

11 Biodiversity

11.1 Introduction

This chapter describes the likely significant direct and indirect effects of the proposed development on biodiversity, including flora (plants), fauna (animals), and habitats in both the terrestrial and aquatic environment.

Chapter 4 provides a full description of the proposed development whilst **Chapter 5** describes the Construction Strategy. The following aspects are particularly relevant to the biodiversity assessment:

- Design:
 - The landscaping at the Alps and along River Walk, and at the WwTP site, will provide some opportunities for habitat creation and mitigation of direct and indirect effects on biodiversity including plants, animals and habitats in the terrestrial environment of Arklow town.
- Operation:
 - Discharge of untreated effluent to the Avoca River and Estuary will cease; and
 - Treated effluent will discharge to the Irish Sea via a 900m long sea outfall fitted with a diffuser. A separate storm water overflow (SWO) will discharge screened stormwater to inshore coastal waters.
- Construction:
 - Construction activities have the potential to impact on terrestrial biodiversity. Specifically, some of the working areas will require tree removal, vegetation clearance and works on structures that are currently used by bats to accommodate construction activities;
 - Construction activities occurring within the Avoca River channel and within the Irish Sea have the potential to impact on aquatic ecology; and
 - Construction activities will be undertaken in the vicinity of invasive plant species.

11.2 Assessment Methodology

11.2.1 General

The biodiversity assessment addresses the likely significant direct and indirect effects of the proposed development on terrestrial and aquatic (including marine) biodiversity, including flora, fauna and habitats in proximity to the site.

The assessment has been carried out in three stages:

1. Desktop assessment to determine existing information and records in relation to:
 - Sites, species and habitats protected under Council Directive 92/43/EEC (Habitats Directive), and sites and species protected under Council Directive 2009/147/EC (Birds Directive)¹, within 15km of the proposed development and more distant hydrologically linked sites; and
 - Biodiversity, habitats and species present in the vicinity of the proposed development.
2. Site visits and field surveys by the specialist aquatic and terrestrial ecologist teams (as described in detail below – Refer to **Appendix 1.2** for team competencies), to establish the existing ecological conditions within the footprint of the proposed development and within the vicinity of all of the proposed development elements. The site visits and field surveys include terrestrial, river, estuarine, and marine surveys.
3. Evaluation of the proposed development and determination of the scale and extent of likely direct and indirect significant effects on biodiversity (i.e. flora, fauna and habitats) and the provision of appropriate mitigation and monitoring.

The ecology team that carried out the biodiversity assessment is as follows:

- BEC Consultants carried out marine, estuarine, and freshwater aquatic ecological surveys;
- Brian Keeley Ecologist and bat licensed specialist carried out bat surveys and assessments; and
- Eleanor Mayes Ecological Consultant carried out terrestrial flora and habitat surveys and assessments, invasive plant surveys, and bird surveys and assessments, and is the lead ecologist for the proposed development.

11.2.2 Guidance and Legislation

The biodiversity assessment has been prepared with reference to the following legislation and guidance:

- Wildlife Acts 1976 to 2018;
- European Communities (EC) (Birds and Natural Habitats) Regulations 2011 – 2015;
- Council Directive 2009/147/EEC, i.e. Birds Directive;
- Council Directive 92/43/EEC (as amended), i.e. Habitats Directive;
- Flora (Protection) Order, S.I. No. 356 of 2015;

¹ Natura 2000 sites, referred to as European sites in Part XAB of the Planning and Development Act 2000 (as amended); these terms are synonymous

- Heritage Council (2011) Best Practice Guidance for Habitat Survey and Mapping;
- Fossitt (2000) A Guide to Habitats in Ireland;
- Transport Infrastructure Ireland (incorporating the National Roads Authority, Revision 1, December 2010). Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Road Schemes;
- National Parks and Wildlife Service, Department of Environment Heritage and Local Government (2006) Bat Mitigation Guidelines for Ireland;
- DoEHLG, (2010). Appropriate Assessment of Plans and Projects in Ireland - Guidance for Planning Authorities – February 2010 edition;
- Department of Arts, Heritage and the Gaeltacht (2014)² Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters;
- EC (2002) Assessment of plans and projects significantly affecting Natura 2000 sites;
- EC (2007) Managing Natura 2000 Sites: Guidance document on Article 6(4) of the Habitats Directive 92/43/EEC;
- EU (2013) Guidelines on Climate Change and Natura 2000: Dealing with the impact of climate change on the management of the Natura 2000 Network of areas of high biodiversity value;
- CIEEM (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal;
- Inland Fisheries Ireland (2016) Guidelines on Protection of Fisheries during Construction Works in and adjacent to Waters
- EPA (2017) Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports; and
- EU (2017) Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU);

11.2.3 Study Area

11.2.3.1 Study area for Terrestrial Biodiversity and Bird Surveys

The study area for desk studies is detailed in **Section 11.2.6.1** and illustrated in **Figure 11.1 in Volume 3**.

The study area for terrestrial biodiversity surveys was defined to include all areas associated with the proposed development, including interceptor sewer route options considered during the development of the design, working areas and construction compounds.

² issued as an official guideline and code of practice under Regulation 71 of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011)

Some adjoining lands, including lands around Arklow Pond, were included in the study area in order to provide context and baseline information on ecological corridors in the vicinity of the proposed development.

Waterbird surveys were carried out at Arklow Ponds as well as in the Avoca River and Estuary, because some waterbird species were observed to be moving between these areas. Marine inshore waters were also covered in bird surveys. These study areas are illustrated in **Figure 11.3 in Volume 3**.

Bat surveys included some additional areas outside the main study area, in order to facilitate assessment of potential cumulative effects of the proposed development with the proposed Arklow Flood Relief Scheme: Brigg's Lane behind Ferrybank and along the eastern margin of Arklow Town Marsh pNHA, and along the Avoca River immediately downstream of the M11 flyover (Refer to **Figure 11.1 in Volume 3**).

11.2.3.2 Study Area for Aquatic Biodiversity Surveys

The study area for desk studies is detailed in **Section 11.2.6.1**. The study area for aquatic biodiversity surveys was within the Avoca River from just upstream of the M11 flyover down to its point of discharge into the Irish Sea (i.e. the harbour mouth), with benthic sampling extending out into the Irish Sea. The locations of the freshwater sample stations are illustrated in **Figure 11.2 in Volume 3**, while the estuarine and marine sample stations are illustrated in **Figure 11.3 in Volume 3**.

Marine mammals are vulnerable to man-made sound sources, thus the distribution of cetaceans (whales, dolphins and porpoises³) within Irish territorial waters, the Irish Sea, and in waters off Arklow are all potentially relevant to identifying the main areas of distribution of recorded species in the context of the proposed development. The catchment of the Avoca River is relevant to the consideration of migratory fish species, including Habitats Directive Annex II listed species, that move between marine and fresh waters through the Avoca Estuary.

