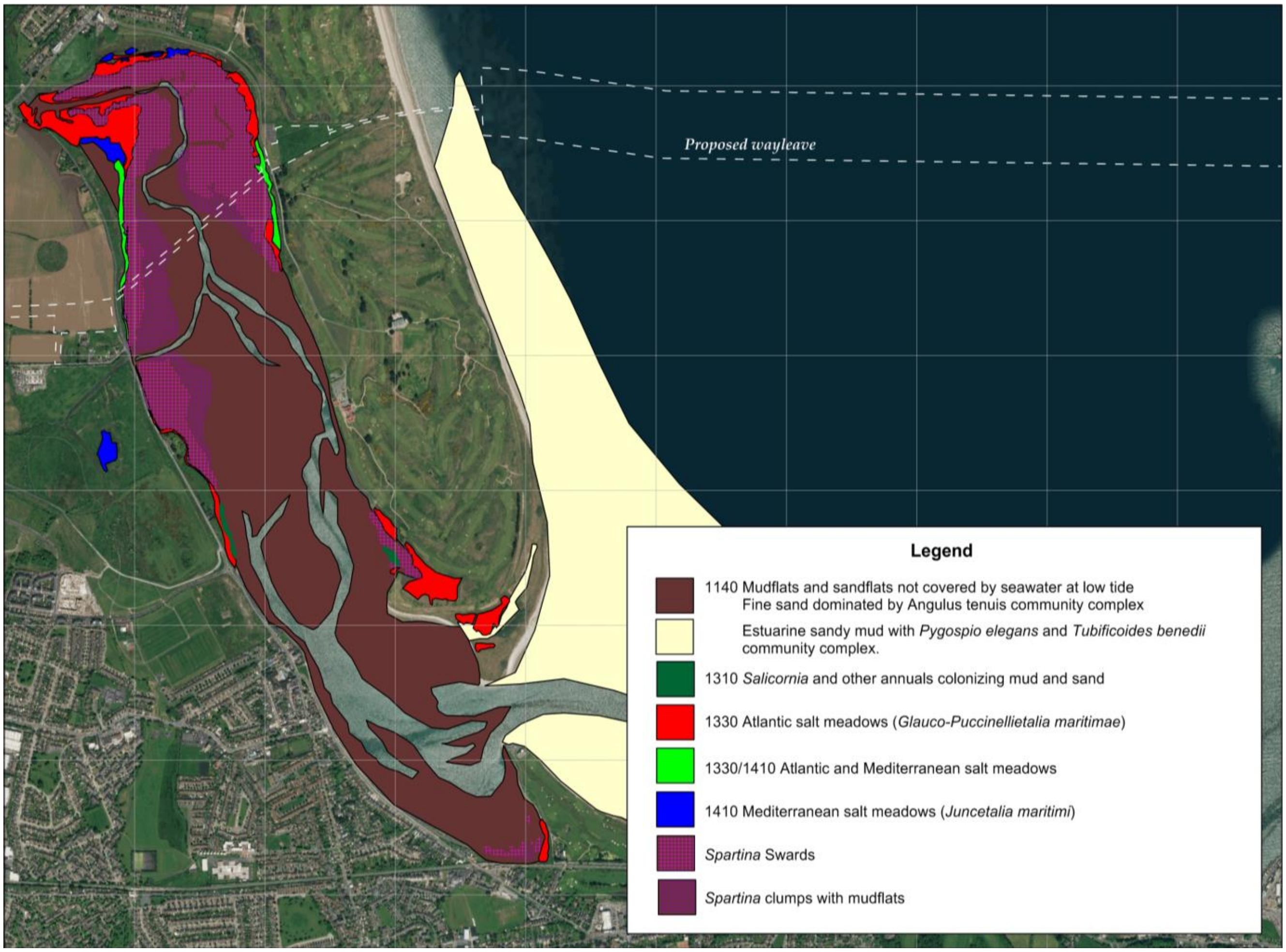

Diagram 9.5: Habitat Map of the Annex I Habitats of Baldoyle Estuary Prepared by McCorry and Ryle (2009).

The full descriptions for these Annex I habitats within the site, described by McCorry and Ryle along with the earlier worked commissioned by Fingal County Council in 2004, are outlined in Appendix A9.1.

Overall, the site was deemed by McCorry and Ryle to be in favourable conservation status.

The site was further visited in November 2013 and the habitat mapping and descriptions prepared by McCorry and Ryle (2009) were reviewed in the field in relation to the current conditions at the site and the proposed outfall pipeline route (marine section). The GIS shapefiles prepared by McCorry and Ryle (2009) were used in the field in conjunction with aerial photographs. This allowed for an accurate assessment in the field of the extent of habitat types as previously described and mapped and to document any changes in them. A photographic record of the habitats recorded was also made and geo-tagged. A selection of site photographs is presented in Appendix A9.1.

Proposed Outfall Pipeline Route (Marine Section) – Eastern Side

The eastern section of the proposed outfall pipeline route (marine section) crosses an area of the estuary near the public car park for the Portmarnock Beach and dune system/entrance to Portmarnock Golf Club. At this side of the estuary, the proposed outfall pipeline route (marine section) crosses a grassy embankment, which is mown and maintained by Fingal County Council, adjoining the public road, before reaching a band 20m to 30m wide in places of a mosaic of Atlantic salt meadows and Mediterranean salt meadows. To the north of the proposed outfall pipeline route (marine section) is an area of Atlantic salt meadow. These areas grade into extensive swards of *Spartina*, which extend towards the centre of the estuary where they become broken up and form a mosaic of clumps of *Spartina* and mudflats.

At the upper extent of the saltmarsh, the vegetation is dominated by creeping bent grass (*Agrostis stolonifera*), with occasional sea beet (*Beta maritima*), sea rush (*Juncus maritimus*), red fescue (*Festuca rubra*), sea purslane (*Halimione portulacoides*), common scurvy grass (*Cochlearia officinalis*) and sea pink (*Armeria maritima*).

These grade into an area of middle marsh with occasional pans and creeks which are dominated by sea pink, sea plantain (*Plantago maritima*), lax-flowered sea lavender (*Limonium humile*) and sea aster (*Aster tripolium*) with occasional stands of saltmeadow rush (*Juncus gerardii*) and sea rush, whilst areas with higher inundation of the tide (lower marsh) contain sea arrow grass (*Triglochin maritima*), common scurvy grass and sea purslane. This then grades into areas of dense stands of common cordgrass (*Spartina anglica*) which dominate the mudflats and creeks with occasional *Enteromorpha*.

North of the main crossing point for the proposed outfall pipeline route (marine section) is an area with better defined pans and creeks that more closely approximates pure Atlantic salt meadows, and a stand of common reed (*Phragmites australis*) is present near where the road turns back to the west.

Proposed Outfall Pipeline Route (Marine Section) – Western Side

The western section of the proposed outfall pipeline route (marine section) crosses an area of the estuary near the Mayne River. The western side contains a much narrower band of saltmarsh vegetation, which is backed by an area of rank grassland adjoining the road. Species recorded here include creeping bent, thistles (*Cirsium arvense* and *Cirsium vulgaris*), docks (*Rumex* sp.), tall fescue (*Festuca arundinacea*), bush vetch (*Vicia sepium*), nettle (*Urtica dioica*) and common comfrey (*Symphytum officinale*). Below this is a narrow band of a mosaic of Atlantic salt meadows and Mediterranean salt meadows, which is no more than 1m to 4m wide. The main species recorded here include sea beet, sea purslane and sea arrowgrass interspersed with stands of common cordgrass. These become more dominant, forming a *Spartina* sward for approximately 30m to 40m before breaking up into a mosaic of clumps of *Spartina* and open mudflats.

The band of saltmarsh vegetation tapers off to the south towards the Mayne River, and occasional sparse patches of sea aster, common scurvy grass, glasswort (*Salicornia* sp.) and common cordgrass are present on the open muds. Backing this is a stone wall with scattered sea aster, lax-flowered sea lavender, sea arrowgrass and sea beet.

Overall, the habitats at Baldoyle Estuary do not appear to have undergone any significant changes in quality or extent at the proposed outfall pipeline route (marine section) since the 2006 surveys conducted by NPWS. The boundaries of the Annex I habitats as mapped by McCorry and Ryle have not changed significantly since that time, and the vegetation composition at the proposed outfall pipeline route (marine section) appears to have remained broadly similar.

Some of the species recorded in the earlier 2004 surveys by Doogue et al., such as *Atriplex portulacoides*, *Juncus gerardii* and *Oenanthe lachenalii*, were not encountered along the proposed outfall pipeline route (marine section) but may be present further north within the estuary where a greater extent of saltmarsh vegetation is present.

9.3.7 Marine Mammals

The IWDG operates an all-Ireland database of casual cetacean sightings (IWDG 2011a) and strandings. Since 2001, regular monthly effort-related surveys from land based stations have been included in the IWDG database. All records are validated and available on www.iwdg.ie. Whilst there have been very occasional records of either large baleen cetacean species, such as the humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*), as well as the orca toothed whale (Odontoceti*; Orcinus orca*), in the Dublin inshore area, these larger whales are rare. A review of the IWDG casual sightings database, showing over 1,400 records over the past 15 years, has revealed that only two species of cetacean are likely to occur within the proposed outfall pipeline route (marine section) on a regular basis and all year round. These are the harbour porpoise (*Phocoena phocoena*) and the bottlenose dolphin (*Tursiops truncatus*) representing 71% and 15.4% of all cetacean sightings recorded, respectively. This equates to a mean monthly observation of approximately 10 casual sightings (30 individuals), for the harbour porpoise or eight sightings (22 individuals) for the bottlenose dolphin. Other rare but regular species recorded in the area are the minke whale (*Balaenoptera acutorostrata*), equivalent to around five observations per year, and the common dolphin (*Delphinus delphis*), equivalent to at least one observation per year. However, as approximately 6.5% of all database sightings included unidentified cetacean species, further species or increased frequency of these identified species are expected to be greater than recorded here. A summary of the possible cetaceans expected to be present within the area of the Proposed Project is listed in Table 9.14.

Table 9.14: Cetacean observations in the Dublin Geographical Area (IWDG 1970-2013)

<table>
<tr><th>Species</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="2">Harbour porpoise</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Ireland’s only common porpoise species, the harbour porpoise is frequently recorded around the entire Irish coast. There are many locations where they can be observed all year round in the Dublin geographical area (constituted 71% of all cetacean sightings for this area on the IWDG database). They are most commonly sighted from June through to the autumn/winter, but reduced encounter rates from well-watched sites suggest they move offshore in spring between March and June for calving/breeding. They breed in Irish waters.</td></tr>
<tr><td rowspan="2">Bottlenose dolphin</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Found in all Irish coastal waters and the second most frequently recorded dolphin species in Ireland, but the most common dolphin recorded in the Dublin geographical area, constituting 15.5% of cetacean observations. Peak occurrences were in June and December. They occur inshore around all Irish coasts with semi-resident groups historically reported in the south and south-west. They also occur offshore in the Celtic Sea and in the Irish Sea. They are present year round and breed in Irish waters. Inshore and offshore ecotypes may exist.</td></tr>
<tr><td rowspan="2">Common dolphin</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Present in the Celtic and Irish Sea, predominantly in the summer and early autumn (Reid et al. 2003). The most frequently recorded dolphin species in Irish waters overall but uncommon in the Dublin geographical area, recording only 0.9% of all cetacean sightings on the IWDG database. Typically recorded in mixed group sizes in the summer months, equivalent to a few sightings each year. Most abundant on the continental shelf and breeding along the south and south-west coasts of Ireland.</td></tr>
</table>

<table>
<tr><th>Species</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="2">Risso's dolphin</td><td></td><td></td><td></td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">This is a continental shelf species which appears to prefer deep offshore waters but on occasion can be seen regularly close inshore around the Irish coast. Sightings and strandings concentrated on the west and south-west coast and occasional sightings in the Irish Sea. Previously sighted only twice in the Dublin geographical area on the IWDG database. They are found year round in Irish waters, perhaps moving inshore in the summer months. Breeds in Irish waters.</td></tr>
<tr><td rowspan="2">Orca whale</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td></tr>
<tr><td colspan="12">This is a continental shelf species which can be recorded briefly in travelling groups in shallow inshore waters off all coasts and in the Irish Sea. The IWDG database has recorded four sightings for Dublin geographical area. Observed inshore sightings tend to increase during late summer and autumn (Berrow et al. 2010).</td></tr>
<tr><td rowspan="2">Minke whale</td><td></td><td></td><td></td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td></td><td></td><td></td></tr>
<tr><td colspan="12">The minke whale is the most common baleen whale recorded in the Dublin geographical area, corresponding to 3.9% of all cetacean sightings on the IWDG database. Observations are typically in the summer months between April and September.</td></tr>
<tr><td rowspan="2">Fin whale</td><td></td><td></td><td></td><td></td><td>Present</td><td>Present</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">The fin whale is the most commonly recorded baleen whale recorded in Irish waters. However, most sightings are recorded along the south coast, observed in shallow waters from headlands. Only three records (0.1% of cetacean sightings) were made in the Dublin geographical area. All were in June, but sightings in the Celtic Sea suggest that this species moves to inshore waters in early summer between May and June.</td></tr>
<tr><td rowspan="2">Humpback whale</td><td></td><td></td><td></td><td>Present</td><td>Present</td><td>Present</td><td>Present</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">With a similar distribution to that of the fin whale, this deep water species is generally found in the west coast of Irish waters. IWDG database has recorded five sightings of this species (0.4% of all cetacean sightings)</td></tr>
<tr><td>Key</td><td colspan="6">Absent</td><td colspan="6">Present</td></tr>
</table>

The diet of cetaceans is an important factor in determining their distribution and seasonality at certain locations around Ireland. Whilst larger baleen whales are typically recorded in the deeper waters of the south and west coast, the toothed cetaceans, which primarily feed on fish and squid, are far more common in the shallower inshore waters and are likely to be encountered within the Proposed Project area. The distribution of toothed whales can also vary with water depth, and for some species, there may be some seasonal variation due to foraging habits (Wall et al. 2006). Harbour porpoise (*P. phocoena*) feed on pelagic fish such as herring, and have been found in areas associated with herring spawning. Many dolphins show seasonal movements into shallow coastal waters, which may coincide with calving or inshore feeding (Boelens et al. 1999).

Protection for Cetaceans

Ireland is a signatory to conservation-orientated agreements under:

- The Berne Convention on Conservation of European Wildlife and Natural Habitats (1982);
- The Bonn Convention on Migratory Species (1983);
- The OSPAR Convention for the Protection of the Marine Environment of the north-east Atlantic (1992); and
- The Habitats Directive.

All cetacean species occurring in European waters are now afforded protection as Annex IV species under the Habitats Directive. Two common species, bottlenose dolphin and harbour porpoise, are Annex II species (i.e. animal species of community interest, whose conservation requires the designation of SACs) (see Section 9.3.1).

In 1991, the Irish government declared all Irish waters extending to the outer continental shelf a whale and dolphin sanctuary, claiming that this was a '*clear indication of Ireland's commitment to contribute to the* *preservation and protection of these magnificent creatures in their natural environment, and to do everything possible to ensure they should not be put in danger of extinction but should be preserved for future generations*' (Rogan and Berrow 1995). According to the declaration, the sanctuary was empowered under the legal framework already in place, which suggested that the Irish government considered the present legislation to be sufficient to provide full habitat protection to cetaceans within the continental shelf area.

The harbour porpoise is a qualifying interest for the conservation objective of the Rockabill to Dalkey Island SAC (Site Code: 003000) within which the proposed outfall pipeline route (marine section) terminates.

Toothed Whales and Dolphins

The harbour porpoise (*Phocoena phocoena*) is the smallest cetacean in Irish waters (IWDG 2010) and the most abundant and widespread cetacean species occurring all around the Irish coast. They have a varied diet of herring, mackerel, sprat, pollack, hake, sardine and sandeel; squid and octopus may also be eaten. As they feed predominantly on pelagic fish, they are rarely found over deep water. The population estimate for the Irish Sea is 15,230 (SCANS-II 2008). Sightings are common from June through the autumn/winter, but reduced encounter rates from well-watched sites such as Howth Head, Dublin, suggest they move offshore in spring between March and June (IWDG 2010). Where they go is unknown, but the fact that encounter rates increase in June, when calves are first recorded, suggests they move to offshore calving/breeding grounds. Casual sightings of this species are both numerous and regular and several attempts in estimating the density and local abundance have been carried out by the IWDG. A summary of the survey areas and the locations of casual sightings is shown in Figure 9.4 Casual Sightings and Dedicated Surveys of the Harbour Porpoise. Vessel based transit surveys were carried out in both years in conjunction with some acoustic techniques (T-POD in 2008 and towed hydrophones in 2011) with observations made from the vessel transiting on a set transect (Berrow et al. 2008; 2011). Results from the earlier survey calculated an estimated abundance of just over two individuals per km^2 in the northern Dublin area and 1.19 individuals per km^2 in a similar area in Dublin Bay. The later study was undertaken in July and covered a much larger area further offshore and to the south of Dublin. This estimated an abundance of 1.58 individuals per km^2 for the offshore site, and estimated the total population to be around 1,800 individuals for this area.

The Rockabill to Dalkey Island SAC (Site Code: 003000) was established off the Dublin coastline in April 2013 with a key designation for Annex II species harbour porpoise. The occurrence of harbour porpoise within the prescribed marine area was estimated using earlier visual observation and passive acoustic methods to estimate population size, density and distribution. However, the community structure, distribution or habitat use by the harbour porpoise within the SAC is not fully understood. A visual and passive acoustic monitoring survey of harbour porpoise was carried out in the summer of 2013 at the Rockabill to Dalkey Island SAC by Berrow and O'Brien (2013) in order to derive local density and abundance estimates. Operations were based on line-transect surveys over six days between July and October using observers and a towed hydrophone array. A combined total of 640km of track-line effort was carried out within the SAC, which recorded a total of 201 sightings (Figure 9.4 Casual Sightings and Dedicated Surveys of the Harbour Porpoise) comprising at least 292 individual harbour porpoise, a single minke whale (*Balaenoptera acutorostrata*) and two acoustic detections of dolphins in the absence of corresponding visual sightings. Sightings were made throughout the survey area, although lower numbers were recorded in Dublin bay, possibly due to high vessel activity recorded at the time of the survey. Observations included the sightings of juveniles and calves combined, making up approximately 7% of observations. The study assessed observations at different sea states and concluded that sightings were not statistically affected up to sea states of a Beaufort wind force of 2. The density of the population was estimated to be 400 individuals within the SAC, with average density varying from 1.13km^2 to 2.61km^2 and an overall average density of 1.44±0.09 porpoises per km^2. This is similar to that previously recorded in 2008.

In 2015, the IWDG and TechWorks Marine Limited were commissioned to carry out a detailed assessment of the nature of marine mammals near the proposed outfall pipeline route (marine section) location as well as monitoring within the SAC. A two-year baseline survey of marine mammals commenced in March 2015 at static acoustic recording sites along the proposed outfall pipeline route (marine section) north of Ireland's Eye and, additionally, at a single site offshore from Loughshinny for six months starting simultaneously. Three types of surveys were conducted relating to land based observations conducted from vantage points overlooking the study areas, boat based line transect surveys to estimate density and abundances of marine mammals over a larger area, and static acoustic monitoring using C-PODs which are designed to passively detect odontocete echolocation clicks on a continuous basis. The acoustic monitoring provides data when visual surveys are limited due to poor weather conditions or during night-time hours, whilst the boat and land based sightings are used to identify species, group details and behaviour. A summary of the survey effort and sampling locations, along with sighting of marine mammals throughout the survey program, is shown in Figure 9.4 Casual Sightings and Dedicated Surveys of the Harbour Porpoise and Appendix A9.2.

Land based monitoring was carried out monthly from 18 March 2015 until 11 March 2017. Just under 144 hours of monitoring was conducted over 23 independent surveys. Marine mammals were sighted on 100% of survey days, with harbour porpoise present on 83% of occasions and 167 sightings recorded made up of 293 animals. Sightings were made up of approximately 80% adults with the remainder juveniles and calves. The calves were only recorded between September 2015 and November 2015, and in August 2016. Sighting rates were calculated based on sightings and number of animals per hour of effort with porpoise sighting rates consistently higher during late summer and autumn (August 2015 - January 2015, and August 2016 - October 2016).

Eleven boat based marine mammal surveys were conducted from April 2015 to January 2017. Track-lines were staggered to provide good coverage of the site and to ensure all habitats were surveyed. Harbour porpoise were recorded on 100% of survey days with the greatest number of sightings recorded in November 2015 and August 2016. Group sizes also increased between August 2015 and November in 2015, and in August 2016. The lowest number of sightings were recorded in June 2015, June 2016 and December 2016. However, the sea state was higher during these surveys which would increase the likelihood of missed sightings; therefore, these results must be treated with caution. Calves were only recorded in August 2015, November 2015 and August 2016. Harbour porpoise sightings were regularly distributed across the study area. The average density of animals was greatest in the summer with both August 2015 and August 2016 recording the highest numbers at 1.91ind/km^2 and 2.29ind/km^2. This fell to between 0.61ind/km^2 and 0.89ind/km^2 between January and April (2015 to 2017).

Static acoustic monitoring was carried out at three sites close to the proposed outfall pipeline route (marine section) using C-PODs for a duration of 750 days (between March 2015 and March 2017). Detections were recorded 96% to 99% of days on average at each site with the daily detection positive minutes (DPM) ranging between 41.3DPM/day to 94.3DPM/day. Detections were categorised into the following categories:

- Season (spring, summer, autumn and winter);
- Diel cycle (day and night-time);
- Tidal state (ebb, flood, slack high, slack low); and
- Tidal phase (spring, neap).

The acoustic data demonstrated that all three sites monitored along the proposed outfall pipeline route (marine section) off Portmarnock were used consistently by harbour porpoise on a daily basis. However, presence was greater during autumn and winter, during hours of darkness and at slack high tides. When the data from Portmarnock are compared to Loughshinny data collected in 2015 (Meade et al. 2015), results were similar with autumn having the highest detections. However, only six months were monitored. The tidal cycle was not significant at Loughshinny in contrast to Portmarnock, where more detections were recorded during the spring tidal phase. Monitoring index at Loughshinny was high at 9.8%, while at Portmarnock values ranged between 2.8% and 6.6% across sites, suggesting Loughshinny is the most important site for harbour porpoise to be monitored throughout the Construction Phase of the Proposed Project.

Trends in the presence of harbour porpoise with diel cycle on the east coast of Ireland have been found to differ geographically, but they are consistently more active at night. The reasons for increased nocturnal activity are uncertain, but could be linked to an increase in prey abundance or activity in the absence of light, as suggested by Todd et al. (2009).

Overall, observations through all survey methods showed that harbour porpoise numbers increased in late summer during both 2015 and 2016, which coincided with the presence of calves and may be due to seasonally abundant food sources such as sprat, herring and *Trisopterus* and gadoid species. Reduced numbers were recorded during late spring/early summer, which may be associated with an offshore movement of this species before calving. The density estimate of harbour porpoise was high and emphasizes the importance of this site for this species, as these are some of the highest densities recorded in Ireland to date (Berrow et al. 2008; 2013; 2015).

Of the other species recorded, the common dolphin (*Delphinus delphis*) is the second most frequently recorded cetacean species in Irish waters (Reid et al. 2003), although it is not the most commonly sighted dolphin off the Fingal coast. Abundance estimates in the Irish Sea from the SCANS-II survey was 366. Between south-eastern Ireland and west Wales, abundance was estimated at 186 in 2004, 1,644 in 2005 and 2,166 in 2006 (Evans et al. 2007). Records from IWDG ferry surveys show a noticeable increase in their numbers in the Irish Sea in the summer and autumn (Berrow et al. 2010).

The bottlenose dolphin (*T. truncatus*) in Irish waters appears to have both a coastal and an offshore distribution (Reid et al. 2003). They are commonly sighted in the Irish Sea and there is a well-studied resident population in Cardigan Bay, Wales. Photo-identification studies suggest that there is a pan-coastal population of bottlenose dolphins which range long distances around all Irish coasts and to the UK (O'Brien et al. 2009). The SCANS-II surveys estimated abundances of 235 in the Irish Sea (SCANS-II 2008). This is the third most frequently recorded species in Irish waters (Berrow et al. 2010), and they have a year-round distribution with a peak between May and September (although this may be due to an increase in observers during these months).

Risso's dolphin (*Grampus griseus*) occur predominantly in shelf and coastal waters in Ireland. The south-east coast is one of the areas of highest abundance for this species. A breeding population appears to be present in the southern Irish Sea and the species is also regularly recorded around the Isle of Man (Berrow et al. 2010; Baines and Evans 2009). They have been recorded throughout the year in Irish waters with a wide distribution (Aecom and Metoc 2010) and there is some evidence of seasonal movements in the Irish Sea (Baines and Evans 2009). Risso's dolphin feed mainly on squid, cuttlefish and octopus, and small quantities of fish and co-operative foraging has often been observed.

The Orca whale (*O. orcinus*) has been observed off all Irish coasts and in the Irish Sea. Sightings occur predominantly in inshore coastal waters (Berrow et al. 2010). There is some evidence of increased sightings during late summer and autumn, with occasional incidences of killer whales entering harbours and estuaries.

The long-finned pilot whale (*Globicephala melas*) occurs predominantly in the deeper waters of the continental slopes and waters to the west of Ireland. The species breeds in Irish waters and groups have been infrequently recorded in shallower waters off the southern and south-western coasts of Ireland, and as far east as the English Channel (southern Irish Sea) (Berrow et al. 2010). This is not a species that is likely to occur within the proposed study area.

Baleen Whales

As noted above, the distribution of large baleen cetacean species in the Dublin inshore geographical area, such as the humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*), is very rare and unlikely. The smaller rare but regular baleen species recorded in the area are the minke whales (*Balaenoptera acutorostrata*), equivalent to around five observations per year (IWDG database).

The distribution of prey is an important factor in the distribution of baleen whales. They typically feed on krill and pelagic schooling fish species, and their distribution is often related to oceanographic features such as fronts, upwellings and associated areas in which prey availability is high. Some species also eat squid depending on the season. In the summer months, minke whales (*B. acutorostrata*), for example, feed mainly on fish in the inshore waters around the UK and Ireland (Pollock et al. 1997). The minke whale is the most widespread and frequently recorded baleen whale in Irish waters. They are present along all Irish coasts (Reid et al. 2003; Berrow et al. 2010) and sightings occur in the Irish Sea from May to July (IWDG 2011a). Minke whales have the most varied diet of all baleen whales, feeding on various small fish, including capelin, sandeel, herring and cod; they may also feed on small squid (IWDG 2011b). Minke whales have been stranded on every coastline in Ireland with the stranding incidence reflecting their distribution and temporal occurrence (IWDG 2011c).

Fin whales (*B. physalus*) are seasonally abundant in shelf edge waters to the west of Ireland and in shelf waters off the southern coast of Ireland. However, there have been rare sightings in the St. George's Channel (southern Irish Sea) and off Dublin (IWDG 2011a) between June and September. Fin whales have a varied diet, comprising fish species such as herring, mackerel, cod, sand lance, squid and capelin, but young whales may take small invertebrates like krill and copepods.

Humpback whales (*M. novaeangliae*) have been recorded in small numbers inshore off all coasts including the Irish Sea (Berrow et al. 2002). This species has been recorded in all months of the year and was sighted off the south-east coast in late 2010 and early 2011. It has also been recorded in St. George's Channel and the Irish Sea (IWDG 2011d).

Pinnipeds

There are two species of seal native to Irish waters, both of which are found within the proposed outfall pipeline route (marine section). These are the grey seal (*Halichoerus grypus*) and the smaller and slightly rarer harbour seal (also known as the common seal (*Phoca vitulina*)). Both species are listed as qualifying interests for the Lambay Island SAC (Site Code: 00204) located 9.3km north-east of the proposed outfall pipeline route (marine section) (including the proposed marine diffuser). Breeding sites exist for both species here, although the grey seal also has breeding sites on Ireland's Eye (approximately 1km south) and on Dalkey Island (approximately 14.9km south). Given the proximity and size of these populations, it is extremely likely that seals currently forage within and around the proposed discharge site.

The grey seal is present at the site throughout the year, including during its breeding (around August to December) and moulting seasons (around December to April). During the breeding season, the relationship between pup production and total population size is not well known. An estimated 56 pups were born in the Lambay Island SAC in 2005. The corresponding minimum population estimate for the site numbered between 196 and 252 grey seals of all ages. Harbour seal are also present on Lambay Island throughout the year, including during its breeding (around May to July) and moulting seasons (around August to September). A total of 31 harbour seal were recorded ashore within Lambay Island SAC in August 2003 during a national aerial survey for the species, while maximum counts of 38 to 47 harbour seal were recorded more recently during the moult season. The haul-out groups of harbour seals have tended historically to be found among inshore bays and islands, coves and estuaries (Lockley 1966; Summers 1980), particularly around the hours of lowest tide. The grey seal breeds on exposed rocky shores, on sand bars or in sea caves with ready access to deep water. Other haul-out areas for the grey seal are located on exposed rocky areas or steeply shelving sandbanks.

Results from the recent IWDG study revealed the presence of seal within the survey area. This survey clearly demonstrated that the area off Portmarnock is important for grey seals, which were recorded throughout the year in small numbers and distributed throughout the survey area. Peaks in sightings from Howth Head occurred during spring and autumn, coinciding with pupping and post-moult periods at the local well-known breeding and haul out sites at Lambay Island, Skerries and Ireland's Eye. In all, 260 sightings of grey seal were recorded during the survey totalling 325 animals. Sighting rates were more consistent over the survey period with the highest sightings in April 2015, although high numbers were also recorded in September 2015, January 2016 and October 2016. Group size also increased during this time. Grey seal was often recorded feeding within close proximity to the northern cliffs of Howth Head.

Otters

In addition to cetaceans and pinnipeds, the otter *Lutra lutra* may be found in shallow intertidal areas of the marine environment (such as estuaries), particularly during winter (Bailey and Rochford 2006). To the north of the proposed outfall pipeline route (marine section) area, the Boyne River (approximately 35km north of the proposed outfall pipeline route (marine section)) is designated as an SAC partly on the basis of the presence of otters. As such, otters may reasonably be expected to occur occasionally in the area. However, whilst this cannot be ruled out for the Baldoyle Estuary, they are unlikely to be found on the exposed sandy beaches of the Velvet Strand.

9.3.8 Fish and Shellfish

Regional Context

Inshore areas of the Irish Sea are generally characterised by sandy substrates where flatfish such as plaice (*Pleuronectes platessa*), dab (*Limanda limanda*) and sole (*Solea solea*) tend to predominate (Cefas 2007). Other common species are thought to include lesser weever (*Echiichthys vipera*), common dragonet (*Callionymus lyra*), tub gurnard (*Chelidonichthys lucerna*) and gobies (*Pomatoschistus* spp.) (Fishery Agencies 2005). Otter trawl survey data also indicate that higher abundances of species such as clupeids, haddock (*Melanogrammus aeglefinus*) and Norway pout (*Trisopterus esmarkii*) are found in the western Irish Sea than in the east (Ellis et al. 2002). Sampling within Dublin Bay revealed a generally sandy seabed, becoming coarser approximately 3km from the beach. This shallow environment will commonly support an array of demersal fish species (in particular flat fish) as well as ecologically and commercially important species such as sandeels and juvenile fish species avoiding deeper waters.

Baseline information regarding the fish and shellfish assemblage in the vicinity was collected through a scientific 2m beam trawl survey, a beach seine net survey and a common whelk survey in September 2015 and September 2017. Sampling was conducted at stations along and adjacent to the proposed outfall pipeline route (marine section), with single reference stations positioned 1km to the north of the proposed outfall pipeline route (marine section) in both the beam trawl and seine net surveys.

Finfish

The site-specific survey findings showed a total of 18 species recorded in the beam trawl survey, and nine species in the beach seine net survey. In both surveys, plaice represented the most abundant species, followed by sand goby (*Pomatoschistus minutus*). Greater abundances for both species were recorded in the seine nets than the trawls. Dab were found to be almost equally abundant in the trawl samples to sand goby, but were almost entirely absent from the seine net catches.

Using a combination of these methods, clupeids, specifically herring (*Clupea harengus*) and sprat (*Sprattus sprattus*), were abundant in the water column but are known to form dense spawning aggregations at the seabed. The presence of many small herring (5cm to 9cm) indicates a potential nursery area; juvenile herring are known to occupy shallow waters separate to the adults before moving into deeper waters after approximately two years (ICES 2006). This is supported by Ellis et al. (2012), who identified a high intensity herring nursery ground within approximately 8km of the proposed outfall pipeline route (marine section).

Landings Data

Beam trawl surveys conducted throughout the Irish Sea from 1993 to 2001 (Parker-Humphreys 2004) provide valuable information on the diversity and relative abundance of demersal fish species in the Malahide Bay area.

The most common species include:

- Commercial flatfish: plaice (*Pleuronectes platessa*), sole (*Solea solea*), dab (*Limanda limanda*) and lemon sole (*Microstomus kitt*);
- Commercial roundfish: cod (*Gadus morhua*) and whiting (*Merlangius merlangus*);
- Monkfish (*Lophius piscatorius*);
- Elasmobranchs (sharks and rays): lesser-spotted dogfish (*Scyliorhinus canicula*), thornback ray (*Raja clavata*) and spotted ray (*Raja montagui*); and
- Non-commercial fish: poor cod (*Trisopterus minutus*), bib (*T. luscus*), scaldfish (*Arnoglossus laterna*), common dragonet (*Callionymus lyra*), gurnards (*Triglidae* sp.), pogge (*Agonus cataphractus*) and lesser weever (*Echiichthys vipera*).

Landings registered with the ICES in the Dublin Bay area recorded an average of 3.79 tonnes of demersal fish, 0.12 tonnes of pelagic fish and 9 tonnes of shellfish for this stretch of coastline between Wicklow and Lambay Island between 2006 and 2008 (Marine Institute 2010). Overall, the demersal fishery is dominated by shellfish. This is partially due to the extended areas of hard ground recorded within the survey area.

Species with Defined Spawning and Nursery Grounds

A number of fish species have defined spawning and nursery grounds within the area of the proposed outfall pipeline route (marine section). These species are detailed in Table 9.15 based on the data provided by Ellis et al. (2010; 2012) and Coull et al. (1998). It should be noted that additional species may utilise the proposed outfall pipeline route (marine section) area as spawning and/or nursery grounds, although these are not expected to be significant enough to be affected by the Proposed Project. The ecology of the principal fish species identified during sampling operations in 2015 and 2017 is described later in this Section.

Table 9.15: Spawning Periods of Key Species

Spawning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nursery
Anglerfish													
Cod		*	*										
Haddock													
Herring													
Horse mackerel					*	*							
Lemon sole													
Ling													
Mackerel					*	*							
Plaice	*	*											
Sandeel													
Sole				*									
Sprat					*	*							
Whiting													
Spotted ray				?	*	*	*	?					
Thornback ray				*	*	*	*	*					
Spurdog	Viviparous species – gravid females can be present year-round												
Tope	Viviparous species – gravid females can be present year-round												

	High Intensity		Low Intensity		Intensity Unknown	*	Peak Spawning	? possible spawning

Species of Conservation Interest

The three species of lampreys (*Petromyzontidae*) that occur in Ireland are listed under Annex II of the Habitats Directive. Kelly and King (2001) summarised their distribution in Irish waters. While the brook lamprey (*Lampetra planeri*) is recorded from the Boyne and Liffey catchments (to the north and south of the proposed outfall pipeline location (land section), respectively), this species is exclusively found in freshwater. The river lamprey (*L. fluviatilis*), which is anadromous (i.e. uses coastal/marine habitat and then ascends rivers to spawn), is the least widely reported of the three species in Ireland, although it is recorded from the lower Boyne River to the north, contributing to its SAC status. The sea lamprey (*Petromyzon marinus*) is also anadromous and this species is more widely distributed in Ireland, although it is not recorded in the Boyne or the Liffey catchments (Kelly and King 2001). Shad are related to herring, and are also anadromous. Both the allis (*Alosa alosa*) and twaite shad (*A. fallax*), occur in Ireland and are designated as Annex II species. Four SACs in Ireland have been designated based on their importance to shad, although these are all in the south of the country (King and Roche 2008). Shad are not regularly recorded in the area of the proposed outfall pipeline route (marine section) location. The smelt (*Osmerus eperlanus*), an anadromous Irish Red Data book species, has not been recorded from the east coast of the Republic of Ireland (Quigley et al. 2004).