³ All cetacean species are listed as species of community interest in need of strict protection in Annex IV of the Habitats Directive

11.2.4 Site Visits

Field survey dates for the different baseline biodiversity elements are given in Table 11.1.

Table 11.1: Biodiversity field survey dates

Biodiversity Survey Element	Survey dates
Flora and habitat and breeding bird surveys	27 June 2016, 10 August 2016, 26 April 2017, 22 August 2017, 12 April 2018, 16 May 2018
Invasive plant species surveys	10 August 2016, 26 April 2017, 22 August 2017, 12 April 2018, 16 May 2018
Waterbird surveys	16 September 2016, 25 October 2016, 24 November 2016, 8 December 2016, 28 January 2017, 24 February 2017, 29 November 2017, 13 February 2018
Bat survey WwTP site	27 June 2016, 22-23 August 2017
Bat survey River Walk, Arklow Castle, The Alps, Arklow Bridge, and the northern bank of the Avoca River at Ferrybank including Brigg's Lane	17 and 19 October 2016, 22 to 29 August 2017
Estuarine and marine benthic survey	24 April 2017
Estuarine walk over survey	25 April 2017
Freshwater macroinvertebrate survey	26 September 2017

11.2.5 Consultation

In its response to the Scoping Report, the EPA indicated that this biodiversity assessment should identify the direct and indirect significant effects of the proposed development on biodiversity, with particular attention to species and habitats protected under the Habitats Directive and the Birds Directive.

Consultation meetings were held with Inland Fisheries Ireland, on 16 March 2018, and with National Parks and Wildlife Service (NPWS) on 27 June 2018, in respect of the proposed development and the proposed Arklow Flood Relief Scheme. Issues discussed related to the Arklow Wastewater Treatment Plant Project included the following:

- An overview of the project was provided;
- Discussion on the design development and baseline biodiversity studies undertaken;
- Habitats Directive Annex II listed fish species that migrate through the Avoca Estuary, potential for River Lamprey adults and larvae to be present in works areas, protocols to remove/protect fish during construction, and seasonal restrictions of in-stream works;
- Water quality protection during construction;
- Habitats Directive Annex IV listed bat species, roost locations including Arklow Bridge, requirements for bat derogation licence and mitigation; and

- Relative proximity to coastal European sites, advice that coastal processes including longshore drift be studied and documented, to facilitate the assessment of potential ex situ effects on these sites to arise from the marine outfalls and revetment upgrade.

Inland Fisheries Ireland provided Avoca River Estuary fish data from monitoring carried out under the Water Framework Directive in 2015.

The NPWS provided information on bat roosts in Arklow, and data on the distribution of the protected plant species⁴ *Equisetum x moorei* in the Arklow area outside the planning boundary of the proposed development.

11.2.6 Categorisation of the Baseline Environment

11.2.6.1 Desk Study

The desk studies carried out accessed information held by the following:

- NPWS metadata website, and NPWS protected plant species data;
- National Biodiversity Data Centre (NBDC) database;
- EPA;
- Inland Fisheries Ireland reports and data;
- Bat Conservation Ireland database;
- Wetland Surveys Ireland database; and
- I-WeBS data held by BirdWatch Ireland. The Irish Wetland Bird Survey (I-WeBS) is a joint scheme of BirdWatch Ireland and the National Parks and Wildlife Service (NPWS).

A literature review of published information on flora and fauna occurring on site and in the surrounding terrestrial, marine, estuarine and riverine environment was also carried out. The geographical extent of the biodiversity desk study varies with the species being considered as outlined in **Section 11.2.3**.

11.2.6.2 Terrestrial Flora and Habitat Survey

Walkover flora and habitat surveys were carried out to determine species composition and distribution in the study area (Refer to **Figure 11.1 in Volume 3**).

⁴ Flora (Protection) Order, S.I. No. 356 of 2015

Habitats present were classified in accordance with Fossitt⁵, and also having regard to Heritage Council⁶, in order to provide a basis for habitat evaluation. Plant species scientific nomenclature follows Parnell and Curtis⁷, common names follow Scannell and Synnott⁸ when common names are not given in Parnell and Curtis.

Habitats are small scale within the urban landscape of the proposed development, and have been subject to change during the course of the baseline studies, so they are described in the text provided, and illustrated by photographs rather than by habitat mapping.

Birds and mammals or mammal signs were also recorded during walk-over surveys.

11.2.6.3 Invasive non-native Plant Survey

Walk over surveys were carried out within the study area (Refer to **Figure 11.1 in Volume 3**), in order to check for the presence of invasive non-native plant species listed in Part 1 of the Third Schedule⁹.

Additional species listed as invasive non-native plant species in the NRA Guidelines¹⁰ were also recorded, together with non-native species encountered that can be spread through distribution of plant material.

A handheld mobile mapper was used during field survey to record the location and extent of any invasive species encountered, together with notes on the characteristics of each stand encountered and the associated plant species, as appropriate.

11.2.6.4 Bird Surveys

Breeding and non-breeding birds, including wintering waterbird surveys were carried out on the dates listed in Table 11.1. The following areas were surveyed:

- Avoca River upstream of Arklow Bridge
- Avoca Estuary east of Arklow Bridge, including the harbour on the South Quay
- Coastal waters within 1.5 km of the shoreline, and shorelines to the north and south of Arklow Harbour (**Figure 11.3 in Volume 3**)
- Arklow Pond, accessed from Seaview Avenue (**Figure 11.1 in Volume 3**)

5 Fossitt, Julie A (2000). A Guide to Habitats in Ireland. The Heritage Council.

6 Best Practice Guidance for Habitat Survey and Mapping (Heritage Council, 2011)

7 Parnell, John, and Tom Curtis (2012). Webb's An Irish Flora. Cork University Press

8 Scannell, Mary J.P, and Donal M. Synnott (1987). Census catalogue of the Flora of Ireland. Stationery Office, Dublin.

9 Part 1 of the Third Schedule, European Communities (EC) (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477/2011)

10 Transport Infrastructure Ireland (incorporating the National Roads Authority) Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Road Schemes (Revision 1, December 2010)

Counts were carried out using binoculars and a telescope fitted with a 32X wide angle lens or a 25-60X zoom lens, during a range of tidal conditions including spring tides and neap tides, at high and low water. Waterbirds and sea birds present were identified and counted, and their activity noted (feeding, roosting, bathing and preening).

All bird species observed during flora and habitat surveys (within the study area shown in **Figure 11.1 in Volume 3**) were recorded, together with bird activities indicative of possible, probable, or confirmed breeding.

11.2.6.5 Bat Surveys

There are a number of specific areas that were targeted for detailed examination, in addition to a general evaluation of bat activity and presence within the planning boundary and adjacent lands:

- WwTP site: the derelict wallboard factory buildings and site;
- Interceptor sewer working areas on the northern bank upstream of Arklow Bridge (that overlap with the proposed Arklow Flood Relief Scheme);
- The Alps area (below the ruined remains of Arklow Castle, confirmed by NPWS as a pipistrelle roost several years previously), and Avoca River corridor immediately upstream (that also overlap with the proposed Arklow Flood Relief Scheme);
- Trees and existing bat boxes on River Walk upstream of Arklow Bridge;
- Arklow Bridge (overlap with proposed the Arklow Flood Relief Scheme);
- The footprint of the embankment area at the eastern margin of Arklow Town Marsh pNHA included as part of the proposed Arklow Flood Relief Scheme; in order to facilitate assessment of cumulative effects of the proposed development with the proposed Arklow Flood Relief Scheme;
- Avoca River corridor immediately upstream of ‘the Alps’ site (included as part of the footprint for the proposed Arklow Flood Relief Scheme) in order to facilitate assessment of cumulative effects of the proposed development with the proposed Arklow Flood Relief Scheme;
- Avoca River corridor downstream of M11 flyover (included as part of the footprint for the proposed Arklow Flood Relief Scheme) in order to facilitate assessment of cumulative effects of the proposed development with the proposed Arklow Flood Relief Scheme

WwTP

The Old Wallboard site at Ferrybank was examined over two consecutive years in 2016 and 2017 for evidence of roosting bats. Surveys were undertaken in daylight for evidence of roosting bats and from prior to sunset for two hours. The site was visually inspected for the presence of bat roost evidence in the buildings on site prior to sunset with the aid of a high-powered beam.

The bat detector assessment commenced prior to dusk (21.30 hours with sunset at 21.53 hours in June 2016 and in 2017, sunset was at 20.33 hours on 23rd August).

Surveying continued for two hours before a pause in surveying and recommencement over one and a half hours before dawn (03.30 hours, sunrise 05.03 hours in 2016 and sunrise at 06.22 hours on 24th August in 2017).

A Song Meter 2 BAT+ (SM2 bat detector) was placed within the site along the edge of the main building for a period of two hours and was then moved at 23.44 hours to the second smaller building closer to the river from this time up to dawn in 2016. In 2017, the SM2 bat detector was again placed on the perimeter of the main building within the site and remained here throughout the survey period. An EM3 and Pettersson D240X were carried for the entire survey and bat activity and species present were noted throughout the site. Additionally, bat activity along the roadway leading to the site was observed and noted.

Interceptor sewer routes and other infrastructure

Bat activity at a number of points along and adjoining the proposed route of the interceptor sewers including Arklow Castle, the Alps, River Walk and the northern bank of the Avoca River close to the Ferrybank roundabout were all assessed in 2016. A further survey period was undertaken on 17 and 19 October 2016. This involved 2 post dusk assessments and 1 pre-dawn survey. On 17 October, there were two areas of assessment; a Cypress treeline at Ferrybank near the northern bank of the Avoca River upstream of Arklow Bridge (this treeline was subsequently felled to facilitate a separate development), and the ruins of Arklow Castle.

The 2016 survey involved the placing of a bat monitor at the side of the ruined castle within the grounds of the Courthouse prior to dusk and monitoring at this location until one hour after sunset (18.24 hours). The trees at Ferrybank were examined from sunset and for 1 hour and 20 minutes for any evidence of bat emergence from these trees. The trees were also examined in daylight for any potential roost cavities or crevices.

Prior to dawn, the area to the rear of Arklow Castle at the Alps was assessed as well as an evaluation of the trees at Ferrybank. During the night, the river was also examined for bat activity between the approach to Arklow Castle and the Cypress trees at Ferrybank.

Surveying was also undertaken in August 2017, a period of the year when many maternity roosts are still intact prior to the autumn disbandment of these gatherings and the formation of lesser mating assemblages and non-breeding groups or individual roosting behaviour. These sites were re-assessed on a number of dates in August including 21, 22, 23, 24 and 28 August up to dawn of 29 August 2017. In addition, the trees and timber bat boxes along River Walk between Arklow the Alps, and Arklow Bridge, were examined in daylight on 22 August 2017 for any evidence of bat activity. A bat detector evaluation of Arklow Bridge was carried out from 21 August to 22 August 2017 (sunset at 20.38 and sunrise at 06.18).

A Schwegler woodcrete bat box at the Arklow Ponds was superficially examined on 23 August 2017 for evidence of bat usage.

Surveying of Arklow Castle was also undertaken in August 2017 and any bat activity around the Castle was sought at dusk and prior to dawn. The family in residence to the rear of the Castle was questioned regarding bat roosts within the Castle and any observations of bats here in recent years.

Surveying included an examination of all areas through which the proposed development passes, from Arklow Castle and the Alps to the WwTP site.

Bat survey conditions and constraints

The survey in June 2016 was carried out on a mild dry night with no wind. There had been rain early in the day but there was no rain at any stage during the night. The Old Wallboard site at Ferrybank is coastal and there is a continuous breeze to the east of the buildings. The remainder of the buildings were sheltered from the breeze. These were ideal conditions for bat activity.

Surveying for bats in late June is a very suitable time to address the summer usage of a site for feeding and commuting and for assessing the use of trees as summer roosts.

The second survey period was a period of mild weather in October 2016 and there was a dry, calm spell that commenced with moderate temperatures and dropping two to three hours after sunset. Bat activity was relatively high especially on 17 October and this is a good representation of the bat fauna in autumn in the survey area. Sunset on 17 October was at 18.24 hours with a temperature of 13 degrees Celsius (°C) and a moderate breeze and dry conditions. Sunset on 19 October 2016 was at 18.20 hours and the temperature at that time was 11 degrees Celsius and cloudy.

The survey in August 2017 was during mild dry weather and bat activity was noted at all periods of the survey. Pre-dawn conditions were cool and dry and bat activity was typically lower during this period. This was a representative survey of the site.

11.2.6.6 Aquatic Ecology Surveys

A desk study was carried out to gather existing information on the aquatic ecology of the study area. This desk study included a review of the NPWS online mapping tool, a review of reports and data held by the NPWS, and a general literature search including Inland Fisheries Ireland reports and publications as described in **Section 11.2.6.1**.

Freshwater macroinvertebrate survey

The macroinvertebrate community of the Avoca River was sampled at six locations on the main channel and at one location on the channel that runs in a south-easterly direction through Arklow Town Marsh (Refer to **Figure 11.2 in Volume 3**) on 26 September 2017. Sweep-samples were taken using a standard pond-net (25cm x 25cm, with 1 mm mesh bag), transferred to a labelled container and preserved in 70% Industrial Methylated Spirits for return to the laboratory for analysis. Basic physico-chemical parameters were recorded at each sample location:

- dissolved oxygen (mg/l and % saturation);
- pH;
- temperature (°C); and
- conductivity (mS/cm).

Also recorded at each sample location were details of the channel morphology and context:

- channel width (m);
- water depth (m);
- discharge;
- siltation;
- water clarity;
- shading;
- filamentous algae;
- slime;
- sewage fungus;
- surrounding land;
- bankside vegetation;
- instream vegetation;
- substratum; and
- other information.