Both salmon (*Salmo salar*, a Habitats Directive Annex II species) and sea trout (*S. trutta morpha trutta*) are anadromous and occur in rivers and coastal waters throughout Ireland. Both species are of great importance to recreational and commercial fisheries. The inshore areas of the proposed outfall pipeline route (marine section) are likely to be used by both species, given that important rivers exist relatively nearby. For example, the Boyne River, 35km to the north of the proposed outfall pipeline route (marine section), is designated as an SAC partly based on the presence of salmon and is renowned as a salmon and sea trout fishing river. Adjacent rivers to the site have the following salmonid status (see Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic) in Volume 3 Part A of this EIAR):

- The Sluice River (IE_EA_09_1532) and its tributaries constitute a salmonid system. The system (main channel and tributaries) supports brown trout (*S. trutta*) throughout and eels (*Anguilla anguilla*) in its lower reaches (in addition to other fish species). It should be highlighted that recent surveys of the Sluice have recorded the presence of brown trout at least as far upstream as the Abbeyville Estate;
- The Mayne River (IE_EA_09_1428) constitutes a non-salmonid system because of the presence of an impassable barrier to fish movement at the lower end of the system. However, water quality has been noted as improving and IFI is currently assessing the viability of a salmonid reintroduction programme. Local developers have installed and configured instream features in compliance with salmonid waters requirements as per 'best practice' for this river;
- The Santry River (IE_EA_09_1507) is non-salmonid because of the presence of a number of impassable features to fish located toward the lower end of the system. IFI's policy is to maintain watercourses in their open natural state in order to prevent habitat loss, preserve biological diversity and aid in pollution detection; and
- The Tolka River and its tributaries constitute a salmonid system. The system (main channel and tributaries) supports brown trout (*S. trutta*) throughout, sea trout (*S. trutta morpha trutta*) and eels (*A. anguilla*) in its lower reaches (in addition to other fish species). Salmon have recently been recorded from the lower reaches of this river system.

In addition to these inshore species, a number of offshore species of conservation interest have been recorded from the area, including the basking shark (*Cetorhinus maximus*) (Berrow 2008), which is more common in the western Irish Sea, and the sunfish (*Mola mola*).

A number of diadromous species of conservation importance may utilise the area of the proposed outfall pipeline route (marine section) during migration or when foraging. These species are listed in Appendix A9.1.

Most elasmobranchs (sharks, skates and rays) are considered slow growing and late maturing with a low rate of reproduction (fecundity) when compared with other bony fishes (Camhi et al. 1998; Musick and Bonfil 2005). They are therefore sensitive to commercial exploitation through their resultant slow rate of stock increase (Musick and Musick 2011). Several common species with conservation designations and/or declining stocks potentially occur near the proposed outfall pipeline route (marine section) and are listed in Appendix A9.1.

A number of commercially exploited species which are expected to be present within the proposed outfall pipeline route (marine section) area are listed under UK Biodiversity Action Plan, OSPAR, IUCN Red List and the Bern Convention and are therefore of conservation interest. A list of relevant species and their designations is given below in Appendix A9.1 or Table 9.16. These include sandeels (*Ammodytes marinus* and *A. tobianus*), cod (*Gadus morhua*), turbot (*Scophthalmus maximus*) and haddock (*Melanogrammus aeglefinus*).

Sand goby (*P. minutus*) and common goby (*P. microps*) are not commercially exploited, and are also of conservation interest. Both species are listed under the Bern Convention (Appendix III), and relatively high numbers of what was assumed to be sand goby in the field (may possibly be common goby) were found in both the scientific 2m beam trawl survey and the beach seine survey.

Species such as herring, sprat and sandeel are considered key prey species for many predators such as marine mammals, piscivorous fish and birds (Furness 2002; Pitcher and Wyche 1982; ICES 2006; 2006b). Cod are known to prey upon small members of the Gadidae family (*Trisopterus* spp. and whiting), various flatfish, herring and sandeel (Arnett and Whelan 2001). There are also records of juvenile plaice in the stomachs of cod, whiting, saithe (*Pollachius virens*), pollack (*P. pollachius*) and older plaice (Nash and Geffen 2000). This suggests that the high intensity plaice nursery ground in the area of the proposed outfall pipeline route (marine section) may be of some importance as a feeding area for other commercial fish species.

Shellfish

The site-specific survey data indicated that a total of 18 species of shellfish were recorded in surveys surrounding the survey area. Six of these were recorded in the targeted whelk survey (RPS 2015) and 10 were recorded as bycatch from the beach seine net survey, three of which were also recorded in the aforementioned survey (Table 9.16). An additional five shellfish species were also noted as commercially targeted by fishermen in the area (Marine Institute 2013). Shellfish species that are commercially targeted in the area are European lobster (*Homarus gammarus*), brown crab (*Cancer pagurus*), velvet crab (*Necora puber*), common shrimp (*Palaemon serratus*), common whelk (*Buccinum undatum*), great scallop (*Pecten maximus*), razor clam (*Ensis siliqua*) and the blue mussel (*Mytilus edulis*). All species are targeted with static fishing gear, with the exception of scallops, mussels and razor clams, which are fished with mobile gear.

Table 9.16: Principal Species of Shellfish Recorded

Common Name	Scientific Name	Conservation Status				Survey*
		Bern Convention	OSPAR	IUCN Red List	UK Biodiversity Action Plan	
European lobster	*Homarus gammarus*	□	-	Least concern	-	MI
Brown crab	*Cancer pagurus*	-	-	na	-	RPS & ASU
Green crab **	*Carcinus maenas*	-	-	na	-	RPS & ASU
Harbour crab**	*Liocarcinus depurator*	-	-	na	-	RPS & ASU
Scorpion spider crab**	*Inachus dorsettensis*	-	-	na	-	RPS
Velvet swimming crab	*Necora puber*	-	-	na	-	ASU
Risso's crab**	*Xantho pilipes*	-	-	na	-	ASU
Small spider crab**	Majoidea	-	-	na	-	ASU
Hermit crab**	*Pagurus bernhardus*	-	-	na	-	ASU
Rock shrimp**	*Palaemon elegans*	-	-	na	-	RPS
Brown shrimp**	*Crangon crangon*	-	-	na	-	ASU
Aesop shrimp**	*Pandalus montagui*	-	-	na	-	ASU
Common shrimp	*Palaemon serratus*	-	-	na	-	MI
Common whelk	*Buccinum undatum*	-	-	na	-	MI & RPS
Queen scallop**	*Aequipecten opercularis*	-	-	na	-	ASU
Great scallop	*Pecten maximus*	-	-	na	-	MI
Razor clam	*Ensis siliqua*	-	-	na	-	MI
Blue mussel	*Mytilus edulis* (in beds)	☒	☒	na	☒	MI

* Survey references: MI = Marine Institute (2013); RPS = RPS (2015); ASU = Aquatic Services Unit (2015).

** Present as bycatch and not commercially fished

na = not assessed by the IUCN

The common whelk fishery off the east coast of Ireland is composed of four sectors (Dublin, Arklow, Courtown and Wexford) and occupies approximately 2,000km^2, of which the Dublin sector (vessels from Dun Laoghaire and Howth) records the lowest landing densities. The main Dublin Whelk fishing grounds are the sandbank areas near the Kish Bank. Additionally, results for the 2013 survey conducted around the proposed outfall pipeline route (marine section) show the whelk abundance to be positively correlated with water depth, with 45% to 56% of whelks sampled considered mature adults (RPS 2013).

The mussel seed fishery is restricted to 70 days per year and occurs in very limited areas. No mussel bycatch was recorded in fishery surveys performed or were conspicuous in sidescan sonar data acquired over the proposed outfall pipeline route (marine section). However, beds have been recorded on ‘sand banks and on coarse current swept sediments and rocky habitat’ (Marine Institute 2013), at the base of the north-west sublittoral reef on Ireland’s Eye (BSL 2015a) or as a seedbed of the horse mussel (*Modiolus modiolus*) on the maerl sands immediately outside Howth harbour (BSL 2012). There is only a small scale coastal scallop fishery in this region with vessels operating from Kilkeel, Dundalk and Howth/Dun Laoghaire: each is under 15m beam length and can carry up to 12 dredges (Marine Institute 2013).

Species of Conservation Interest

Of the shellfish species recorded, it is only the European lobster (*H. gammarus*) that, as a species, is of conservation interest. However, where found in high densities, the blue mussel (*M. edulis*) can form beds that are a designated habitat and biotope, ‘Intertidal *M.edulis* Beds on Mixed & Sandy Sediments’, listed by the OSPAR commission as threatened or in decline where they occur in the Celtic Seas. Smothering through siltation and physical damage are ranked as medium and high threats to this habitat, as were heavy metal pollution and introduction of microbial pathogens, respectively. The blue mussel, along with the larger horse mussel (*M. modiolus*), can also be found in large aggregations to form biogenic reefs which are designated as an Annex I habitat under the Habitats Directive, although these have not been recorded within close proximity of the proposed outfall pipeline route (marine section).

The European lobster is listed in Appendix III of the Bern Convention as a protected fauna species. This species is listed as least concern on the IUCN Red List with a stable population and is not listed as a Habitats Directive Annex II species. The fishery is currently managed in the UK with a minimum landing size of 87mm carapace length, and it is strictly forbidden to land buried females. Numerous regions successfully manage the stocks with schemes such as V-notching and introduction of maximum landing sizes; however, no such schemes are currently in place along the Fingal coastline.

Commercial Shellfish

Landings registered with the International Commission for the Exploration of the Sea (ICESin the Dublin Bay area recorded an average of nine tonnes of shellfish for this stretch of coastline between Wicklow and Lambay Island between 2006 and 2008 (Marine Institute 2010). Overall, the demersal fishery is dominated by shellfish as bottom trawling is generally poor. This is partially due to the extended areas of hard ground recorded within the survey area.

Fishing activity in the Irish inshore section is from vessels targeting razor clams (with the majority also able to target cockles) and those operating static gear, specifically potting for crab and lobster. Razor clam vessels active in the area are from home ports between Dundalk in the north down to Howth in the south, and number more than 30. In addition to the razor clam fishery, there are a small number of local boats who target shellfish on ground north of Lambay Island throughout the year for different gears. The whelk fishery is a small fishery but has been growing in recent years with the interest from overseas markets (Korea). Some boats are known to land in Howth and Dublin, but the majority of the fishery is south of Dalkey Island (Fahy et al. 2005). It should be noted that the proposed outfall pipeline route (marine section) lies outside designated shellfish waters under the Quality of Shellfish Waters Regulations 1994 (S.I. No. 200 of 1994). All of these inshore fisheries are summarised in Table 9.17 and in Figure 9.5 Inshore Shellfish Grounds Along the Fingal Coast. A detailed biology of these commercial fish species is included in Appendix A9.1.

Table 9.17: Summary of Local Shellfish Fisheries in Northern Fingal

Species	No. of Boats	Season
Brown (edible) crab (*Cancer pagurus*)	4	June to December
Velvet swimming crab (*Necora puber*)	11* 4	All year: These boats fish brown crab later in the summer and velvet crab for only part of the season
European lobster (*Homarus gammarus*)	4-5	All year round
Whelk (Buccinum undatum)	unknown	Summer through to later autumn
Razor clam *(Ensis* sp.)	Unknown	October to April
Shrimp (*Palaemon serratus*)	4	September to February

* All of the boats that target velvet crab would also have a bi-catch of lobster and brown crab.

Dredging is restricted inshore (as defined by the Sea Fisheries Protection Authority). However, fishermen have previously stated that activity often occurs in grounds in between designated dredging sites. As the activity is mostly concentrated in small areas, the result is that the seabed can be excavated to depths of 30cm.

Recreational Fisheries

Recreational fishing is also important in the region of. Angling is very active along the Fingal coastline with fishing from beaches, harbours, piers and from boats both close to shore and offshore over wrecks and reefs (Ecoserve 2006).

Near the proposed outfall pipeline route (marine section), there is notable Angling activity at Howth Harbour at the East and West Pier where whiting, pollack, coalfish and codling can be caught during summer and autumn. Small boats can be launched for general ground fishing around Ireland's Eye and on the Kish Bank. Species to be expected are coalfish, pollack, whiting, dogfish, mackerel and flatfish. To the east of the harbour is Balscadden Rocks where rock fishing takes place for mackerel (in season), plaice, dabs, dogfish, pouting, whiting and codling. At the Baily, mackerel (in season), coalfish, plaice, dab, dogfish, wrasse and whiting have been recorded. At Red Rock in Sutton, bass and flatfish have been recorded.

Velvet Strand in Portmarnock is an important shore angling venue. Around the Martello Tower, occasional bass and flounder can be fished for from the rocks, whilst the beach at the strand is used for distance casting and will produce dogfish and occasional codling and whiting in the Autumn.

Estuarine Fisheries

Many species avail of the highly productive nature of many estuaries and their use will vary with the seasons. Some fish species can be found in the estuaries the whole year round. Other fish are migratory, travelling through estuaries from the sea to reach spawning grounds in freshwater, such as salmon and lamprey, while others, such as eel, migrate down estuaries to the sea. The proposed outfall pipeline route (marine section) is close to Baldoyle Estuary. Rogerstown Estuary lies to the north. Between the two is the Malahide - Broadmeadow Estuary. A total of 24 species or taxa were recorded, from this and the Rogerstown Estuary by King and Green in 2003. A summary of these is listed in Appendix A9.1.

9.3.9 Summary Evaluation (Importance) of Key Marine Ecological Receptors and Habitats

A summary of the key sites, habitats and sensitive receptor species are listed in Table 9.18. The Proposed Project area overlaps directly with two marine related SACs, although additional habitats and species of conservation importance are recorded within the general vicinity. Some sensitive receptors represent qualifying species at neighbouring SACs or are known to exist in the region of the Proposed Project.

Table 9.18: A Summary of the Key Sites, Habitats and Sensitive Receptor Species

Receptor	Importance	Justification
Designated sites		
Baldoyle Bay SAC	Very high	Designated as an SAC for salt meadows and mudflats (see Table 9.7). (Also qualifies for designation as an SPA by regularly supporting internationally important populations of wintering and nationally important populations of birds. Baldoyle Bay also qualifies for a Ramsar Site). The Proposed Project passes through the site.
Rockabill to Dalkey Island SAC	Very high	Designated SAC for qualifying marine habitat and Annex II species. The Proposed Project (proposed marine diffuser and part of the proposed outfall pipeline route (marine section)) is located within the SAC.
Ireland's Eye SAC	Very high	Designated SAC for terrestrial habitats. The proposed outfall pipeline route (marine section) is 0.8km north of the island.
Marine habitats		
Mudflats and sandflats not covered by seawater at low tide	Medium	Several muddy biotopes are present. Important habitat for the wintering birds (see Chapter 10 Marine Ornithology).
Salicornia and other annuals colonising mud and sand	Very high	Qualifying saltmarsh interest for the Baldoyle SAC in close association with the other saltmarsh habitats.
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Very high	Qualifying saltmarsh interest for the Baldoyle SAC in close association with the other saltmarsh habitats.
Mediterranean salt meadows (*Juncetalia maritimi*)	Very high	Qualifying saltmarsh interest for the Baldoyle SAC in close association with the other saltmarsh habitats.
Rocky Reefs	Very high	Rock coastline with steep-sided, wave-swept, littoral and sublittoral rocky reef complexes. This is a qualifying interest for the SAC, although acknowledged as poor quality due to high siltation. Conservation objective is to maintain favourable conservation status and to prevent the permanent removal of habitat area.
Species of conservation/commercial value		
Atlantic salmon	Medium	Not listed as a qualifying species in the Rockabill to Dalkey Island or Baldoyle Estuary SACs. It is expected to be present within the project area. Listed in Annex II (Habitats Directive). It is also OSPAR listed as a threatened species. Migratory species.
Sea and river lamprey	Medium	Listed in Annex II (Habitats Directive), also recorded in river systems north and south of the Proposed Project area. Migratory species.
Harbour porpoise	Very high	Annex II designated species and qualifying interest for the Rockabill to Dalkey Island SAC. This is a species of international importance resident in Irish waters and occurring regularly in the Celtic sea. A European Protected Species.
Bottlenose dolphin	Medium	Annex II species of international importance and occurs in the region. A European Protected Species.
Grey seal	Medium	Annex II species and a qualifying species in neighbouring SAC, with an important breeding population on Lambay Island but may also breed in Ireland's Eye. Regularly sighted within the region.
Common seal	Medium	This species is of national importance and is sighted in the region, although not in high numbers. Annex II species and a qualifying species in neighbouring SAC, with

Receptor	Importance	Justification
		an important breeding population on Lambay Island. Occasionally sighted within the region.
Otters	Low	Boyne River is designated as an SAC partly on the basis of the presence of otters, so they could possibly occur occasionally in the area, particularly in the Baldoyle Estuary area. Otters are a European Protected Species (see Chapter 11 Biodiversity (Terrestrial and Freshwater Aquatic) in Volume 3 Part A of this EIAR.
Shellfish	Low	Mussel reefs (*M. edulis*) can be found in dense reefs to the west of Ireland's Eye and form an Annex I biogenic reefs habitat listed by OSPAR as threatened or in decline where they occur in the Celtic Sea. Not found along the proposed outfall pipeline route (marine section).
Marine fish	Low	Several fish species use the Proposed Project area for spawning and/or nursery. Key species include cod and spurdog, both listed as threatened under OSPAR and vulnerable under the IUCN Red List. Sandeels, herring, sprat and plaice are important to avian and mammal predators. Whiting are also found to spawn in the Proposed Project area or use the shallow embayment as a nursery area.
Benthos	Negligible	The benthos over the Proposed Project area is diverse but typical for this area of the Irish coastline. There are no key species of conservational importance, although the benthos is a resource that is important to other ecological groups (e.g. birds and fish species), as well as some shellfish fisheries.

9.4 Impact of the Proposed Project – Construction Phase

The construction and operational methodology is described in Chapter 4 Description of the Proposed Project in Volume 2 Part A of this EIAR. The proposed outfall pipeline route (marine section) is broken down into different geographical sections which each relate to different construction methodologies and consequently have varying potential for impacts to the marine ecology. These can be summarised as follows:

- Two proposed temporary construction compounds for microtunnelling will be built adjacent to the Baldoyle Estuary SAC and SPA;
- A tunnel will be constructed beneath Baldoyle Bay SAC and SPA and will run for approximately 2km below Velvet Strand out to 600m from the coast. It is estimated that microtunnelling would progress at a rate of approximately 60m per week and that the tunnelling would take in the region of 12 months including site mobilisation;
- The remaining section of the proposed outfall pipeline route (marine section) runs a further 4km out to north of Ireland's Eye and terminates with the proposed marine diffuser. This section of the proposed outfall pipeline route (marine section) will be constructed using surface dredging using a combination of backhoe dredger and/or TSHD in the deeper section (water >15m deep):
    - Where the backhoe dredger is used, the dredged material will be disposed to a hopper barge, which will then deposit the dredged material through its bottom doors in a linear stockpile parallel to the pipeline trench within the 250m proposed construction corridor for subsequent reuse;
    - Where the TSHD is used, one or two suction tubes, equipped with a drag head, will be lowered on the seabed and the drag head trailed over the trench. A pump system will suck up a mixture of sand or soil and water, and discharge it in the 'hopper' or hold of the vessel. Once fully loaded, the vessel will move off the trench alignment and deposit the material through its bottom doors in a linear stockpile parallel to the pipeline trench within the 250m proposed construction corridor for subsequent reuse;

  - The trench is envisaged to be 2.5m deep and 5.0m wide at base but between 20 and 40m wide at the surface, subject to seabed sediment type; and
  - The construction period is estimated to take six months;
- The proposed outfall pipeline route (marine section) will be installed using a float and lower method using a long length large diameter polyethylene pipe and lowering this into the dredged sections. These pipes will be delivered to Dublin Port or to sheltered waters along the proposed outfall pipeline (marine section) prior to ballasting and final pipe assembly operation. In sheltered waters, a floating jack up platform supported by tugs and multicat vessels would be used to assemble the pipe strings and place the concrete collars. Collars would be delivered on a daily basis by ship to platform. Pipe assembly along a quay wall requires mobile cranes to lift the concrete collars into place. Collars would be delivered by road to the port;
- At the tunnel/subsea pipeline interface, approximately 600m offshore, a temporary structure will be required consisting either of a cofferdam or a pre-excavated section of trench (filled with loose sand/granular material sourced from elsewhere along the trench alignment) to retrieve the TBM from the microtunnelled section;
- As the proposed outfall pipeline route (marine section) will cross the Hibernia Atlantic fibre optic cable, a temporary construction supporting the cable during pipeline excavation will be required. This will require additional sheet piling operations at this location; and
- The diffuser section consists of one or more vertical riser pipes which are attached to the main pipeline after it is lowered into the trench. The actual diffuser valves are then attached to the riser pipes. The main pipeline will be supplied with pre-installed flanged openings (capped) for the diffusers. Once the pipe is lowered into the trench, divers will remove the flanged caps and attach the riser pipes via bolted connections. The trench is then backfilled. Divers will then attach the diffuser valves, again using bolted connections, to the end of the riser pipes which are protruding above the reinstated seabed. Protective covers in the form of precast concrete or steel are then placed over the diffuser valves.

9.4.1 Construction of the Microtunnelling Compounds Adjacent to the Baldoyle Estuary and Construction Works Upstream of Marine Environment with Potential for Contaminated Runoff

The driveshaft for the proposed microtunnel will be located outside the Baldoyle Bay SPA/SAC. Consequently, the potential impact to the marine ecology from this part of the operation would be limited to an indirect impact where disturbance occurs through visual and airborne noise impacts, or by the escape of waste products into the estuary. The most sensitive receptor within the estuary from the compound construction is over-wintering birds (see Chapter 10 Marine Ornithology). Migratory and juvenile fish may also use the estuary during higher states of the tide and benthos are an important food source for the over-wintering bird population. However, the use of bunded protection within the compound would negate the impact from these terrestrial operations to the marine system, and the Baldoyle Estuary is not a known migration route for any sensitive marine species.

The three saltmarsh related qualifying species within the estuary (i.e. *Salicornia* and other annuals colonizing mud and sand, and Atlantic and Mediterranean salt meadows) are all located on the upper parts of the estuary and are surrounded by existing erosion channels below the level of the habitat. The main channel, fed by the Sluice River in the north and met by the Mayne River along the western shoreline, meanders along the central part of the estuary below the main vegetation zone. The tidal range within the estuary is 4.1m during spring high waters, with the saltmarsh only surrounded by water during the upper third of the tidal cycle, and only covered by estuarine waters during high water spring events. Consequently, the main saltmarsh is largely unaffected by the water quality during the majority of the tidal cycle and from riverine inputs for a significant period of time. When a spring high water event occurs, the overall volume of Baldoyle Bay increases by approximately 1.5 million cubic meters due to the additional 80cm rise in tidal height, increasing the dilution effect of any pollutant within the estuary during this period.

Pollution events that may occur upstream during construction or from the adjacent compounds are deemed to be of low risk, with mitigation applied within the Construction Environmental Management Plan (CEMP) to trap or isolate discharges where they are likely to occur. However, in the event that a small pollution event does occur, the likely route for this material into the estuary would be the existing eroded riverine flow channels within the estuary which remain away from the main saltmarsh areas. In the event that the estuary is at high water during a spring event where this material may be dispersed onto qualifying saltmarsh habitats, the higher level of seawater exchange within the estuary is expected to dilute this material to a negligible level of impact.

In addition to the saltmarsh habitats, Baldoyle Bay SAC is also designated for mudflats and sandflats not covered by seawater at low tide (1140), located throughout the whole of the Bay and a section of coastline named the Velvet Strand along the Portmarnock coastline. The properties of supporting sediments within this habitat varies from fine sand dominated by *Angulus tenuis* and *Tubificoides benedii* in the mouth and along the eastern shoreline and Estuarine sandy mud with *Pygospio elegans* within the bay, based on changes in the hydrodynamic regime within the SAC. The pathway of possible discharges described above would be directly over this habitat, but the permanent habitat area is stable or increasing, subject to natural processes. As the nature and scale of possible contamination to the site from upstream activities is deemed to be rare, minor and very short lived, it is concluded that the resilience of the receiving habitat is such that this potential would have a negligible impact within the designated site.

Impact

The magnitude of any noise/vibration impact or pollution impact will be negligible based on the limiting factors as described above and the protocols outlined in the CEMP, suggesting a Negligible impact significance to sensitive saltmarsh, benthos and juvenile fish species (including migratory fish species). Otters may occasionally use the estuary whilst other marine mammals are not expected to populate the estuary due to its very shallow nature and limited coverage by the tide. Whilst their ecological value varies from low (otters) through to high (harbour porpoises outside of the SAC), the negligible impact magnitude would produce a likely Negligible impact significance.

9.4.2 Tunnelling Underneath Baldoyle Bay and Tunnelling Compounds

Habitat Loss/Disturbance

No wetland habitat loss or disturbance is predicted within Baldoyle Bay SAC, as a trenchless construction method is to be adopted from west of Baldoyle Bay to approximately 600m east of the Velvet Strand shoreline. Whilst the use of this tunnelling technique will reduce the possibility of surface impacts to a very low level, the risk of low level noise/vibration, a surface breakout or the requirements for a surface intervention cannot be negated completely as will be discussed below.

Surface Venting (Air Breakout)

The risk and magnitude of air breakout may vary significantly when comparing different microtunnelling techniques, due to the requirement for compressed air within varying technical solutions. It is therefore possible that this risk can be removed completely for some microtunnelling techniques.

Compressed air is used within the TBM to maintain a slight positive pressure. This can occasionally escape to the surface through a trickle of air bubbles and create small areas of surface sediment loss through liquefaction and winnowing of fines in prevailing marine currents. Whilst this does not have a chemical impact on the surrounding sediments, this can create a small area of physical impact to the SAC wetland habitat in the form of a small pock mark or shallow crater. This may have a very localised impact on the Wetlands. Wetland habitats typically would reinstate themselves naturally over an extended period of tidal activity, although occasionally, some surface intervention may be required to assist in reinstatement for larger features in cohesive sediments, if encountered.

Impact

Overall, the potential for this impact would be highly unlikely. However, as this may create some minor physical damage, this could have an adverse effect on the saltmarsh habitat, which is of very high ecological value but of negligible magnitude, resulting in a likely Minor significant impact. Should this occur, this would be a very small localised impact and would not affect the overall integrity of the habitat in this area. As such, a Negligible impact is predicted for both benthos and fish species (including migratory fish) present, which is not significant.

Bentonite Breakout

Owing to variability in the prevailing geology, the risk of a surface breakout by bentonite drilling fluid cannot be negated completely. Bentonite will be used during the drilling operation to lubricate the TBM during microtunnelling during construction and will be pumped into the cuttings annulus during operations at the ambient pressure at the rock face. Should the TBM encounter voids within the formation (such as a fissure or weathered area of rock), material can be forced to the surface under pressure to create a breakout. In the littoral and sublittoral environments, the presence of bentonite at the surface can have a notable impact on sediment turbidity and suspended load. This increase in turbidity could result in increased siltation and the smothering of sediments and organisms accompanied by a reduction in the light available to the seabed for photosynthesis. High levels of suspended solids settling on the seabed can alter habitats, resulting in a potential loss of food resources for qualifying waterbird species of Baldoyle Bay SPA.

Impacts of increased turbidity are likely to be minimal in the overall context of Baldoyle Bay, as the water depth is extremely shallow and the natural suspended sediment very fine. A release of bentonite may marginally increase the levels of some chemical components near the discharge. These may include some metals, although the components within the bentonite drilling fluid are naturally occurring and non-toxic to marine benthic fauna. A small quantity of this suspended clay escaping into the watercourse will produce a plume effect. In small quantities and areas of low tidal movement, the viscous high density clay will initially remain localised before becoming suspended and flushed out of Baldoyle Bay over subsequent tidal cycles. A bentonite release outside the Baldoyle Estuary will be exposed to a winnowing effect of the semi-diurnal tidal effects and wave action and will disperse into the water column within a very short period of time. This may create a localised plume of limited size and duration which may induce some avoidance behaviour by some ecological groups (i.e. fish and seals) within the area.

Impact

Overall, this is an unlikely occurrence and the potential impact would have a negligible magnitude and be for a short-term duration. This results in only Minor significance. Whilst the saltmarsh habitat is of very high ecological value, bentonite is unlikely to have any impact upon it if this occurs in the channel or open water environments, where this material will disperse harmlessly. If this occurs within the saltmarsh vegetation, then this material is unlikely to disperse quickly due to the lack of tidal flow in these areas, and may require some intervention to recover and disperse to avoid a smothering effect. However, as bentonite is naturally occurring and non-toxic to marine benthic fauna, and the water depth in Baldoyle Bay estuary is extremely shallow and the natural suspended sediment very fine, a small quantity of this suspended clay escaping into the watercourse would produce a negligible impact on benthic communities found within the bay. Consequently, the impact from a bentonite breakout, should it occur, would not affect the integrity of the habitat in this area. An expected short-term plume of increased fines within the estuary is also predicted to have a Negligible impact on the fish species (including migratory fish) present.

Noise and Vibration

Measurement Units and Background

Tunnelling operations will produce low level noise emissions into the water column above the proposed outfall pipeline route (marine section). Whilst underwater noise is measured in decibels (dB), principally the same as airborne noise measurements, the reference pressure for underwater noise measurements is 1 micropascal (µPa) compared to the reference pressure for airborne noise of 20µPa. This has the effect of making the underwater decibel level (ref. 1µPa) approximately 26dB higher than that of airborne decibel level (ref. 20µPa) for the same sound pressure. Furthermore, airborne sound pressure levels are commonly quoted as 'A'-weighted decibel levels. This means that care must also be taken when quoting or comparing dB levels, as the same pressure level can be represented in different ways. For example, a small boat (approximately 5m long) with an outboard engine is quoted as having a source level of 152dB re 1µPa (this is a nominal underwater sound pressure level at 1m from an idealised point source (Richardson et al. 1995)). On the basis of a crude propagation model using only hemispherical geometric spreading, the received underwater sound level at 25m is approximately 138dB re 1µPa, which is a sound pressure of 8Pa. This sound pressure in air is equivalent to approximately 112dB(A) re 20µPa, which is approximately a typical sound pressure level at an amplified rock concert (Kinsler et al. 1982). The point of the above comparison is that a boat is fairly loud, but that, taken out of context (e.g. if one were to compare the underwater source level of 152dB with standard comparison tables) one may erroneously suggest that underwater noise from a boat is louder than two jet engines at 30m.

In tunnelling and microtunnelling, the TBM operates by slowly rotating a cutter head which will produce a low level ground vibration through the sediments and water column above the proposed outfall pipeline route (marine section). Different microtunnelling machines will rotate at different speeds. The likely vibration produced from a similar TBM in a shallow marine estuary has been compared to other projects (Sruwaddacon Bay, Co. Mayo, Hamburg to Elbe and Boston MWWST tunnels) which showed that the frequencies expected from the operation would typically range from 20Hz to 100Hz, but with a max peak of 400kHz. A maximum modelled sound pressure for the proposed outfall pipeline route (marine section) is expected to be approximately 100Pa (160dB re 1µPal) in the sublittoral zone, decreasing to less than approximately 30Pa (149.5dB re 1µPa) within a 30m distance from the TBM. This would be at a dominant frequency of 31.5Hz, but with 4Hz, 25Hz, and 63Hz outputs also significant frequencies. Outside of these, the responses would generally be below 10Pa (140dB re 1µPa). Measured frequency spectrums have actually shown this to be lower (Subacoustech 2014 pers.comm).

Ambient subsea noise levels depend upon a number of factors, including wind/wave surface interaction, rainfall, and sound emitted from marine animals and shipping. Early studies into ambient noise levels (Knudsen 1948; Wenz 1962) determined relationships between descriptors of physical and anthropogenic noise sources (e.g. quantum of ships; wind speed) and the noise spectrum level produced. In shallow water (which includes the North Sea and the waters around Ireland), there is greater spatial and temporal variability in ambient noise level. Ambient noise levels would be expected to be higher in coastal locations due to the noise from breaking surf; the movement of shingle, sand, gravel and other sea/coast interactions; and from ships near ports, harbours and shipping lanes and smaller vessels. Thomsen et al. (2006) published results on the measurements of ambient noise around wind farms in the North Sea, with results showing a 1/3rd-octave spectrum typically peaking at just below 115dB re 1µPa at around 20Hz to 30Hz but falling to below 95dB re 1µPa above 250Hz (Diagram 9.6). Other common ambient background noises are quite natural and relate to the clicking of communicating crustacea (1kHz to 100kHz) or are anthropogenic and relate to fast-running outboard motors (152dB re 1µPa to

156dB re 1µPa @ 630Hz to 6.3kHz) or slower-running fishing type vessels (151dB re 1µPa @ 250Hz to 1kHz). Vessel noise is broadband, ranging from 10Hz to 10kHz or more, and source levels can vary by vessel type from 157dB re 1µPa to 187dB re 1µPa for vessels traveling at 10 knots (Kipple and Gabriele 2007). Other ship borne devices, such as sonars and echo sounders, typically operate at 100kHz to 500kHz frequency in shallow water environments and are also large noise sources.

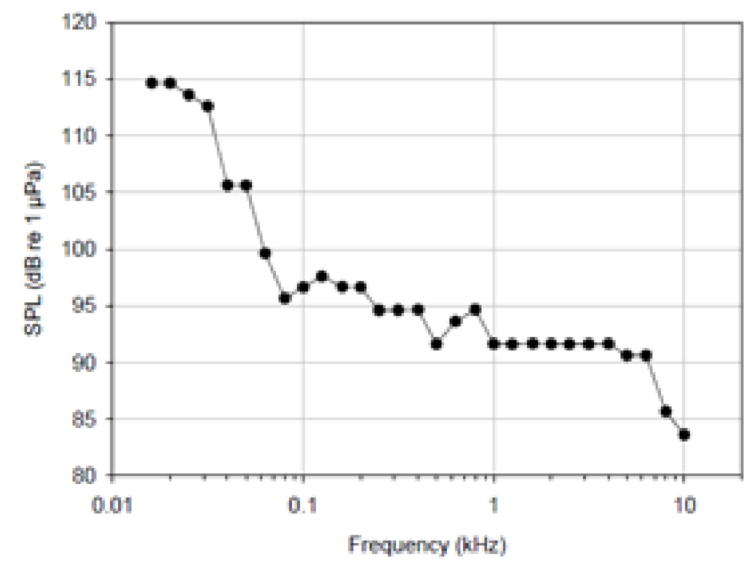

Diagram 9.6: Ambient Background Noise in the North Sea Shallow Water (Thomsen et al. 2006)

The background noise levels were surveyed for the proposed outfall pipeline route (marine section) and the proposed marine diffuser location using a static recorder (LAB 2015). A single recorder was deployed throughout August 2015 and sampled at 16kHz in 24 bits and processed using third-octave band sound pressure level measurements over 10 second snapshots. The results showed that the impulse detector was being triggered almost continuously throughout the deployment by self-noise of the mooring system (possible vibration of the cables on the mooring). There was little or no noise recorded from biological sources (shrimp, bivalves or other animals), including cetaceans. The mean background noise level was approximately 105dB re 1µPa at 25Hz and 92dB re 1µPa at 2kHz. However, it is not possible to separate out the background from the self-noise signal, so a general background level of around 95dB re 1µPa at 2kHz is assumed.

Microtunnelling using a Tunnel Boring Machine

Noise levels from microtunnelling and TBM operations are created from a slowly rotating cutter head which will produce a low level ground vibration through the sediments and water column above the proposed outfall pipeline route (marine section). Different microtunnelling machines will rotate at different speeds but the likely vibration produced from a similar TBM in a shallow marine estuary, compared to other similar projects (Sruwaddacon, Hamburg to Elbe and Boston MWWST tunnels), typically produced 160dB re 1µPa in the range from 20Hz to 100Hz, but max peak decreasing to 149.5dB re 1µPa within a 30m distance from the TBM.