Estuarine and marine benthic survey

Estuarine walkover survey

A walkover survey was carried out on 25 April 2017 in order to identify the intertidal habitats within the relevant sections of the study area. The survey was carried out at low water spring tide in order to be able to view the greatest expanse of intertidal habitat. The study area included the Avoca River estuary and the coast to the north of the river in the vicinity of the alignment of the proposed outfall (see **Figure 11.2 in Volume 3**).

Otter survey

The study area was walked and signs of Otter (*Lutra lutra*) activity noted. Such signs included spraints, slides, and footprints. Where notable otter signs were recorded, a location was recorded using a hand-held global positioning system (GPS) receiver to allow mapping.

Benthic survey

A benthic field survey was carried out on 24 April 2017 using a 0.1m² Day grab deployed from the boat M.V. Sharpshooter.

A total of 13 stations were sampled for macroinvertebrate and sediment analysis (granulometry and total organic carbon (TOC)). As outlined in **Figure 11.3 in Volume 3**, three sample stations were situated within the Avoca River Estuary, while the remaining ten were located outside the breakwaters of Arklow Port. Sample stations were located using the Sharpshooter's on-board GPS system, onto which pre-selected sample station locations were loaded.

The 0.1 m² Day grab was deployed from an A-frame on the survey boat. Sediment samples were taken as a core into the retrieved sediment, labelled and placed in a cooler box. These were subsequently frozen on return to shore. Macroinvertebrate samples were washed through a 1 mm mesh sieve. The residue was transferred to labelled sample containers and fixed with 10% Formalin before being transported back to the laboratory for processing.

Macroinvertebrate sample analysis

In the laboratory, macroinvertebrate samples were logged to track the processing. Each freshwater macroinvertebrate sample was washed through a 1mm sieve and the residue transferred to a white tray for sorting. Macroinvertebrates present were removed and separated by major group for identification and enumeration.

Rose Bengal was added to the marine and estuarine macroinvertebrate samples on arrival in the laboratory in order to aid sorting. After 72 hours, samples were transferred to 70% Industrial Methylated Spirits as preservative prior to sorting and identification. Samples were sorted in a white tray, with animals being transferred to labelled containers and preserved with 70% Industrial Methylated Spirits prior to identification.

The species lists produced were checked against the Pan-European Species directory Infrastructure¹¹. Identification was carried out using stereoscopic and compound microscopes and appropriate keys.

Sediment sample analysis

Sediment analysis for granulometry and TOC was carried out by Nautilus, Dublin.

Data analysis

On completion of estuarine and marine macroinvertebrate and sediment sample analysis, the data were used to describe the benthic environment. R-Statistic was used to carry out data analysis on the macroinvertebrate and sediment data. The following statistical analyses were undertaken:

- **Univariate ecological indices:** On completion of sorting and identification, several ecological univariate ecological indices were calculated to characterise the invertebrate community within the study area. These included Species Richness (number of species), Shannon-Wiener diversity index and Pielou's evenness index.

¹¹ PESI (2017) Pan-European Species directories Infrastructure. Accessed through www.eu-nomen.eu/portal on 2017-05-31.

- **Community structure:** Abundance data were fourth-root transformed to down-weight the importance of the highly abundant species and to give rarer species more importance (Clarke, 1993¹²) and used to calculate a Bray-Curtis similarity matrix. The similarity matrix was then used in cluster analysis to find sample groupings, i.e. samples within a group that are more similar to each other, than they are similar to samples in different groups. Similarity profile routine (SIMPROF) was used to identify significant ($P < 0.05$) groupings and the results were represented graphically on a dendrogram.
- **Sediment:** Sediment data were fourth-root transformed and normalised to equalise variance and standardise contributory importance of each variable. Cluster analysis based on Euclidian distances was used to find sample groupings, i.e. samples within a group that are more similar to each other, than they are similar to samples in different groups. Similarity profile routine (SIMPROF) was used to identify significant ($P < 0.05$) groupings and the results were represented graphically on a dendrogram.

11.2.7 Impact Assessment Methodology

Likely significant direct and indirect effects are assessed during both the construction and operation of the proposed development.

Consideration has been given to the presence of European sites, habitats and species protected under the Habitats Directive, species listed in Annex IV of the Habitats Directive, and sites and species protected under the Birds Directive. The occurrence of mobile species listed as Qualifying Interests for European sites protected under the Habitats Directive ex situ in the zone of influence of the proposed development, has been considered. The sensitivity of individual species to individual construction and operational phase activities has been considered.

Individual assessments of direct and indirect effects on biodiversity, plants, animals, and habitats include reference to the qualitative and quantitative methodologies and guidance listed in **Section 11.2.2**. The description of likely significant effects follows Table 3.3 of the draft EPA guidance¹³.

11.3 Baseline Conditions

11.3.1 Overview of the Area

The Avoca River drains a primarily upland catchment of some 650km², and enters the Irish Sea at Arklow via a short riverine estuary that is largely contained by existing sea and harbour walls. The Avoca River is formed by the joining of the Avonmore and Avonbeg rivers.

The Avonmore River flows from Lough Dan, just west of Roundwood, and flows in a generally south-easterly direction for approximately 30 km before meeting the Avonbeg River (which rises near Table Mountain at the top of Glenmalure valley), just north of the village of Avoca, and becomes the Avoca River.

12 Clarke, K.R. (1993) Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology* 18: 117-143.

13 EPA (2017) Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports

Closer to Arklow, the Aughrim River and the Avoca River flow through steeply sloping wooded valleys, and join at Woodenbridge.

The Avoca River flows through lower ground from Shelton Abbey towards Arklow, and forms a west - east corridor through the town. Tidal influence in the Avoca River extends upstream of Arklow Bridge and to the west of 'the Alps'. Gravel banks in the Avoca River channel and estuary, both upstream and immediately downstream of Arklow Bridge, become exposed at low tide.

The largest area of exposure of gravel banks occurs during low water spring tides. Waterbirds use these areas, and are discussed further in **Section 11.3.4**.

There is a coastal north - south corridor of sand dunes habitats, interspersed with rocky headlands, along the coast of Wicklow and Wexford (Refer to **Figures 11.4 in Volume 3**). In the Arklow area, this coastal corridor is modified by recreational, commercial and industrial land uses on both sides of the Avoca estuary and Arklow Harbour. To the south of Arklow, there is a narrow strip of modified sand dune habitat, including a golf course, between Arklow Head and the south harbour wall. To the north of Arklow Harbour, part of an area of sandhills was reclaimed in the Ferrybank area during the 19th Century for commercial and industrial uses, while lands in the vicinity of Arklow Pond and to the north remain relatively natural although modified by residential, commercial and recreational land uses.

11.3.1.1 Protected areas: European Sites

The proposed development does not lie within or adjoining any European sites.

European sites located along the Wicklow and Wexford coasts within 15km of the proposed development, and more distant hydrologically linked European sites, are shown in **Figure 11.4 in Volume 3** and summarised in Table 11.2.