Impacts on fish from noise and vibration from trenchless river crossings and coastal marine operations have been carried out for a number of similar projects (e.g. Felindre to Tirley Pipeline and the Uskmouth Pipeline), particularly in areas that relate to qualifying fish species and Annex II species (such as salmonids). BSL conducted a review of the potential impact of similar construction activities on Annex II fish species. Behavioural response to noise and vibration was related to the perceived loudness of the sound.

In fish species, the sensation of 'hearing' can refer to auditory sensation both in the form of sensitivity to acoustic pressure or vibration from local particle velocity variations. The loudness of the noise and vibration is related to its level above the hearing threshold of a particular fish species. To assess perceived loudness, it is therefore a requirement that the auditory sensitivity of the species being assessed is known. A review of available fish hearing threshold data indicated that good quality audiograms are available for Atlantic salmon (*Salmo salar*) and trout, but that no data exist for anadromous species such as sea and river lampreys which have poor hearing due to their anatomy.

As no species-specific data were available, Lampreys were assumed to have a poorer hearing response to salmonids due to their primitive anatomy, with minimum threshold hearing levels of 95dB re 1µPa, and to have a hearing response range from 30Hz to 400Hz. This information is summarised in Table 9.19.

Table 9.19: Hearing Threshold for Fish Species Found in Local Rivers (Parvin et al. 2007)

Species	Surrogate Species	Hearing Threshold (dB re 1 µPa)	Optimum Frequency	Frequency Range
Atlantic salmon	N/A	95	160Hz	30Hz to 400Hz
Trout	N/A	115	100Hz	20Hz to 1,000Hz

Impacts on fish from noise and vibration can be gathered from the Subacoustech SPEAR model to predict approximate ranges of impact and effect from the noise sources using the dB_{ht}(Species) metric.

The likelihood of fish behavioural response to underwater noise and vibration was assessed using the dB_{ht} noise assessment metric. This compares the frequency components of the noise with the hearing threshold of the fish and provides a measure of dB above threshold ($_{ht}$).

On the basis of a large body of measurements of fish avoidance of noise (Nedwell et al. 2003; 2007), the following assessment criteria is proposed for assessing the potential impact of construction noise and vibration:

- 130dB_{ht} and over – Auditory injury threshold;
- 100dB_{ht} and over – 100% avoidance;
- 90dB_{ht} – Strong avoidance reaction by most individuals;
- 75dB_{ht} – Mild avoidance reaction occurs in a majority of individuals; and
- 0–50dB_{ht} – Low likelihood of disturbance.

The studies presented a typical time history of the waterborne noise recorded at a position immediately above the 26" microtunnelling operation (River Tees) and the frequency spectrum of the underwater noise during drilling and non-drilling periods. The data have similar spectral levels over the frequency range from 80Hz to 100kHz. The data therefore indicate that the microtunnelling activity did not increase the ambient noise in the river over this frequency range. At very low frequencies, less than 80Hz, there is a marginal increase in the spectra levels. This is probably due to the variability of the background noise in the river at these very low frequencies, and may not be due to the microtunnelling. These data are presented on Diagram 9.7, in addition to published hearing thresholds for various species of fish (Parvin et al. 2007; Enger 1967; Hawkins and Johnstone 1978; Higgs et al. 2003; Nedwell 2006; Wahlberg and Westerberg 2005), as well as a background frequency spectrum of a similar TBM measured directly above the unit in a dry estuary (Nedwell 2013 unpublished). These data indicate that any waterborne noise from microtunnelling operation is generally below the hearing threshold (minimum perceived levels of sound) for the trout and salmon (also representing Lampreys). The data therefore indicate that the activity would be on the very limits of perception for these species. However, as the level will be less than 50dB_{ht} above the background threshold for the species, this perception is not likely to induce a behavioural response. As such, no significant adverse impact is expected. The study concluded that no risk of fish injury/fatality from microtunnelling, with only a short-term negligible behavioural response. A similar impact can be classified for the Proposed Project. It is worth noting that TBMs, if employed, do not always run a continuous operation, as segment lining is often required every 1m (approximately) with between 10 and 20 sections added each day. This will result in a temporary break in the progress of the TBM and introduce short temporary breaks in the noise profile history.

Fish with swim bladders and specialised auditory couplings to the inner ear (e.g. goldfish, herrings) are highly sensitive to sound pressure, while fish with a swim bladder but without a specialised auditory coupling (e.g. cod) are moderately sensitive, and fish with a reduced swim bladder or lacking a swim bladder (e.g. dab), mackerels, sharks, skates and rays) have low sensitivity (Fay 1988).

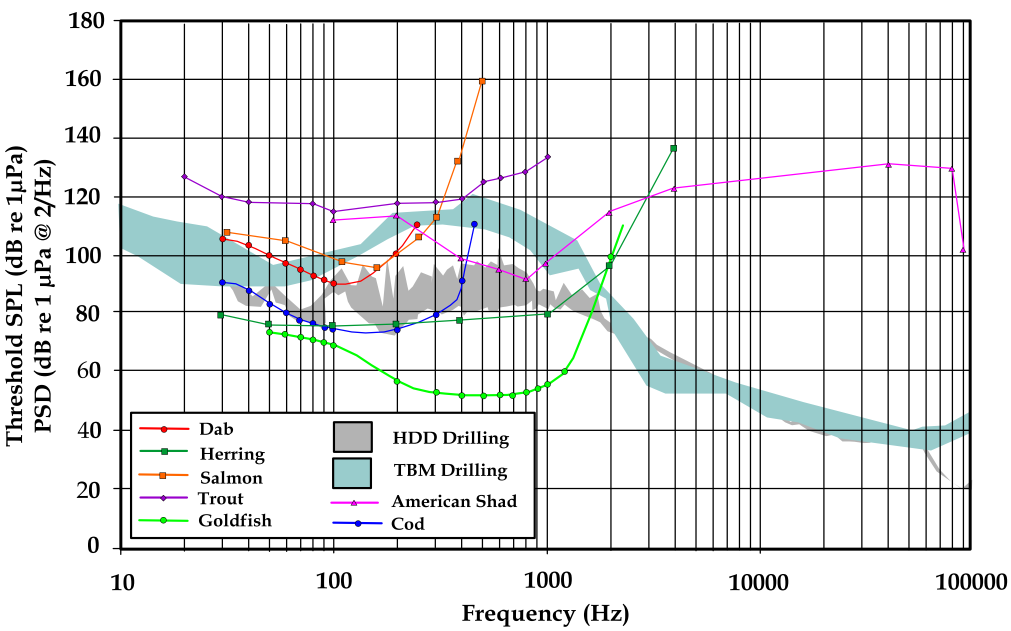

Diagram 9.7: Composite Figure of Microtunnelling and TBM Frequency Spectrum Compared to the Published Hearing Threshold for Various Fish Species (Composite from Parvin et al. 2007; Enger 1967; Hawkins and Johnstone 1978; Higgs et al. 2003; Nedwell 2006 and 2013 unpublished for the TBM frequency band; and Wahlberg and Westerberg 2005)

Auditory thresholds, being the minimal level of sound that a fish can detect at a particular frequency 50% of the time, have been developed for a number of fish species. Auditory threshold curves for species that can be classified as having low, moderate and high hearing sensitivity have been included on Diagram 9.7.

The highly sensitive group has a hearing threshold of less than 80dB re 1µPa. The moderately sensitive threshold is between 80 and 100dB re 1µPa, and those fish with a low sensitivity require noises greater than 100dB re 1µPa. These sensitivity thresholds were derived under quiet laboratory conditions. Therefore, thresholds under actual field conditions would be considerably higher, as the signal to noise ratio would have to be sufficiently high for sounds not to be ‘masked’ by the ambient, broadband noise levels produced by shipping, wind, currents or sediment movement. Vessel noise is broadband, ranging from 10Hz to 10kHz or more, and source levels for a variety of vessel types traveling at 10 knots range from 157 to 182dB re 1µPa (Kipple and Gabriele 2007).

As sound waves propagate from the seabed, transmission loss occurs through geometric spreading as sound radiates outward from a source. This spreading loss causes sound levels to decrease in proportion to the square of the distance from the sound source. Sound loss for a specific site is dependent on bottom composition, bathymetric profile and other factors, but generally, spreading loss rates range from a 3dB to 6dB decrease per doubling of distance, and from 10dB to 20dB per 10-fold increase in distance. Other causes of sound loss include absorption by the water itself, and scattering due to air bubbles or suspended sediment. As a result of sound loss, fish located higher in the water column or located some distance away from the construction activity would be exposed to significantly reduced noise levels than a fish close to the source. For example, a fish located approximately 2m above the seabed and directly above the TBM exposed to a noise level of 60dB would only be exposed to noise levels of 40dB to 50dB at a distance of 20m from the same location.

Fish have a ‘lateral line’ system that runs lengthwise down each side of the body and over the head. The lateral line consists of pressure-sensitive cells that convert subtle changes in water pressure into neural pulses that allow fish to avoid collisions, participate in schooling behaviour, orient to water currents, elude predators and detect prey. For most fish, the lateral line is only sensitive to low frequency (10Hz to 30Hz) (Popper and Fay 1993) near-field pressure changes, perhaps only as near as two body lengths or less (Palmer et al. 2005). Little is known about the sensitivity threshold of fish lateral line systems, but Voigt et al. (2000) found that the lateral line sensitivity threshold of eels to currents was approximately 0.5cm/s (0.2 inches/s). It appears that the sensitivity threshold of the lateral line system is limited to the area immediately surrounding a fish, and is approximately two orders of magnitude greater than the peak particle velocities that would be transmitted to the seabed from a subsurface tunnelling operation (such as a TBM). Fish would not be able to detect this degree of water movement with their lateral line system, and would not become disoriented or experience interference while foraging or sensing predators.

The marine benthos is not affected by noise but will be exposed to ground vibration as the TBM travels below. The vibration output from the TBM at other similar tunnel construction sites has been modelled in the range of 0.1 to 0.6mm/s/metre of TBM diameter. Recent measurements of vibration above a very similar TBM in the west of Ireland has shown that the actual peak particle velocity was found almost an order of magnitude below this when the seabed was exposed (approx. 0.06mm/s to 0.12mm/s) (Nedwell 2014 pers.comm). This is far below a minimum action level of 2.5mm/s where this vibration can be perceived by passing fauna. This study was subject to an investigation by BSL (2014) on a similar segment lined tunnel in the west of Ireland. Results concluded that there was no significant impact to the benthos from the passage of a TBM.

The geographical extent of the proposed TBM operations is limited to within 500m of the coast. No TBM operations are proposed within the Rockabill to Dalkey Island SAC, although qualifying species and other sensitive receptors may potentially encounter this area where TBM operations are proposed closer inshore. These impacts will vary with the sensitivity of the receptor. The baleen whales (mysticetes) which typically vocalise at very low frequencies (40Hz to100Hz) are not generally found in the shallow waters along the proposed outfall pipeline route (marine section) and therefore are not likely to be impacted by the Construction Phase. Of the toothed whales and dolphins (odontocetes), only the harbour porpoise and bottlenose dolphin, along with the seals (pinnipeds), are commonly recorded in the area. Table 9.20 summarises the typical auditory range for all of these species, although the sensitivity of these ranges may alter significantly with the frequency. Kastelein et al. (2002) showed that the sensitivity of the harbour porpoises (*Phocoena phocoena*) exhibited a very wide hearing range, with relatively high hearing thresholds at high frequencies but with a relatively poor hearing threshold of 92 to 115dB re 1µPa at the lower frequencies produced by the TBM. Hearing was notably more sensitive (i.e. lower thresholds) in the mid and higher frequency bands (60dB to 80dB between 1kHz to 8kHz, falling to only 32dB to 46dB from 16kHz to 140kHz, respectively). Consequently, noise output from the TBM below 100Hz is likely to be imperceptible to these cetaceans.

The hearing sensitivity of the seals is marginally greater than that of the cetaceans at the lower frequency, with a central hearing range of around 8kHz to 16kHz, but with some infrasonic perception. However, the noise at a frequency of 75Hz would need to be at least 100dB to be perceived by the seal. Therefore, the impact of noise is also likely to be imperceptible to this group. Whilst the TBM vibrations might be at the very limit of the seals auditory range, the consequence of this is not expected to be significant.

The majority of noise energy produced from the TBM operation in water is below 100Hz. The sensitivity of the high and mid frequency cetaceans along with the pinnipeds falls rapidly below 100Hz. Table 9.20 lists example criteria contained within Southall et al. (2007) which have been adopted by the Joint Nature Conservation Committee (UK) as suitable criteria to determine what constitutes an 'injury offence' in accordance with Article 12 of the Habitats Directive. The expected maximum noise outputs from the TBM is 160dB re 1µPa. This is below these limits for marine mammals in water. The vibration output from the TBM at other similar tunnel construction sites has been modelled in the range of 0.1 to 0.6mm/s/metre TBM diameter. Recent measurements of vibration above a very similar TBM in the west of Ireland have shown that the recorded peak particle velocity was an order of magnitude below this (approx. 0.06mm/s to 0.12mm/s) when the seabed was exposed above the tide. This level is far below a minimum action level of 2.5mm/s where this vibration can be perceived by passing fauna.

Table 9.20: Criteria for Injury (from Southall et al. 2007)

Animal Group	Single Pulses	Multiple Pulses	Non-Pulse
High frequency cetaceans			
Sound pressure level	230dB$_{peak}$ re 1µPa (flat)	230dB$_{peak}$ re 1µPa (flat)	230dB$_{peak}$ re 1µPa (flat)
Sound exposure level	198dB re 1µPa^2-s(M$_{hf}$)	198dB re 1µPa^2-s(M$_{hf}$)	215dB re 1µPa^2-s(M$_{hf}$)
Pinnipeds (water)			
Sound pressure level	218dB$_{peak}$ re 1µPa (flat)	218dB$_{peak}$ re 1µPa (flat)	218dB$_{peak}$ re 1µPa (flat)
Sound exposure level	186dB re 1µPa^2-s(M$_{pw}$)	186dB re 1µPa^2-s(M$_{pw}$)	203dB re 1µPa^2-s(M$_{pw}$)
Pinnipeds (air)			
Sound pressure level	149dB$_{peak}$ re 20µPa (flat)	149dB$_{peak}$ re 20µPa (flat)	149dB$_{peak}$ re 20µPa (flat)
Sound exposure level	144dB re 20µPa^2-s(M$_{pa}$)	144dB re (20µPa^2)-s(M$_{pa}$)	144dB re (20µPa^2)-s(M$_{pa}$)

Impact on Fish and Benthos

The potential for impacts to the ecology through TBM noise is Negligible, based on an unlikely occurrence of negligible magnitude with short-term duration. Furthermore, it is concluded that neither fish (through sound) nor benthos (through vibration) would be aware of the TBM operation, although it is possible that tunnelling will be audible to selected fish species but of insufficient amplitude to provoke a behavioural response. Overall, it is concluded that the risk of fish injury/fatality from subsurface operations and behavioural response is classified as short-term and of Negligible significance.

Impact on Marine Mammals

Overall, the noise output from the construction of the microtunnelling to marine mammals (pinnipeds) and Annex II species is potentially short-term with negligible magnitude. Given their respective ecological value of medium to high, this impact is expected to be of Negligible significance.

9.4.3 Dredging of Proposed Outfall Pipeline Route (Marine Section)

Suspended Sediments and Habitat Loss

Marcon Computations International was commissioned to inform the potential spread and extent of suspended sediment plumes arising from dredging works associated with the construction of the proposed outfall pipeline route (marine section). The computational models used in this study were based on the MIKE3 coastal process software using the 3D hydrodynamic flow model and particle tracking (MIKE PT) modules. The model consisted of a regular 50m grid encompassing the general area within the proposed outfall pipeline route (marine section) and expanded out into a flexible mesh model of varying grid sizes. This particle tracking model used the hydraulic flow regime from the MIKE3 hydrodynamic model to simulate the transport and fate of material discharged to the water column. The model included variable graded material along with temporally and spatially varying discharges.

The outfall will be constructed using a combination of a backhoe dredger in shallower areas, and a trailer suction hopper dredger (TSHD) where the water depths are beyond the limits of the backhoe dredger. The backhoe dredger or similar will be used for the dredging activity during 12-hour operations, which gives a maximum dredging quantity of about 78m^3 per hour while the dredger is working. It is estimated that the total volume of material to be excavated ranges between 200,000m^3 to 400,000m^3 and that the dredging operation will take approximately six months.

Details of the sediment characteristics were obtained from the surface and sub-surface sediments along the proposed outfall pipeline route (marine section) from the vibrocoring and borehole data, with calculations based on their proposed excavation locations along the proposed outfall pipeline route (marine section) (i.e. BH03, BH05 and BH08). These samples showed that sediments ranged from grey silty sand to grey sandy gravel. Whilst grey silty sand predominates along the entire proposed outfall pipeline route (marine section), the increase in gravel fraction over depth and towards the offshore end of the trench have largely been ignored for suspended sediment dispersion purposes, as the heavier fractions settle out within a few metres of the dredger.

Material losses through suspension in the water column were assumed to be conservative 10% of total dredged volume, representing a 7.5% loss at 1m above the seabed and a 2.5% loss at 1m below the surface. The MIKE model simulates the fate of the loss of material from the dredgers by releasing particles into the water column and tracking each particle throughout the simulation process. A range of grain sizes was used in order to cater for the variation in sediment grading of the bed sediment material. Assuming a density of 2,000kg/m^3 for in-site consolidated sand/gravel mix, the extraction rate equates approximately to 1,852kg/s and a 10% loss of 185.2kg/s occurring through sediment suspension. A dredging simulation was then run over the full excavation period with the origin for dispersion and the source of the material moved to keep track with the dredgers' simulated progress along the route.

The results of the dredging simulations were shown graphically by a series of model output diagrams based on operations from different borehole locations or different states of the tide. These have been summarised into a single chart (refer to Figure 9.6). At almost all locations, snapshots of suspended sediment concentrations were taken over the course of spring or neap tides, with the majority observed within the 0mg/l to 100mg/l range. In only two of the snapshots were the suspended sediment concentrations predicted to be greater than 100mg/l. The deposition depth of dredged material is greatest in the immediate vicinity (within 8m) of the trench (>300mm) with deposition depths reducing to less than 3mm within a few hundred meters of the trench route. The spread of the sediment plume shows the controlled release of spoil material by hopper barge every seven hours producing a northerly plume drifting away from Ireland’s Eye, with the greatest plume concentration recorded in the shallower first 2km of the route from landfall. The highest concentrations of suspended sediments >10 g/l were recorded at bed level within 50m to 100m from the discharge point. The granular nature of these sediments results in a fast settlement of material to the bottom, with seabed and mid-depth concentrations generally falling to below 1g/l within 200m from the discharge. Lower levels of sediment fines (silts and clays), recorded in the sub-surface layers of the corridor are modelled to travel further on discharge, and with concentrations of between 10mg/l and 100mg/l recorded out to a maximum distance of around 1,400m north of the route. Most suspended material would be recorded just above bed level concentrations in the surface waters generally limited to discharges made only in the offshore half of the proposed route. Here, low level concentrations of between 5mg/l and 10mg/l were recorded out to 1,500m from the corridor or remained just detectable out to 2,600m. With the exception of a small surface plume of 1mg/l to 5mg/l and 200m to 300m across caught in a small back-eddy 350m north of the Ireland’s Eye, all of the plume discharge is predicted to disperse to the north of the proposed outfall pipeline route following a controlled discharge. None of the discharged sediment is predicted to impact the qualifying Annex I habitats of littoral and sublittoral reef features of the Rockabill to Dalkey Island SAC along the north and eastern coastline of Ireland’s Eye. Suspended sediments throughout the remainder of the SAC were limited to near bed impacts in the main part of the SAC area.

Scientific investigations of these features in 2015 identified diverse biological populations, consistent with this habitat type and area. However, no species of particular conservation interest were noted during the studies with no rare or particularly fragile biotopes recorded. The natural siltation levels were high in the sublittoral environment, a fact that has not appeared to have had a significant impact to the biological diversity around Ireland’s Eye. Whilst siltation levels are already high in the sublittoral environment, a significant increase in suspended sediment over a prolonged period, particularly during the summer months during peak algal growth, potentially could have an adverse impact on the algal biotopes present through reduced light penetration and availability. However, this limited exposure to high turbidity will be limited due to the short period of dredging. The precise tidal state and lunar cycle required to transport this material to the south (i.e. ebbing during spring tides) and the moderately strong tidal currents experienced in this area will also reduce the likelihood of deposition of significant silt material on these reef habitats, the resultant degradation of the sublittoral benthic biotopes through smothering and the burial of the infralittoral and circalittoral communities.

Sediment plumes from the discharge of dredge spoil may present habitat disturbance to local cetacean foraging in the area. The combined surface and seabed plume created during the dredging process recorded a maximum area with elevated suspended sediment above 5mg/l of 4.5km^2, of which approximately 1.5km^2 is currently within Rockabill to Dalkey Island SAC. This is equivalent to only 0.55% of the total SAC area (of 273km^2). The duration of the dredging within the SAC is expected to be 60 days.

This plume is expected to have a temporary but localised impact on the foraging behaviour of the visual hunters such as seals and harbour porpoise due to the reduced visibility near the dredging. It should be noted that the noise created during the dredging in the waters surrounding the dredgers is likely to induce avoidance behaviour by these species prior to species encountering the discharge plume itself. The harbour porpoise feeds mainly on small shoaling fish, such as herring, but may also feed upon prey taken at or close to the benthos. As harbour porpoises use a series of high frequency clicks for echo-location during navigation and hunting, they are less susceptible to the impacts of suspended sediment plumes during foraging and are routinely found in inshore areas of high natural turbidity (e.g. southern North Sea, Liverpool Bay in the Irish Sea).

When not feeding, the impact of the plume on other visual hunters, such as migratory fish species and pinnipeds, is likely to induce an avoidance reaction. There is also a potential to encourage predation within the plume, where fish feed on suspended benthos and the seals feed upon the fish. The size of the plume into the area surrounding the SAC is not likely to be significant at any given time, and the area negligible when compared to the potential foraging range of pinnipeds from the Lambay Island SAC. Seals are expected to show a simple avoidance reaction if a plume is encountered. The maximum concentration of the plume is predicted to be around 50mg/l near the surface, which is approximately within the range expected for natural suspended sediment loads recorded near the proposed marine diffuser. The duration of the dredging is expected to take 60 days, and analysis of the pre-dredged sediments results indicated natural uncontaminated sediments throughout the route based on the samples analysed.

Overall, the impact to Annex II species from Lambay Island SAC from the construction dredging plume will be negligible, although this may introduce minor behavioural changes for the short construction period. As the direct impact by the plume will be very localised (within 1,500m of the source), short-term (<60 days) and will not deteriorate any resources within the range of the species. The magnitude of impact on migratory fish (such as salmonids) and pinnipeds is expected to be low and very short-term. Given the medium ecological value of these species, it is considered that this will be of Minor impact significance.

The area of the proposed outfall pipeline route (marine section) is considered a low intensity spawning and nursery ground for sandeel, and whilst local populations may potentially be affected by habitat loss and disturbance through sediment excavation and deposition during dredging and trenching activities (Ellis et al. 2010; 2012), this is likely to have a minimal impact to the wider Irish Sea population.

The ecological value for fish and shellfish spawning with regards to dredging is considered low. The magnitude is negligible due to the small scale of the Proposed Project and the low intensity nature of the demersal spawners, and the duration of impact is anticipated to be short-term (up to five years).

Most mobile adult and juvenile fish (including herring) are able to avoid the impacts of physical disturbance and habitat loss by moving to adjacent areas (Wenger et al. 2017). The impact of dredging/trenching is therefore anticipated to be low for most species. Sandeel, as a generally sedentary species, may be less able to avoid physical disturbance than others, particularly after spawning when they reportedly remain in their burrows for approximately two months. Their specific substrate requirements are very limiting to their distribution, hence the renowned patchiness. They have been found to be adversely affected in areas with sediment containing >2% silt. Dredging and temporary storage of dredged materials on the seabed may cause smothering of sandeel habitat, and could potentially affect the local substrate composition through disturbance of the seabed and potentially increasing suspended sediment concentrations. Overall, the sandeel effect-receptor interaction is expected to be low. Adult and juvenile sandeel are considered to be of medium vulnerability and high recoverability, and may be of regional importance in terms of a prey source.

Cod are nationally important and considered in decline, and as such are subject to recovery measures (Cod Recovery Plan). There is a high intensity cod nursery near the proposed outfall pipeline route (marine section) (Ellis et al. 2010), and several specimens were recorded during the inshore fisheries assessments carried out in 2015 and 2017 (ASU 2017). For these reasons, cod have been assessed as of high ecological value. However, the magnitude of the impact is considered negligible due to the small footprint of the Proposed Project, and the impact duration is expected to be very short-term. Therefore, the likely effects are insignificant.

Disturbance to the marine benthos and the sand dwelling shellfish (such as the razor clam) are expected to be high, although this will be limited to a relatively small area directly relating to the trenched route (approximately

0.16km^2), or neighbouring sediments (approximately 1km^2) affected by localised smothering of stored or plume-dispersed material. The area is routinely disturbed by clam dredgers and routinely repopulates the substrates within the short-term.

The benthos may be impacted by dredging activities as a result of the physical removal of substratum and associated organisms from the seabed along the path of the dredge head, and the subsequent deposition of material through side casting or settlement of a dispersed plume of suspended sediment. A review of the impact of aggregate dredging in European coastal waters suggests that marine communities conform to well-established principles of ecological succession, and that these allow some realistic predictions on the likely recovery of benthic communities following cessation of dredging (Newell et al. 1998). In general, communities living in fine mobile deposits, such as that occur in estuaries, are characterised by large populations of a restricted variety of species that are well adapted to rapid recolonisation of deposits that are subject to frequent disturbance. Recolonisation of dredged deposits is initially by these 'opportunistic' species, and the community is subsequently supplemented by an increased species variety of long-lived and slow-growing 'equilibrium' species that characterise stable undisturbed deposits such as coarse gravels and reefs. Rates of recovery reported in the literature suggest that a recovery time of six to eight months is characteristic of many estuarine muds where frequent disturbance of the deposits precludes the establishment of long-lived components. In contrast, the community of sands and gravels may take two to three years to establish, depending on the proportion of sand and level of environmental disturbance by waves and currents, and may take even longer where rare slow-growing components were present in the community prior to dredging. As the deposits get coarser along a gradient of environmental stability, estimates of five to 10 years are probably realistic for development of the complex biological associations between the slow-growing components of equilibrium community characteristic of reef structures.

The benthos along the proposed outfall pipeline route (marine section) are based predominantly on sands, particularly in the western inshore section of the proposed outfall pipeline route (marine section). Here, the water depth is very shallow and subject to continuous reworking by wave induced currents. The central part of the proposed outfall pipeline route (marine section) is a silty sand, becoming increasingly coarser towards a muddy sandy gravel near the proposed marine diffuser location. There is an absence of any developed biogenic or geogenic features with any significant epifaunal component. The physical recovery of the surface sediments along the proposed outfall pipeline route (marine section) is expected to show recovery within a few months, with a recolonisation by the benthos to occur within six months for the majority of species, but possibly one to two years for some the of larger slower-growing taxa.

Impact

The potential impacts on Annex I reef habitats within the Rockabill to Dalkey Island SAC from the dredging plume will be short-term with negligible magnitude. Based on a very high ecological value, this would have an impact of Minor potential significance on this qualifying habitat. The impact of a suspended sediment plume to the Annex II species recorded within the Rockabill to Dalkey Island SAC, in particular the harbour porpoise, is expected to be short-term, and of negligible magnitude. Based on a very high ecological value, this would also have a Minor impact significance.

The potential for impacts to non-migratory fish and shellfish areas from the dredging plume or habitat loss will be spatially limited to a small area, short-term, with low magnitude and are therefore of Negligible significance. The impact to benthos is also expected to be short-term, localised and of low magnitude arising from the plume with a negligible magnitude for loss of habitat. The overall significance of these impacts will also be Negligible.

Noise and Vibration

The noise created by backhoe dredgers is produced from a repetitive sequence of sounds generated by winches, bucket impact with the substrate, bucket closing, and bucket emptying (Dickerson et al. 2001; Robinson et al. 2012). Grab and backhoe dredgers are also characterised by sharp transients from operation of the mechanical parts. Suction dredgers produce a combination of sounds from relatively continuous sources, including material passing through the suction pipe and the drag head moving across the substrate. However, it is the noise of the support vessels (engine and propeller noise) that can often be the most significant source of noise.

Noise levels produced by a backhoe dredger operating around the Shetland Islands, UK, were recorded by Nedwell et al. (2008). They recorded a calculated source level of 163dB re 1 Pa at 1m (bandwidth = 20Hz – 100kHz), although Reine et al. (2012) calculated source levels of 179dB re 1µPa at 1m (bandwidth = 3Hz – 20kHz).

Noise produced by suction dredgers has been measured on a number of occasions. Robinson et al. (2011) measured six trailer suction hopper dredgers, finding that the sound levels recorded below 500Hz were in line with those expected for a cargo ship travelling at modest speeds (8–16kn). The maximum broadband source was 189.9dB re 1µPa at 1m (calculated based on a bandwidth 31.6Hz to 39.8kHz). Estimated source levels above 1kHz were relatively high, probably a result of the coarse aggregate pumped through the dredge pipe. Using an identical approach, de Jong et al. (2010) found very similar results to Robinson et al. (2011), with source levels recording a decline beyond 1kHz when dredging sandy rather than gravel sediments. Consequently, the variation in sediment types from sands to mixed gravels encountered along the proposed outfall pipeline route (marine section) is expected to alter the source levels during dredging, particular at the higher frequencies at the eastern end of the proposed outfall pipeline route (marine section).

A collation of dredger related noise profiles was carried out by Subacoustech Environmental using their SPEAR model based on measured recordings retained within their database. The SPEAR model gives unweighted source levels of 186dB re 1µPa for suction dredgers and 165dB re 1µPa for backhoe dredgers. Therefore, the predicted noise from suction dredgers is expected to be approximately 20dB above that of backhoe dredgers, which is due largely to the typical size difference between the two types of vessel operating the dredging equipment as well as the increased size of plant necessary for suction dredging. A model of expected underwater noise created during the dredging exercise was based on Parvin (2008) and Robinson et al. (2011) and estimated at 188dB ref 1µPa in the 50Hz to 89kHz range. The output using third-octave bands of 125Hz, 1kHz and 8kHz were calculated to range between 172dB and 176dB ref 1µPa. The contouring of sound exposure levels from a source along the proposed outfall pipeline route (marine section) at these three frequencies showed a propagation of sound to a sound exposure level of around 100dB re 1µPa, within 1km at 125Hz, around 30km for 1kHz and 12km for 8kHz.

When assessing impacts to cetaceans, knowledge about the hearing range of species is not fully understood, although it is assumed that whales and dolphins hear over similar frequency ranges to the sounds they produce, noting that hearing ranges can extend beyond that of frequencies used for vocalisations (Southall et al. 2007). If anthropogenic noise, such as that produced during dredging operations, coincides with species' hearing ranges, it has the potential to affect individuals and populations of marine mammals present within the area at the time. Table 9.21 summarises the typical auditory range for all of these species, although the sensitivity of these ranges may alter significantly with the frequency. Based on these criteria, the majority of sounds produced by dredgers will be at frequencies within the lower frequencies of the cetacean’s auditory range. The noise levels expected from the dredging activities during the Construction Phase are not expected to be sufficient to cause any damage, but may alter the species behaviour either through avoidance or curiosity.

Table 9.21: Auditory Range of Qualifying and Sensitive Receptors in the Proposed Outfall Pipeline Route (Marine Section) Location

Species Of Marine Mammal	Vocalisation	Frequency Range	Expected Residency in Construction Area	Criteria for injury (from Southall et al. 2007)
Common dolphin (*Delphinus delphis*)	Whistles Clicks Barks	2–18kHz 8–14kHz <0.5–3kHz	Rare	Sound pressure: 230dB_{peak} re 1µPa (flat) Sound exposure: 198dB re 1 $µPa^2$-s(M_{hf})
Bottlenose dolphin (*Tursiops truncatus*)	Whistles Clicks Barks Low freq.	0.8–24kHz 0.2–150kHz 0.2–16kHz 0.05–0.9kHz	Common	
Harbour porpoise (*Phocoena phocoena*)	Whistles Clicks Barks	2–18kHz 8–14kHz <0.5–3kHz	Frequent	
Common seal (*Phoca vitulina*)	Various	~0.05–100kHz	Common	In water: Sound pressure: 230dB_{peak} re 1µPa (flat) Sound exposure: 198dB re 1$µPa^2$-s(M_{hf}) In air: Sound pressure: 230dB_{peak} re 1µPa (flat) Sound exposure: 198dB re 1$µPa^2$-s(M_{hf})
Grey seal (*Halichoerus grypus*)			Common	

Impact on Marine Mammals

The noise from dredging activities during the Construction Phase on marine mammals and Annex II species is expected to be short-term and of negligible magnitude. The duration of the dredging phase of the work is expected to be six months, although the actual duration of the dredging activity is expected to be much shorter. The overall significance of impact is therefore Minor for harbour porpoises (within the SAC) but Negligible for other cetaceans and pinnipeds.

Impact on Fish

The abundance of fish recorded within the area is not expected to be high, although there is a high diversity of species for the area. Whilst these do not constitute a population of significant commercial interest, they may represent an important food source for the sea birds and species related to the surrounding SPA (see Section 9.4.2 and Chapter 10 Biodiversity (Marine) in Volume 3 Part A of this EIAR).

As with the construction noise during tunnelling, impacts on fish from noise and vibration from dredging operations can also be gathered from the Subacoustech SPEAR model to predict approximate ranges of impact and effect from the noise sources using the dB_{ht}(Species) metric.

A summary of SPEAR dB_{ht} impact threshold and the effect of noise on common marine species is outlined in Table 9.22.

Table 9.22: Impact Distances Based on Strong (90dB$_{ht}$) or Mild (75dB$_{ht}$) Avoidance Behaviour of Four Common Fish Species (Subacoustech SPEAR dB$_{ht}$(Species) metric)

Fish Species	Cod		Dab		Herring		Salmon	
Dredger type	90dB$_{ht}$	75dB$_{ht}$	90dB$_{ht}$	75dB$_{ht}$	90dB$_{ht}$	75dB$_{ht}$	90dB$_{ht}$	75dB$_{ht}$
Backhoe dredging	<1m	3m	<1m	1m	1m	4m	<1m	<1m
Suction dredging	7m	39m	1m	7m	13m	65m	1m	5m

At levels of 90dB$_{ht}$ a strong avoidance reaction is expected in virtually all individuals, whilst at levels of 75dB$_{ht}$ some avoidance reaction is expected by the majority of individuals. However, habituation or context may limit the effect over longer operational periods. All the predicted noise levels for the Proposed Project are well below the auditory injury criteria of 130dB$_{ht}$.

The predicted impact ranges are very low and, at most, extend out to a few tens of metres. This is because of the relative low level of noise produced by the dredging vessels and that the noise from these vessels while in operation tends to be higher in frequency than most fish can perceive. Consequently, this model concluded that the risk of fish injury/fatality from dredging and behavioural response is classified as short-term and of negligible magnitude.

Overall, the noise output from construction dredging on fish species (including migratory fish which have a medium ecological value) is expected to be short-term, and the impact significance is expected to be Negligible.

Pollution

Other than the small risks relating to pollution emissions connected with all marine vessels, the operation of dredging does not introduce any pollutant components into the environment. The main impact from dredging relates to the resuspension of seabed material into the water column and transported away from the site in a suspended sediment plume. The spread and concentration of the dredging plume and its potential interaction with qualifying features in the Rockabill to Dalkey Island SAC is summarised in Figure 9.6 Maximum Suspended Sediment Plume Concentrations Arising from Dredging over the Duration of Dredging Works for the Proposed Outfall Pipeline Route (Marine Section) .

The dredged material within this plume was analysed for both natural and historical anthropogenic contaminants from the surface and sub-surface sediments (and summarised in Section 9.3.3). Results indicated natural uncontaminated sediments throughout the sediments tested.

Impact

The impact from pollution during dredging on immediate marine ecology (marine mammals, passing fish species and surrounding benthos) will be short-term and of negligible to no magnitude, and therefore the likely impact significance is expected to be of Negligible to Minor significance.