Screening for Appropriate Assessment has identified that part of the European site Buckronev – Brittas Dunes and Fen SAC (Site Code 000729) lies within the Zone of Influence of the proposed development. Since mitigation is provided under the precautionary principle to ensure that no adverse effects (slight, moderate or significant) arise to the European site Buckronev – Brittas Dunes and Fen SAC (Site Code 000729), A Natura Impact Statement (NIS) has been prepared in respect of the proposed development.

Table 11.2: Qualifying Interests of SACs and Special Conservation Interests of SPAs located within 15km, and more distant hydrologically linked sites

European site	Distance from proposed development	Qualifying Interests * indicates a priority habitat under the Habitats Directive
Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)	Coastal site 4.5km to the north at its closest point	Annual vegetation of drift lines [1210]
		Perennial vegetation of stony banks [1220]
		Mediterranean salt meadows (<i>Juncetalia maritimi</i>) [1410]
		Embryonic shifting dunes [2110]
		Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes) [2120]
		Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
		Atlantic decalcified fixed dunes (<i>Calluno-Ulicetea</i>) [2150]*
		Dunes with <i>Salix repens</i> ssp. <i>argentea</i> (<i>Salicion arenariae</i>) [2170]
		Humid dune slacks [2190]
Alkaline fens [7230]		
Kilpatrick Sandhills SAC (Site Code 001742)	Coastal site 6.5km to the south at its closest point	Annual vegetation of drift lines [1210]
		Embryonic shifting dunes [2110]
		Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes) [2120]
		Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
		Atlantic decalcified fixed dunes (<i>Calluno-Ulicetea</i>) [2150]*
Magharabeg Dunes SAC (Site Code 001766)	Coastal site partly within 15km of the proposed development	Annual vegetation of drift lines [1210]
		Embryonic shifting dunes [2110]
		Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes) [2120]
		Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
		Atlantic decalcified fixed dunes (<i>Calluno-Ulicetea</i>) [2150]*
		Petrifying springs with tufa formation (<i>Cratoneurion</i>) [7220]*
Wicklow Reef SAC (Site Code 002274)	Marine site located c. 20km to the north	Reefs [1170]
Blackwater Bank SAC (Site Code 002953)	Marine site located c. 30km to the south	Sandbanks which are slightly covered by sea water all the time [1110]

European site	Distance from proposed development	Qualifying Interests * indicates a priority habitat under the Habitats Directive
Wicklow Mountains SAC (Site Code 002122)	Upland site located some 25 to 30km upstream, including some of the headwaters of the Avoca River	Oligotrophic waters containing very few minerals of sandy plains (<i>Littorelletalia uniflorae</i>) [3110]
		Natural dystrophic lakes and ponds [3160]
		Northern Atlantic wet heaths with <i>Erica tetralix</i> [4010]
		European dry heaths [4030]
		Alpine and Boreal heaths [4060]
		Calaminarian grasslands of the <i>Violetalia calaminariae</i> [6130]
		Species-rich <i>Nardus</i> grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe) [6230]*
		Blanket bogs (* if active bog) [7130]
		Siliceous scree of the montane to snow levels (<i>Androsacetalia alpinae</i> and <i>Galeopsietalia ladani</i>) [8110]
		Calcareous rocky slopes with chasmophytic vegetation [8210]
		Siliceous rocky slopes with chasmophytic vegetation [8220]
		Old sessile oak woods with <i>Ilex</i> and <i>Blechnum</i> in the British Isles [91A0]
Lutra lutra (Otter) [1355]		
Vale of Clara (Rathdrum Wood) SAC (Site Code 000733)	Located 15km or more upstream of Arklow	Old sessile oak woods with <i>Ilex</i> and <i>Blechnum</i> in the British Isles [91A0]
		Special Conservation Interest
Wicklow Mountains SPA (Site Code 004040)	Upland site located some 25 to 30km upstream	Merlin (<i>Falco columbarius</i>) [A098]
		Peregrine (<i>Falco peregrinus</i>) [A103]

11.3.1.2 Protected Areas: Proposed Natural Heritage Areas

Upstream of Arklow, the Aughrim River and the Avoca River flow through steeply sloping wooded valleys, and join at Woodenbridge. The valley sides, with both coniferous and deciduous woodlands, are included within Avoca River Valley pNHA (Site Code 001748). The best examples of deciduous woodland occur in the Shelton Abbey area, and are dominated by Oak *Quercus petraea*. Parts of the river corridors are included in the pNHA area (Refer to **Figure 11.5 in Volume 3**).

The proposed development does encroach on parts of Arklow Town Marsh pNHA (Site Code 001931), along the south and north banks of the Avoca River upstream of Arklow Bridge (Refer to **Figure 11.6 in Volume 3**). Arklow Town Marsh pNHA includes the Avoca River channel upstream of Arklow Bridge, and the wetland habitats that extend northwards from the bank of the river (Refer to **Figure 11.6 in Volume 3**). Arklow Town Marsh pNHA covers an area of approximately 0.84 km², including the adjoining river channel. Arklow Town Marsh was included in the Wicklow Wetlands Survey in 2012¹⁴, and assigned the evaluation National Conservation Value.

Arklow Town Marsh has been surveyed more recently as part of the baseline studies for the proposed Arklow Flood Relief Scheme in June 2017 by the lead ecologist for that project (Richard Nairn - Natura Consultants). Habitats recorded in the two surveys referenced are as follows:

- Reed and large sedge swamp FS1;
- Tall herb swamp FS2;
- Marsh GM1;
- Depositing/lowland rivers FW2;
- Drainage Ditches FW4;
- Wet willow-alder-ash woodland WN6;
- Treelines WL1;
- Scrub WS1;
- Oak-Birch-Holly woodland WN1;
- Wet grassland GS4; and
- Dry meadow and grassy verges GS2.

The NPWS site synopses for Avoca River Valley and Arklow Town Marsh pNHAs are reproduced in **Appendix 11.1**. It should be noted that these site descriptions were drafted in 1995, at which time industrial air pollution was problematic in the Arklow area.

Arklow Sand Dunes pNHA (Site Code 001746) lies along the coast to the north of the proposed development (Refer to **Figure 11.5 in Volume 3**), the site synopsis is reproduced in **Appendix 11.1**. Arklow Rock-Askintinny pNHA (Site Code 001745) lies to the south of Arklow at Arklow Head.

11.3.1.3 Natural Heritage and Biodiversity Objectives

The proposed development lies within the boundary of the Arklow and Environs Local Area Plan 2018 – 2024 (Arklow LAP). The plan includes the following natural heritage objectives:

14 Wilson, F., Crushell, P. Curtis, T. & Foss, P.J. (2012). The County Wicklow Wetland Survey II. Report prepared for Wicklow County Council and The Heritage Council.