9.4.4 Piling for Tunnel Interface and/or Fibre Optic Cable

Noise and Vibration

The construction of the interface between the initial section of the microtunnelling and the dredged area may require sheet piling or an installation of a caisson during construction. Furthermore, sheet piling may also be required during operations to cross the existing fibre optic cable during the proposed outfall pipeline route (marine section) installation. The noise impact from these operations would be significant. Whilst both of these areas are located outside of SACs, qualifying species relating to the Rockabill to Dalkey SAC (i.e. harbour porpoises) or other potentially sensitive receptors including migratory species (such as salmonids) or mobile species from other nearby designated sites (i.e. pinnipeds) may be exposed to potentially harmful noise levels during this phase of the construction.

The same acoustic model was used to assess the noise impact from an impact hammer source that might be used at the tunnel interface or at a telecom cable crossing, midway along the proposed outfall pipeline route (marine section). The source was based on a piling of 600mm with the sounds generated impulsively. In order to translate the potential impacts more accurately, the sound exposure level is expressed as 'dB 1µPa²@1m', which corresponds to the acoustic energy received integrated over a given frequency band and over the significant duration of the sound pulse (100ms in this study; De Jong et al. 2008). At two of the same lower third-octave bands used for the dredging assessments, the sound pressure level of the piling was estimated to be 186dB 1µPa²@1m at 125Hz, dropping to 172dB 1µPa²@1m at 1kHz. Contouring of sound exposure levels from a source along the proposed outfall pipeline route (marine section) at these two frequencies showed a propagation of sound to a sound exposure level of around 100dB re 1µPa, within 2km at 250Hz, and around 12km for 1kHz.

Impact

The noise output from piling during construction of the proposed outfall pipeline route (marine section) interface or fibre optic crossing point could have a potential impact on fish, including salmonid species. Both of the possible areas of operation are within an open water environment and would induce an avoidance reaction in these mobile species. Consequently, the impact magnitude is considered to be low with a likely significance of Negligible (marine fish) to Minor (salmonids).

Pinnipeds and cetaceans are of a medium to high ecological value, given their proximity to nearby SACs where they represent qualifying species. This results in a Minor significant impact. Further mitigation to monitor for the presence of these species during these activities will be required.

9.4.5 Installation of the Proposed Marine Diffuser

Habitat Loss/Disturbance

The construction of a marine riser is required to make the hydraulic connection between the outfall pipeline and the seabed and is necessary to discharge the treated wastewater from the proposed outfall pipeline route (marine section) at the discharge point. The diffuser section consists of one or more vertical riser pipes which are attached to the marine outfall pipeline after it is lowered into the trench. The actual diffuser valves (Tideflex duckbill valves or similar) are then attached to the riser pipes.

The remaining structure will have a direct impact on the seabed, but this is anticipated to be a very small footprint. Whilst this is located within the Rockabill to Dalkey Island SAC, there are no qualifying interests in this area of impact relating to the seabed.

Impact

Overall impact to the benthos will be permanent but expected to be of negligible magnitude and Negligible significance.

Noise and Vibration

The proposed marine diffuser will have a diameter of 2m and be positioned 2m above the seabed, with four 400mm diameter ports arranged concentrically. The final method of construction for the riser will be mounted/installed during assembly of the concrete ballasts in the final outfall section. This section will then be sunk into position by controlling the flooding of the pipe using divers. This will result in no additional noise impacts at the proposed marine diffuser location other than those already present from the activity of vessels during the Construction Phase. Currently, no piling is anticipated within the Rockabill to Dalkey SAC.

Impact

The noise impacts from the construction of the proposed marine diffuser (as part of the dredging operation) on marine mammals and Annex II species is expected to be less than that of the dredging activities. The operation will be short-term and of negligible magnitude and therefore Minor significance A summary of the construction impacts on marine ecology is shown in Table 9.23.

Table 9.23: Summary of Impacts During the Construction Phase on Marine Ecology

Activity	Impact	Receptor	Ecological Value	Magnitude	Duration	Significance
Construction of compounds	Noise/vibration	Benthos	Negligible	Negligible	Short-term	Negligible
		Fish species	Low to medium	Negligible	Short-term	Negligible
		Otter	Low	Negligible	Short-term	Negligible
	Pollution	Benthos	Negligible	Negligible	Short-term	Negligible
		Fish species	Low to medium	Negligible	Short-term	Negligible
		Marine mammals	Medium to high	Negligible	Short-term	Negligible
		Otter	Low	Negligible	Short-term	Negligible
Microtunnelling below Baldoyle Estuary	Air breakout	Saltmarsh habitat	Very high	Negligible	Short-term	Minor
		Benthos and fish	Medium to negligible	Negligible	Short-term	Negligible
	Bentonite breakout	Saltmarsh habitat	Very high	Negligible	Short-term	Minor
		Benthos and fish	Medium to negligible	Negligible	Short-term	Negligible
	Noise and vibration	Benthos and fish	Medium to negligible	Negligible	Short-term	Negligible
		Pinnipeds	Medium	Negligible	Short-term	Negligible
		Harbour porpoise	High	Negligible	Short-term	Negligible
Dredging of proposed outfall pipeline (marine section)	Suspended sediment plume	Benthos	Negligible	Low (short range)	Short-term	Negligible
		Migratory fish and pinnipeds	Medium	Low (short range)	Short-term	Minor
		Other fish species and shellfish	Low	Low (short range)	Short-term	Negligible
		Reef habitat (SAC)	Very high	Negligible	Short-term	Minor
		Harbour porpoise (SAC)	Very high	Negligible	Short-term	Minor
	Loss of habitat	Benthos and fish	Medium to negligible	Negligible	Short-term	Negligible
	Noise and vibration	Pinnipeds	Medium	Negligible	Short-term	Negligible
		Harbour porpoise	Very high (SAC)	Negligible	Short-term	Minor
		Fish species	Low to medium	Negligible	Short-term	Negligible

Activity	Impact	Receptor	Ecological Value	Magnitude	Duration	Significance
	Pollution	All marine species	Negligible to very high	Negligible to none	Short-term	Negligible to Minor
Tunnel interface using piling and/or caisson installation (outside the SAC)	Noise and vibration	Salmonids and other fish species	Low to medium	Low	Short-term	Negligible to Minor
		Pinnipeds	Medium	Low	Short-term	Minor
		Harbour porpoise and dolphins	High	Low	Short-term	Minor
Installation of proposed marine diffuser (inside the SAC)	Habitat loss	Benthos	Negligible	Negligible	Permanent	Negligible
	Noise and vibration	Harbour porpoise	Very high (SAC)	Negligible	Short-term	Minor

9.5 Impact of the Proposed Project – Operational Phase

Impacts during the Operational Phase relate to the presence of infrastructure in the marine environment and the potential for changes to water quality.

For the operation of the proposed outfall pipeline route (marine section), the dilution rates and area of plotted plume dispersion are discussed in detail in Chapter 8 Marine Water Quality. The expected levels of suspended solids and nutrient emissions during the Operational Phase of the Proposed Project can have a direct impact on the marine ecology near the proposed outfall marine diffuser. Following results from the three-dimensional hydrodynamic modelling studies, the final treated wastewater produced at the new proposed WwTP would conform to the standards outlined in Table 9.24.

Table 9.24: Final Target Treated Wastewater Emission Limits for the Proposed Wastewater Treatment Plant

Parameter	Emission Limit	
	95th Percentile	Not to Exceed
pH	6–9	
Temperature	25°C (max)	
Biological Oxygen Demand (BOD_5)	25mg/l O_2	50mg/l O_2
Chemical Oxygen Demand	125mg/l O_2	250mg/l O_2
Total suspended solids	35mg/l	87mg/l

Note: BOD_5 on a five-day test

The dispersion of the treated wastewater from the proposed marine diffuser when discharged is expected to be significant in the near field mixing zone. The water quality is expected to reach standards set out in the Water Framework Directive, European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. No. 272 of 2009) and Directive 2006/7/EC of 15 February 2006 concerning the management of bathing water quality (Bathing Waters Directive) to maintain a ‘good’ water quality status set out for ‘coastal’ waters and to prevent impact to nearby bathing waters or protected areas (such as shellfish waters). For peak flow, the European Communities Environmental Objectives (Surface Waters) Regulations 2009 set out a DIN limit of 0.25mg/l, a Molybdate Reactive Phosphorus limit of 0.04mg/l (for transitional waters, as no standard is set for coastal), Biochemical Oxygen Demand of 4.0mg/l and Escherichia coliform (COLI) counts of <500 per 100ml (95th percentile). The model showed that, with the exception of DIN immediately within the near-field mixing zone, the compliance levels within the plume or of the surrounding waters were not compromised.

Details of the plume discharged into the Irish Sea by the proposed outfall pipeline are discussed in Chapter 8 Marine Water Quality in Volume 3 Part A of the EIAR, and the standards of the treated wastewater are summarised above and characterised in Table 9.24. The proposed outfall marine diffuser is designed to enhance the dilution of the treated wastewater into the receiving waters on discharge. A numerical model of the expected dilution was produced based on the Cornell Mixing Zone Expert System (CORMIX) to predict the near-field dilution characteristics of a proposed outfall discharging to the receiving waters. The CORMIX model predicted the plume development, dilution and treated wastewater concentrations within the plume. Near the discharge port, the plume tends to behave as a coherent jet, dominated by its initial momentum and buoyancy. Eventually, these are dissipated by interaction with the surrounding medium, and the plume becomes a diffuse mass carried along by the ambient current. Mixing initially occurs by turbulent flows at the boundaries of the plume, and later primarily by pure diffusion processes.

Simulations were run using the CORMIX using hydrodynamic data applied for the tidal cycle, ambient water quality and structure and profiled currents recorded during an earlier survey campaign at the proposed outfall pipeline route (marine section). Hourly simulations were carried out over the full tidal cycle for both neap and spring tidal scenarios, with results indicating a consistent 20-fold dilution recorded within the near field (50m) from the discharge point on both neap and spring tidal streams. Far-field dilutions (500m) showed greater variability based on the tides but generally varied from a 33-fold dilution during slack events to 100-fold dilution during mid flood or ebb tidal streams. Therefore, for total suspended solids, a 35mg/l (95th percentile) discharge would therefore dissipate to an increased background of 1.75mg/l within 50m at all states of the tide, but vary from 1.06mg/l to 0.35mg/l at 500m, subject to tidal stream.

Habitat Loss/Disturbance

Long-term observations of turbidity recorded at the proposed marine diffuser location throughout 2015 and 2016 (TechWorks 2016) indicated a variable ambient suspended sediment load ranging from 4mg/l to 120mg/l calculated from converted turbidity measurements (using Guillen et al. 2000) or 15mg/l to 160mg/l from sampled water quality measurements taken throughout the same survey period. The longer-term observations in turbidity revealed a significant variability in water clarity by season as well as by tidal state, with a regular semi-diurnal pattern recorded over a slow seasonal decrease in turbidity (i.e. increased water clarity) recorded during the summer months. Spring and neap tidal cycles had a marked effect on the suspended sediment load, increasing ambient levels by between 7mg/l and 25mg/l during the stronger spring tidal flows. Ambient suspended sediments were also affected by strong winds and poor weather periods.

No loss of pelagic habitats is predicted due to the level of treatment being applied to the outfall discharge where a maximum suspended sediment load of 35mg/l will be applied (95th percentile). As noted above, this is currently within the range routinely recorded for suspended sediments at this water mass and would be expected to disperse with the ambient seawater by a factor of 20 within 50m on discharge. Whilst this discharge is expected to provide a localised plume visible to marine mammals, particularly for visual hunters (such as pinnipeds), at certain times of the year, the presence of the plume is not expected to have a direct effect on the presence of harbour porpoises, as this species is routinely found in high turbidity shallow waters. However, both seals and porpoises may be attracted to the proposed marine diffuser in search of prey species, which themselves might be attracted to the increased productivity surrounding the outfall discharge.

Details of the treated wastewater discharge qualities modelled during the Operational Phase are outlined in Table 9.24. Results indicate that the plume created by the treated wastewater discharge will be subject to significant dispersion, with a 20-fold dilution achieved within 50m of the diffuser and between a 33- and 100-fold dilution within 500m of the diffuser. Based on a maximum suspended sediment load of 89mg/l, a worst case scenario would show a minimum dilution rate of 33 fold within 500m of the diffuser. This is an increase of only 2.7mg/l above a minimum background concentration of between 4mg/l and 15mg/l. This is an almost imperceptible increase in the background turbidity at this distance. The majority of treated wastewater diluting to below 5mg/l will occur within 50m of the outfall. A radius of 500m is equivalent to an area of approximately 0.2km^2 or 0.07% of the total SAC area.

Discharge modelling shows that the resulting suspended sediment plume discharged from the proposed marine diffuser will disperse away from the site following a trajectory north and east of the Ireland's Eye coastline. This will therefore not impact on the sublittoral reef area recorded on the northern and eastern parts of this island within the Rockabill to Dalkey Island SAC.

Impact

The impact of the discharged plume into the Rockabill to Dalkey Island SAC will be long-term (the lifetime of the outfall discharge). However, the magnitude of this impact is expected to be negligible for the Annex II designated species, harbour porpoise, as this area constitutes a small fraction of the animal's habitat range, and would be imperceptible above background conditions for the majority of the time with no significant effect on the animals foraging ability or behaviour. Therefore, it is considered that the likely impact significance is Minor. The plume is also unlikely to impact the designated sublittoral reef features within the SAC as the plume is predicted to disperse and dissipate away from these locations. Therefore, with no magnitude of impact, the predicted significance of this impact will be none or Negligible.

Pollution

All discharges to the aquatic environment from sewerage systems owned, managed and operated by water service authorities require a wastewater discharge licence or certificate of authorisation from the EPA. This authorisation process provides for the EPA to place conditions on the operation of such discharges to ensure that potential effects on the receiving water bodies are limited and controlled, with the aim of achieving good surface water status and good groundwater status. The proposed WwTP will require a wastewater discharge licence to be granted by the EPA under the Waste Water Discharge (Authorisation) Regulations 2007 (S.I No. 684 of 2007) prior to commissioning.

Impact

The risk of an impact by pollution from the discharge plume will be long-term (the lifetime of the outfall discharge). However, the magnitude of this impact is expected to be negligible based on the standards applied to the discharge from the proposed WwTP. Furthermore, the dispersion qualities predicted by the model show that, should a problem occur and the discharge fails to meet the criteria outlined in the regulations, levels will dissipate quickly from the diffuser. Consequently, the predicted significance of this impact will be none or Negligible.

Benthos and Reef

The potential impacts on the benthos near the proposed marine diffuser are expected to be low, as a result of increased nutrient enrichment through elevated primary productivity.

The marine benthic macroinvertebrate communities within this area of the Irish Sea currently cover a number of habitat types, mostly granular in nature (sands and gravels). The benthic surveys generally indicated a relatively high diversity and species abundance indicative of a thriving benthic population in and around the proposed outfall pipeline route (marine section). For this to exist, the sediments are regularly replenished with organic material transported into the area by currents and suspended solids, which provide an important food source to both the infaunal and epifaunal communities. However, these animals have evolved over time to exist in a variety of habitats with different levels of organic enrichment and oxygen. Consequently, benthic communities, including those around the proposed outfall pipeline route (marine section), can tolerate large variations in organic enrichment, and subsequently oxygen levels, as conditions around them change. A typical community change as a result of organic enrichment, generally resulting from depleted oxygen levels from microbial respiration, is a notable increase in the number of small opportunistic species creating high species dominance. The reverse is generally true for low organic (subsequently high oxygen) communities where the number of species can be high but are represented by relatively few individuals. This latter group can help to regulate the conditions on the seabed through bioturbation, where the fauna reworks the substrates and creates burrows and tubes which maintain oxygenation of the lower sediments throughout the flow of oxygenated water into the interstitial spaces.

The proposed outfall pipeline route (marine section) will create a plume of nutrient-enriched waters which will mostly disperse naturally on the prevailing tidal currents over a large area. The siting of the outfall has been undertaken based on modelling of the oceanography to maximise the dilutions and spread of this material so that localised enrichment will not occur. However, as the levels of DIN will increase slightly within close proximity of the marine diffuser, there is a possibility of increased organic enrichment to the seabed through increased primary productivity and organic flux to the seabed via the food chain, particularly during the summer months, when sea temperature and light conditions are suitable for photosynthesis.

A summary of the different increases in DIN modelled are given in Chapter 8 Marine Water Quality in Volume 3 Part A of this EIAR.

Results show that the dissipation of DIN over the area will not create eutrophication and associated decrease in oxygen levels in the sediments around the proposed outfall pipeline route (marine section). A similar example is demonstrated from a benthic monitoring programme in Massachusetts Bay conducted by the Massachusetts Water Resource Authority. This was to investigate soft-bottom sediment and macroinvertebrate conditions surrounding a similar secondarily treated wastewater outfall located 15 kilometres offshore (Nestler et al. 2013). The study was based on long-term monitoring over a 20-year period (between 1992 and 2012) and a relocation of an outfall in the year 2000, following concerns about potential effects of the discharge on the offshore benthic environment. These concerns focused on three issues: (1) eutrophication and related low levels of dissolved oxygen; (2) accumulation of toxic contaminants in depositional areas; and (3) smothering of animals by particulate matter.

The study included surveys of sediments and soft-bottom communities at 14 near-field and far-field stations using traditional grab sampling, as well as sediment profile imaging and other camera techniques. Sediment conditions were characterised based on spore counts of the anaerobic bacterium, *Clostridium perfringens*, along with analyses of the macroinvertebrate community, sediment grain size composition and TOC. Results from the latest survey were consistent with previous monitoring results at this site and showed that the latest concentration of *C. perfringens* were highest at sites closest to the discharge, indicative of some solids from the treated wastewater at sites in close proximity (within 2km) to the outfall, but no variation was recorded within sediment grain size or TOC analysis (Diagram 9.8). An assessment of the macrofauna similarly indicated that there were no statistical impacts attributable to the outfall (Diagram 9.8), with some minor fluctuations recorded between years, reflecting regional population changes over time. The sediment profile imaging survey found no detrimental impact from the wastewater discharge resulting in low levels of dissolved oxygen in near-field sediments. The average thickness of the oxygenated sediment layer was greater in 2012 than previously reported during the baseline period.