- HT1 - To maintain the favourable conservation status of all proposed and future Natural Heritage Areas (NHAs) in the plan area in particular the Arklow Marsh and to support environmentally sensitive measures to enhance the understanding and enjoyment of such natural areas; and
- HT9 - To maintain the conservation value of all proposed and future Natural Heritage Areas (NHAs) and to protect other designated ecological sites in Arklow and Environs.

Consideration should be given to separate Natural Heritage Objectives based on the County Development Plan objectives;

- NH3 – relating to protection of designated sites;
- NH5 – relating to maintain the conservation value of designated sites;
- NH6 – relating to the requirement for ecological impact assessment of proposed development likely to have a significant impact on rare or protected sites, habitats and species; and
- NH12 – in relation to protection and enhancement of biodiversity and ecological connectivity within the plan area in accordance with Article 10 of the Habitats Directive.

Further, the aim of Objective NH12 of Wicklow County Development Plan 2016-2022 is:

“To support the protection and enhancement of biodiversity and ecological connectivity within the plan area in accordance with Article 10 of the Habitats Directive, including linear landscape features like watercourses (rivers, streams, canals, ponds, drainage channels, etc.), woodlands, trees, hedgerows, road and railway margins, semi-natural grasslands, natural springs, wetlands, stonewalls, geological and geo-morphological systems, features which act as stepping stones, such as marshes and woodlands, other landscape features and associated wildlife where these form part of the ecological network and/or may be considered as ecological corridors or stepping stones that taken as a whole help to improve the coherence of the Natura 2000 network in Wicklow.”

11.3.2 Terrestrial Flora and Habitats

Terrestrial and non-marine habitats recorded within the study area (**Figure 11.1 in Volume 3**) are summarised in Table 11.3. The extent of these habitats, and the dominant species present, has varied during the baseline survey period, arising from variations in land use and management, and natural succession, in the primarily urban environment of Arklow. The characteristics of the individual habitats recorded within and immediately adjoining the four areas are described in the following sections:

- **Section 11.3.2.1** - The Alps SWO and Stormwater Storage Tank;
- **Section 11.3.2.2** - River Walk and South Quay;
- **Section 11.3.2.3** - North Quay; and
- **Section 11.3.2.4** - WwTP site.

Habitats within the study area to the north of the WwTP site are summarised in **Section 11.3.2.5**.

Table 11.3: Terrestrial and non-marine habitats present in the planning boundary and the study area (i.e. outside the planning boundary of the proposed development)

Habitat (Fossitt classification)	The Alps SWO and Stormwater Storage Tank	River Walk and South Quay	North Quay	WwTP site	Habitats in the study area outside the planning boundary
Exposed siliceous rock ER1	✓				✓
Scrub WS1	✓		✓	✓	✓
Treelines WL2		✓	✓		✓
Riparian woodland WN5					✓
Buildings and artificial surfaces BL3	✓	✓	✓	✓	✓
Stone walls and other stonework BL1		✓	✓		✓
Spoil and bare ground ED2		✓	✓	✓	
Recolonising bare ground ED3		✓	✓	✓	
Amenity grassland GA2		✓	✓	✓	✓
Ornamental non-native shrub WS3	✓	✓	✓	✓	✓
Flower beds and borders BC4		✓			✓
Depositing lowland rivers FW2	✓	✓	✓		✓
Drainage ditches FW4			✓		
Tidal rivers CW2		✓	✓		✓
Wet grassland GS4					✓
Improved agricultural grassland GA1					✓
Reed and large sedge swamp FS1					✓
Dune scrub and woodland CD4					✓

11.3.2.1 The Alps SWO and Stormwater Storage Tank

Upstream to the west of the Alps SWO and Stormwater Storage Tank site, immediately outside the footprint of the proposed development, small areas of Gorse *Ulex europaeus* and Bramble *Rubus fruticosus* agg. dominated Scrub **WS1** and Exposed siliceous rock **ER1** occur, with mown grassland adjoining the footpaths. Sloping ground north of the railway line includes extensive areas of Bramble and Gorse Scrub **WS1** with Elder *Sambucus nigra*, and overgrown hedgerows **WL1** of Hawthorn *Crataegus monogyna*, Elder and Holly *Ilex aquifolium*, Birch *Betula* spp., Blackthorn *Prunus spinosa*, and Sycamore *Acer pseudoplatanus* extending into Improved agricultural grassland **GA1**. Species poor Wet grassland **GS4** on low ground to the south of the riverside footpath appears to be liable to flooding from the Avoca River, Reed Canary-grass *Phalaris arundinacea* and Floating Sweet-Grass *Glyceria fluitans* occur here with Soft Rush *Juncus effusus*. Grey Willows *Salix cinerea* grow along the Avoca River bank on the northern side of the footpath.

Thin soils and outcropping rock in and adjoining the western part of the Alps SWO and Stormwater Storage Tank site are vegetated with Bramble and Gorse dominated Scrub **WS1**, with Ivy *Hedera helix* (Refer to Plate 11.1.2). Navelwort *Umbilicus rupestris*, Foxglove *Digitalis purpurea*, Field Wood-rush *Luzula campestris*, Wood Sage *Teucrium scorodonia*, Sweet Vernal Grass *Anthoxanthum odoratum*, Common Sorrel *Rumex acetosa*, and the fern Common Polypody *Polypodium vulgare* grow on outcropping rock and thin soil over rock (dark grey slate with minor pale sandstone, Refer to **Chapter 14**); this habitat corresponds to Exposed siliceous rock **ER1**, occurring in small areas in mosaic with Gorse and Bramble Scrub **WS1**.

The Alps SWO and Stormwater Storage Tank site is a small shaded valley, some 20m wide and 100m long, between rock outcrops in higher ground to the east, west, and to the south where the ruins of Arklow Castle are located. Soil depth varies within the SWO and Stormwater Storage Tank site.

Vegetation was cleared from relatively level ground in the main area of the site during the winter of 2012/13 and again in 2016/17 to facilitate site investigation works; the site was surveyed before and after clearance. The site area is dominated by species poor Bramble Scrub **WS1** with Nettle *Urtica dioica*, (Plate 11.1.1) and occasional Bittersweet *Solanum dulcamara*, and a ground flora including Cleavers *Galium aparine*, Creeping Buttercup *Ranunculus repens*, Rose-bay Willowherb *Epilobium angustifolium*, Common Sorrel, Broad-leaved Dock *Rumex obtusifolius*, Celandine *Ranunculus ficaria*, Lords-and-Ladies *Arum maculatum*, Cow Parsley *Anthriscus sylvestris*, and Ivy, with the grasses False Oat-grass *Arrhenatherum elatius*, Cock's-foot *Dactylis glomerata*, and Creeping Bent *Agrostis stolonifera*.



1. View into the Alps site from River Walk
2. River Walk immediately west of the Alps, showing rock outcrops on both sides of the footpath to Vale Road



3. View eastwards from River Walk opposite the Alps site
4. View westwards along River Walk towards the Alps site

Plate 11.1: Views of the Alps site and surrounding areas

Sloping ground in the eastern part of the SWO and stormwater storage tank site, below Coomie Lane, is vegetated with Bramble and Buddleia *Buddleja davidii* dominated Ornamental non-native Shrub **WS3**, with Sycamore and Cypress higher on the slope, and regrowth of some previously felled young trees of Ash *Fraxinus excelsior*, Sycamore and Elder on the lower slope. To the south east, tree and shrub cover on sloping ground includes Cypress, a mature Sycamore tree with ivy cover, and younger Sycamore, with mature Cherry Laurel *Prunus laurocerasus*, and Grey Willow, growing among Bramble and Buddleia. Cherry Laurel and Buddleia cast dense shade and there is little ground flora below them (see also **Section 11.3.3**). The ruins of Arklow Castle are partly overgrown with ivy, and are located on higher ground more than 20m south of the Alps SWO and Stormwater Storage Tank site boundary.

11.3.2.2 River Walk and South Quay

Access to the Alps SWO and Stormwater Storage Tank site is via the existing River Walk footpath **BL3** on the southern bank of the Avoca River.



1. Erosion along the south bank of the Avoca River
2. Small area of Bramble along the south bank of the Avoca River



3. Amenity grassland and young trees adjoining River Walk
4. Amenity grassland with Daffodils and trees at the car park at River Lane

Plate 11.2: Views vegetation and habitats along River Walk

Within the area of the proposed development, a semi-continuous Treeline **WL2** planted along the river bank from the Alps to Arklow Bridge includes Weeping Willow *Salix* hybrids (Plate 11.2, 3 and 4), Ash, Hawthorn, Silver Birch *Betula pendula*, and Alder *Alnus glutinosa*. Self-sown Grey Willow shrubs were cut back during the winter of 2017 - 2018.

Herbaceous vegetation along the river bank is mown and is grass dominated Amenity grassland **GA2** with Ryegrass *Lolium perenne*, Daisy *Bellis perennis*, Ribwort *Plantago lanceolata*, with occasional Alexanders *Smyrniolum olusatrum*, Dock *Rumex spp.*, Cuckooflower *Cardamine pratensis*, Yarrow *Achillea millefolium*, and with occasional Cow Parsley and Soft Rush along the river bank. The river bank grassland is c. 7m wide at the Alps, reducing in width downstream, with evidence of river bank erosion, and occasional patches of Bramble. From near Condren's Lane Upper, the natural riverbank is replaced by retaining walls **BL1** and **BL3**, these continue along South Quay to the coast.

The ground on the southern side of River Walk rises steeply between The Alps and River Lane. There is mown amenity grassland slopes **GA2** and a retaining wall **BL3** between the car park at River Lane and River Walk, Daffodils are planted in the amenity grassland, and trees planted here include Lime, Sycamore, and ornamental Cherry (Plate 11.2.4). The adjoining slope at Sunbeam House has some mature Sycamore and Grey Willow trees, with developing Bramble and Grey Willow scrub **WS1** that is cut back periodically, and small areas of ornamental shrub planting **WS3**.

The Avoca River channel (**FW2, CW2**) upstream of Arklow Bridge is largely un-vegetated. Gravel banks in the centre and south of the channel expose during most of the tidal cycle and low river flows, and are not vegetated. Towards the northern side of the river channel, there is a linear gravel bank overlain with silt, and this supports a line of Grey Willow trees, corresponding to Riparian woodland **WN5**. Some areas of this woodland bank appear to have washed out during recent floods (Refer to Plate 11.3).



Avoca River viewed from Arklow Bridge, view of Riparian woodland on gravel and silt bank in the river channel near the north bank

Avoca River upstream of Arklow Bridge, gravel banks exposed at low tide

Plate 11.3: Gravel banks in the Avoca River upstream of Arklow Bridge

There is a small area of Ornamental/non-native shrub **WS3** on each side of the footpath leading from River Walk to Arklow Bridge.

Downstream of Arklow Bridge, the South Quay wall **BL1** and **BL3** is sparsely vegetated with plants that can colonise masonry and cement walls; Buddleia and Grey Willow seedlings, Red Valerian *Centranthus ruber*, Ivy-leaved Toadflax *Cymbalaria muralis*, Ribwort, Daisy and Dandelion, with Red Fescue and Cock's-foot grass (Plate 11.4). There is a narrow strip of amenity grassland **GA2** above the Avoca Estuary retaining wall **BL3**, extending from South Green to Harbour Road. Trees planted within this grassland are mostly ornamental Acer cultivars, with some Lime, Rowan, Cherry Poplar, and a Hawthorn. A seating area on the South Quay opposite Harbour Road has ornamental planting **WS3** including *Escallonia*, *Cordyline*, *Viburnum davidii*, and *Montbretia*, with some Ground Elder *Aegopodium podagraria* occurring as a weed species.



1. View along South Quay towards Arklow Bridge

2. View along South Quay towards South Green



3. Amenity grassland and trees at South Green, looking west

4. Amenity grassland and trees at South Green, looking east

Plate 11.4: Vegetation and habitats from Arklow Bridge to Harbour Road

Amenity grassland **GA2** occurs along the southern side of South Green, adjoining residential properties (Plate 11.4.3 and 4). A **Treeline WL2** planted in this area includes a Horse Chestnut *Aesculus hippocastanum*, two mature *Acer* cultivars, two mature ornamental Cherry *Prunus* trees, and two recently planted Apple *Malus* trees.

A temporary construction compound (at working area S19) for the proposed development is located in a vacant site south of Arklow Harbour. This site includes concrete and gravel surfaces **BL3**, with spoil and bare ground **ED2** with a sparse vegetation of False Oat-grass *Arrhenatherum elatius*, Red Valerian, Bramble, and Bird's-foot Trefoil *Lotus corniculatus*, and with mounded areas of Recolonising bare ground **ED3** at the sides and back of the site, vegetated with Gorse, Grey Willow, grasses, and Alexanders.

The Third Schedule listed non-native plant species Sea-buckthorn *Hippophae rhamnoides* was recorded within a treeline of Whitebeam on the eastern side of the road linking the proposed Contractor's Compound with South Quay (see **Section 11.3.3**).

11.3.2.3 North Quay

Working Area TSN1 is located on the north bank of the Avoca River, on the western side of Arklow Bridge (Plate 11.5). This site was partially cleared in late 2016 in connection with a road upgrade project. A line of Cypress trees and adjoining Willow, Ash and Sycamore were felled at that time, and a hard core working area installed adjoining the road. When re-surveyed in May 2018, the hard core surface was classified as spoil and bare ground **ED2**, with a sparse colonising vegetation of Buddleia seedlings, Bramble, Common Ragwort *Senecio jacobaea*, Groundsel *S. vulgaris*, Smooth Sow-thistle *Sonchus oleraceus*, and Common Mouse-ear *Cerastium fontanum*.