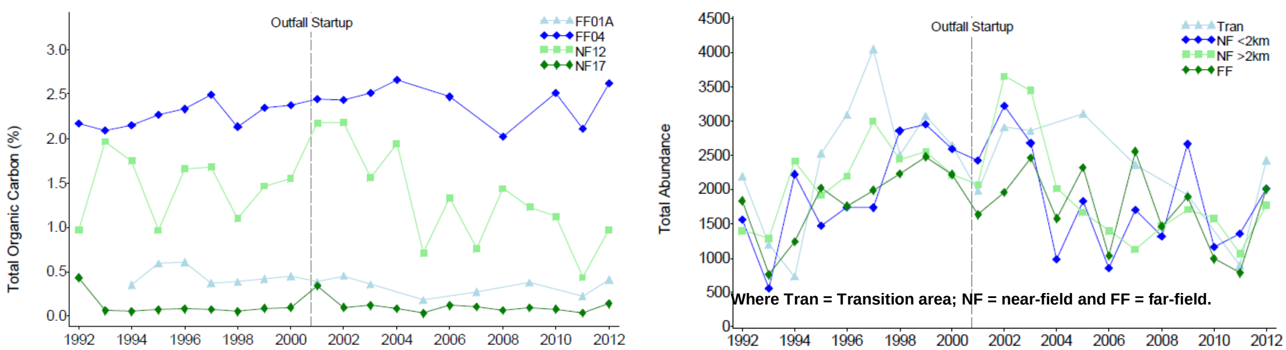

Diagram 9.8: (A) Mean Concentrations of Total Organic Carbon and (B) Infaunal Abundance in Four Areas of Massachusetts Bay (1992 to 2012)

Impact

The modelling of the discharge shows that the discharge from the proposed marine diffuser will disperse and dissipate over a large area. This is predicted to have negligible long-term impacts to the marine benthos with possible minor changes recorded within the immediate vicinity of the proposed marine diffuser. The ecological value of the benthos is negligible, and therefore the significance of impact on the benthos in this area is likely to be Negligible. At a distance of >750m from the proposed marine diffuser location, the reef features within the Ireland's Eye SAC are not predicted to be impacted by the dispersed discharge. Therefore, the significance of the impact is predicted to be none or Negligible.

Plankton

Although the level of DIN may imperceptibly increase regionally over a larger area, the impact to primary productivity and possible eutrophication to the surrounding sediments is expected to be negligible owing to the dispersion predicted by the hydrodynamic model. Where minor increases in DIN are recorded, this is likely to have a minor increase in phytoplankton productivity during the summer months. This may have a further enhancement to both the zooplankton populations and other biota further up the food chain (e.g. fish, suspension feeders, birds and marine mammals) where recorded.

Impact

The modelling of the discharge shows that the discharge from the proposed marine diffuser will disperse and dissipate over a large area. Any increase in the levels of nutrients that does occur within the water column in the surrounding waters of the proposed marine diffuser is likely to have a negligible increase in phytoplankton activity (during the summer months) and, consequently, impact on some dependent groups further up the food chain. However, this is predicted to be of negligible magnitude and Negligible significance.

Marine Mammals

As for the predicted impact relating to habitat loss, secondary treated wastewater is predicted to have a maximum suspended sediment load of 35mg/l (95th percentile) over a naturally variable annual background of up to 45mg/l. As noted above, this is currently within the range routinely recorded for suspended sediments in this region and would be expected to disperse with the ambient seawater by a factor of 20 within 50m on discharge. Whilst this discharge is expected to provide a localised plume visible to marine mammals, particularly visual hunters such as pinnipeds, the presence of the plume is not expected to have a direct effect on the presence of cetaceans (such as bottlenose dolphins and harbour porpoises), as these species are routinely found in high turbidity shallow waters. However, as active hunters, these species may be attracted towards the proposed marine diffuser in search of prey species that themselves might be attracted to the physical structure of the outfall diffuser, the discharge itself or the increased productivity that may be found surrounding it.

Impact

Owing to possible enhancement of fish life around the proposed marine diffuser location (attracted by the seabed structure and/or possible increased productivity), the impact is likely to be slightly beneficial to the marine mammals, particularly the seals, with a long-term duration (the lifetime of the proposed outfall pipeline route (marine section)) but generally negligible magnitude. This would result in a Negligible Beneficial impact for pinnipeds, but a Minor Beneficial impact to harbour porpoises in magnitude. However, as this area represents only a very small proportion of their foraging range, this significance of this impact is expected to be Negligible.

Marine Fish and Shellfish

The output from the hydrodynamic model indicates that the nutrient enriched plume will not affect inshore water quality as it disperses offshore. A 20-fold dilution will occur within 50m of the proposed marine diffuser. No negative impact on fish or shellfish species is expected at the site, or within the surrounding environment. The potential impacts on water quality, primarily as a result of elevated DIN levels, may impact on primary productivity in the immediate vicinity of the proposed marine diffuser, which in turn will pass up the food chain through increased zooplankton, although water quality is expected to increase in the area overall as a result of the Proposed Project.

Effluent based nutrient enrichment may stimulate excessive algal growth locally, which has the potential to affect trophic interactions in the immediate vicinity of the proposed outfall pipeline route (marine section) (including the proposed marine diffuser) (Owili 2003). Through altering the food availability for various organisms, this may in turn impact localised commercial fish and shellfish populations positively or negatively. Other potential impacts may include bioaccumulation of in/organic compounds and depletion of oxygen in the immediate locale of the plume (Owili 2003). The findings of the hydrodynamic model indicate that the nutrient enrichment levels anticipated, and the modelled rate of dispersion offshore, are likely to have a negligible impact both locally and regionally upon fish and shellfish populations.

Impact

The potential to increase a food source as well as the existence of a seabed structure over a long-term duration (the lifecycle of the Proposed Project), may increase fish densities in the area, although the level of this impact is expected to be of negligible magnitude for both fish (including migratory fish) and shellfish. The significance of this impact is expected, therefore, to be Negligible but beneficial throughout.

A summary of the operational impacts is shown in Table 9.25 .

Table 9.25: Summary of Impacts During the Operational Phase on Marine Ecology

Activity	Impact	Receptor	Ecological Value	Magnitude	Duration	Significance
Operation	Loss of habitat	Harbour porpoise	Very high	Negligible	Long-term	Minor (Negligible due to proportion of range and impact type)
		Reef	Very high	None	Long-term	None or Negligible
	Water quality	Benthos	Negligible	Negligible	Long-term	Negligible
		Reef	Very high	None	Long-term	None or Negligible
		Plankton	Negligible	Negligible	Long-term	Negligible
		Harbour porpoise and bottlenose dolphins	Very high to medium	Negligible (potentially beneficial due to increased productivity)	Long-term	Minor Beneficial (Negligible due to proportion of range) to Negligible Beneficial
		Pinnipeds	Medium	Negligible (potentially beneficial due to increased productivity)	Long-term	Negligible Beneficial
		Fish (including salmonids)	Low to medium	Negligible	Long-term	Negligible Beneficial
		Shellfish	Low (shellfish waters nearby)	Negligible	Long-term	Negligible Beneficial

9.6 'Do Nothing' Impact

The impact to the current ecological status based on a 'do nothing' scenario is likely to be Negligible, with a potential for increased pressures from deteriorating water quality conditions in certain locations during certain times of the year or during peak events (such as storms). However, overall, no significant change is expected within the current marine ecology environment.

9.7 Mitigation Measures

9.7.1 Construction Phase

The use of trenchless construction methods beneath the Baldoyle Estuary SAC will minimise the impact to the marine ecology in the sensitive inshore areas during construction, although there is a minor risk of an air or bentonite breakout. On completion of the tunnel, the remainder of the planned surface construction is based on dredging in the offshore location. Additional mitigation will be required to minimise the impacts of noise and suspended sediments in order to prevent negative interaction with sensitive receptors in the area (in particular the cetaceans and the pinnipeds). A summary of mitigation for the marine ecology is summarised in Table 9.26. This mitigation is also included in the Outline CEMP, which will form part of the contract documents. Irish Water will be responsible for ensuring all mitigation measures are implemented and complied with by the contractor(s).

Table 9.26: Summary of Proposed Mitigation Requirements for Marine Ecology

Activity	Area at Risk	Sensitive Receptor	Mitigation Required
Construction Phase			
Microtunnelling Beneath Baldoyle Estuary	Leakage of pollutants and suspended sediment loads from compound into estuary	Feeding birds, benthos and juvenile fish	No discharges to estuary under any circumstances. Managed operations with bunded storage areas and sediment settlement areas. CEMP including Surface Water Management Plan.
	Air breakout to surface		Management of pressures No surface mitigation required
	Bentonite breakout		Managed volumes and pressures of bentonite used.
	Noise and vibration	All marine ecology	No mitigation required.
Dredging for the proposed outfall pipeline route (marine section)	Habitat loss	Benthos area of 0.04km^2 by removal and 0.12km^2 by smothering	No mitigation required.
	Suspended sediments	Impact to Annex I Reef within SAC	Dredging discharges from the hopper will be restricted to flooding tides only. Monitoring of plume during dredging operations (see text below table).
		Other marine ecology	No mitigation required.
	Noise and vibration if option for piling in a caisson for connection with dredging required	Marine mammals	Detailed mitigation plan (see text below table) required and seasonal considerations. Passive acoustic monitoring and marine mammal observers (MMOs) to establish safe zone.
	Noise and vibration of dredging	Marine mammals	Minimise duration of dredging operations. Monitoring of acoustic output levels and carrying out marine mammal observations.
		Fish	No mitigation required.
	Pollution	All marine ecology	Implementation of CEMP. This includes strict adherence to MARPOL guidelines, auditing of CEMP, bunded storage areas for fuels and control of compound drainage, etc. No discharge or disposal of waste to sea under any circumstances.
Installation of proposed marine diffuser	Habitat disturbance	Benthos	No mitigation required.
	Noise and vibration	Marine mammals	Minimise duration of dredging operations. Monitoring of acoustic output levels and carry out marine mammal observations.
Operational	Habitat loss	Benthos on-site	No mitigation required.
		Annex I Reef (Ireland's Eye)	No mitigation required.
	Pollution	All marine ecology	Output to be secondary treated with strict targets for suspended sediment and DIN level outputs (see Chapter 4 Description of the Proposed Project in Volume 2 Part A of this EIAR).

Monitoring of Plume During Dredging Operations

The turbidity will be monitored using a buoy-mounted turbidity meter with telemetering back to the dredger to monitor potential impacts from dredging activity. As the reef is only prone to sedimentation during slack water periods, a slightly elevated level of Total Suspended Solids (TSS) up to 40mg/l (the natural standard deviation for the year) above a daily background will be permitted off the northern coastline of Ireland's Eye. If this level increases above this threshold as a result of dredging activity, then the discharge of material will be temporarily halted to allow the resulting plume to disperse. This is particularly important 30 minutes before and after slack water where increased suspended sediments can settle within the SAC.

Microtunnelling – Bentonite Breakout

The control and management of pressures during the microtunnelling processes will be undertaken to prevent air and bentonite breakouts. However, in the unlikely event of a bentonite breakout occurring, which results in a saltmarsh area high up on the foreshore being covered, intervention will be required. Intervention will involve washing the vegetation using a seawater pump and spray. Typically, this would be carried out during a high water period where washings can disperse out of the estuary naturally. Sites will only be accessed by foot (without the use of plant). Should bentonite breakout in a saltmarsh area lower down on the shoreline in areas routinely covered by seawater, this will be left to disperse naturally over the tidal cycle.

All bentonite usage will be monitored through materials balance calculations, pressure monitoring in the lines and above ground visual assessment of the works to ensure that, should a breakout occur, the volume is minimised. In the event of a bentonite breakout, the site will be monitored for chemistry and macroinvertebrate communities to ensure no residual impacts. This may include both benthic and water quality measurements.

Increased Suspended Solids

Disturbance of intertidal and subtidal habitats will be minimised so as to reduce the creation of suspended solids within the marine and estuarine habitats. The tunnelling compound spanning either side of the Baldoyle Estuary will be subject to surface water management as part of the CEMP to prevent all runoff into the watercourses and the estuary.

The potential for an accidental release of bentonite will be minimised by closely monitoring its use during all works.

Dredging works in the shallow areas will be carried out using a backhoe dredger with the spoil side cast at the seabed to minimise the lifting of the bucket through the water column. This will reduce losses of suspended sediments from this material and preserve the sediment composition as much as possible at bed level. Dredging carried out close to the Ireland's Eye SAC will be carried out on neap tides where possible. Monitoring of turbidity will be carried out during peak dredging activity, and operations will be restricted to flooding tides if a plume is detected >50mg/l TSS above background on the northern coastline of Ireland's Eye.

Noise and Vibration Pollution

Noise and vibration from the microtunnelling and dredging operations during the construction of the proposed outfall pipeline route (marine section) (including the proposed marine diffuser) will be minimised by selecting the most appropriate equipment, dependent upon ground conditions and noise signatures. The specifications of piling systems for caisson deployments for the construction of the proposed marine diffuser, the interface connection with the microtunnelling or the fibre optic cable crossing will be assessed for likely noise outputs to assess noise impacts when working within the Rockabill to Dalkey Island SAC.

Mitigation will be undertaken during piling and dredging works to ensure the are no noise impacts to marine mammals (including harbour porpoises) near the works. This will include MMOs using a high frequency hydrophone system to establish an operational safe zone around the site. This will prevent the commencement of operations in the event that sensitive receptors (pinnipeds and cetaceans) are observed within this perimeter. The following mitigation measures will also be implemented:

- Following appropriate guidelines from the regulatory authorities, the NPWS (2014), the following measures are proposed to remove the risk of direct injury to marine mammals in the area of operations: A trained and experienced MMO will be put in place during piling, dredging and pipeline laying. The MMO will scan the surrounding area to ensure no marine mammals are in a pre-determined exclusion zone in the 30-minute period prior to operations. It is proposed that this exclusion zone is 500m for dredging activities and 1,000m for piling activities. No works will take place should mammals be recorded in the exclusion zone.
- Noise-producing activities will only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring is not possible, the sound-producing activities will be postponed until effective visual monitoring is possible. Visual mitigation for marine mammals (in particular harbour porpoise) will only be effective during daylight hours and if the sea state is 2-3 or less (Beaufort scale) or less.
- For piling activities, where the output peak sound pressure level (in water) exceeds 170dB, a ramp-up procedure must be employed following the pre-start monitoring. Underwater acoustic energy output will commence from a lower energy start-up and thereafter be allowed to gradually build up to the necessary maximum output over a period of 20 to 40 minutes.
    - Once operations have begun, operations will cease temporarily if a cetacean or seal is observed swimming in the immediate (<50m) area of piling and dredging and work can be resumed once the animal(s) have moved away.
    - Any approach by marine mammals into the immediate (<50m) works area should be reported to the NPWS.
    - If there is a break in piling activity for a period greater than 30 minutes, then all pre-activity monitoring measures and ramp-up will recommence as for start-up.
- Once normal operations commence (including appropriate ramp-up procedures), there is no requirement to halt or discontinue the activity at night-time, nor if weather or visibility conditions deteriorate, nor if marine mammals occur within a radial distance of the sound source that is 500m for dredging works, and 1,000m for piling activities.
- The MMO will keep a record of the monitoring using 'MMO form location and effort (coastal works)' available from the NPWS and submit to the NPWS on completion of the works, as described in the NPWS guidance (2014).
- In order to reliably quantify the zone of responsiveness associated with the proposed programme of piling activities associated with the interface pit or cable crossing, a vessel-deployed hydrophone will be used to confirm the sound source level of the operation. Additionally, passive acoustic monitoring will be used to provide additional support to the identification of harbour porpoises or other cetaceans within the survey area. The effective range of the passive acoustic monitoring system will be dictated by the frequency, with the ultra-high frequency used by porpoises likely to be limited to within 500m of the passive acoustic monitoring system.

Pollutants and Waste

A detailed CEMP will be established prior to construction (see Outline CEMP). This will follow best practice for the storage, handling and disposal of hazardous/non-hazardous materials to prevent chemical pollution. All fuels or chemicals kept on the construction site will be stored in protected containers, and all refuelling and maintenance will be carried out in bunded containment areas. Refuelling and maintenance in areas draining directly to water habitats will be avoided where possible. Oil interceptors will also be installed in appropriate locations. Equipment will be regularly maintained and leaks repaired immediately. Accidental spillages will be contained and cleaned up immediately. Remediation measures will be carried out in the unlikely event of pollution of the marine environment.

9.7.2 Operational Phase

The Sustainable Drainage Systems in place at the proposed WwTP and Abbotstown pumping station will need to be maintained to ensure proper functioning during the operation of the Proposed Project.

9.8 Residual Impacts

A summary of the residual impacts where non-negligible impacts were identified and where options for mitigation can be applied are outlined in Table 9.27.

Table 9.27: Summary of Residual Impacts following Proposed Mitigation Measures on the Marine Ecology

Activity	Impact	Receptor	Ecological Value	Significance (Pre-Mitigation)	Mitigation Description	Residual Significance
Tunnelling beneath Baldoyle Estuary	Air breakout	Saltmarsh habitat	Very high	Minor	Pressure management	Negligible to Minor
	Bentonite breakout	Saltmarsh habitat	Very high	Minor		Negligible
Dredging of outfall	Suspended sediment plume	Migratory fish and pinnipeds	Medium	Minor	None expected due to very limited exposure	Negligible
		Reef habitat (SAC)	Very high	Minor to Moderate	Turbidity monitoring and control of timings during peak periods if plume effects detected	Negligible
		Harbour porpoise (SAC)	Very high	Minor	No mitigation possible	Minor
	Noise and vibration	Harbour porpoise	Very high (SAC)	Minor	Restricting operations around marine mammal observations and passive acoustic monitoring. Possible seasonal restrictions	Negligible
Tunnel interface using piling and/or caisson installation	Noise and vibration	Pinnipeds	Medium	Minor		Negligible
		Harbour porpoise and bottlenose dolphins	High	Minor		Negligible
		Migratory fish	Medium	Minor	No mitigation possible	Minor
Installation of proposed marine diffuser	Noise and vibration	Harbour porpoise	Very high (SAC)	Minor	Restricting operations around marine mammal observations and passive acoustic monitoring. Possible seasonal restrictions	Negligible

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