1. Spoil and bare ground **ED2** and Scrub **WS1** in TSN1

2. Scrub **WS1** along the north bank of the Avoca River at TSN1



3. View west over overgrown amenity grassland towards Arklow Town Marsh pNHA

4 Scrub along the northern margin of overgrown amenity grassland

Plate 11.5: Habitat and vegetation cover in Working Area TSN1

The north bank of the Avoca River slopes steeply down into tidal silt and gravels at this site; the bank is vegetated with Willow, Sycamore, Birch and Ash that have been cut back previously and are re-growing as multi-stemmed trees, among a dense shrub layer of Bramble, Elder *Sambucus nigra*, and Gorse, with occasional shrubs of Broom *Cytisus scoparius* and Snowberry *Symphoricarpos albus*. This habitat developed along the margins of a former garden and is currently best described as Scrub **WS1**.

At the western end of Working Area TSN1, the vegetation is grass dominated, with Yorkshire Fog *Holcus lanatus* the dominant species, with Alexanders, and Soft Rush on lower ground adjoining a drainage channel **CW2** that forms the boundary with Arklow Town Marsh to the west. Adjoining ground to the north includes Buddleia and Bramble scrub, with Sycamore and Apple trees, Lilac and other ornamental shrubs of garden origin. This part of the TSN1 site is best described as overgrown amenity grassland **GA2**, that remains relatively species poor currently. An overgrown drainage ditch **FW4** adjoins this site.

Along the North Quay, vegetation is limited to the curtilage of some existing properties, and to a narrow strip c. 2m wide between the road and the quay wall. The road level is higher than the quay wall (Refer to Plate 11.6). This narrow strip includes occasionally cut amenity grassland opposite the Bridgewater Shopping Centre, and a crushed stone surface further east, planted mainly with a **Treeline WL2** ornamental Acer cultivars, and some Whitebeam *Sorbus aria* cultivars, Horse Chestnut, Lime, and Poplar cultivars throughout. Some Bramble and Gorse also occur in the quayside area, and there is some re-growth of Grey willow which was cut back previously. Grey Willow and Sycamore of self-sown origin occur along the quay wall near the marina on the North Quay.

There are some mounds of soil and stone within the Avoca River estuary immediately downstream of Arklow Bridge, adjoining North Quay (Plate 11.6). This small area supports colonising vegetation of Gorse, Grey Willow, Birch and Alder, with wetland species including Reed Canary-grass *Phalaris arundinacea* and Common Valerian *Valeriana officinalis* that occur upstream within Arklow Town Marsh pNHA (Wilson *et al*, 2012), and is classified as Spoil and bare ground **ED2**.



Plate 11.6: River bank habitat at the North Quay

The road around the marina at North Quay is not vegetated (**BL3**). Rough ground to the east of the marina has been colonised by Alder and Grey Willow, this early growth has been cut back recently and re-growth has commenced, among sparse grass and Bramble cover and the vetch species *Vicia hirsuta* and *V. sativa*. Access to the WwTP site from Mill Road is via a recently cleared area of Bramble dominated Scrub **WS1**.

Working area N14 has a concrete surface **BL3**, sparsely vegetated with Yellow Clover *Trifolium dubium*, Dandelion, Mugwort *Artemisia vulgaris*, and Biting Stonecrop *Sedum acre*. The boundaries of this area are vegetated with Bramble dominated Scrub **WS1**.

11.3.2.4 WwTP site

The Old Wallboard site at Ferrybank (i.e. WwTP site) is located on the northern side of Avoca River estuary, which is retained by the north quay of Arklow Harbour, the coastal revetment forms the eastern site boundary. The WwTP site includes a derelict wallboard factory and habitats present are listed in Table 11.3.

The WwTP site was originally occupied by sand hills, before Arklow Harbour walls were constructed and the site area reclaimed. Minor elements of the original coastal vegetation have persisted, or have re-colonised the site from the immediate locality; a small stand of Bracken *Pteridium aquilinum* and Bluebell *Hyacinthoides non-scripta* was recorded in April 2017 near the northern tip of the site, and a few plants of Autumn Gorse *Ulex gallii* occur near the southern site boundary, together with occasional plants of species of coastal grassland that have colonised hard core and tarmac surfaces, including Yellow-wort *Blackstonia perfoliata*, Wild Carrot *Daucus carota*, Sea Mayweed *Tripleurospermum maritimum*, Biting Stonecrop *Sedum acre*, Hare's-foot Clover *Trifolium arvense*, Kidney Vetch *Anthyllis vulneraria*, and Buck's-horn Plantain *Plantago coronopus*.

The WwTP site is largely occupied by derelict buildings and paved surfaces. Soil substrates are largely confined to the north-eastern part of the site adjoining the coastal rock armour. A treeline of Ornamental non-native shrub **WS3** of New Zealand Daisy Bush *Oleria macrodonta* of planted origin extends from the site entrance along the northern site boundary with the road. Red Fescue grass *Festuca rubra*, probably associated with previous Amenity grassland **GA2** landscaping extends along the eastern side of the main building and the base of the rock armoured revetment.



1. Bramble Scrub WS1 along the site boundary with working area N14, to the left
2. Recolonising bare ground ED3 and Gorse and Bramble Scrub WS1 between the two existing buildings on site

Plate 11.7: Existing vegetation and habitats on the WwTP site

Derelict buildings and tanks occupy c. 60% of the site area. Ivy *Hedera helix* is present on some existing cement walls, and gutters are overgrown with grasses. The derelict buildings are otherwise un-vegetated.

Most of the existing vegetation on the site has developed as sparse cover on hard-core and tarmac surfaces, extending into the site from the site boundaries, from seed in gravel or hard-core brought in during site development, from wind-blown seed and seed transported by birds. Silver Birch has colonised sheltered parts of the site near the western boundary, with occasional Alder and Elder. Grey Willow occurs in sheltered and more exposed parts of the site. Bramble and Gorse Scrub **WS1** extends into the site from the western site boundary (Plate 11.7).

Spoil and bare ground **ED2**, comprising paved and gravel surfaces, is vegetated with common colonising plant species. At the southern end of the site adjoining the quay wall of Arklow Harbour, a marine influence is evident and a sparse flora includes Buck's-horn Plantain, Biting Stonecrop, and Sea Mayweed.

Elsewhere within the parcel colonising plant species of Spoil and bare ground **ED2** include mosses, Creeping Bent-grass, Annual Meadow-grass *Poa annua*, Willowherb *Epilobium* species, Ribwort, Common Ragwort, White Clover *Trifolium repens*, Yellow Clover, Hairy bittercress *Cardamine hirsuta*, and Dandelion *Taraxacum officinale* agg.

Recolonising bare ground **ED3** is more densely vegetated with more than 50% plant cover, and includes the species listed above with additional grass species Red Fescue *Festuca rubra*, Cock's-foot grass *Dactylis glomerata*, and Yorkshire Fog *Holcus lanatus*.

The habitats present within the WwTP site have been disturbed by informal land uses, and by recent site investigation works carried out in respect of the proposed development.

11.3.2.5 Habitats in the Vicinity of the WwTP Site

Another currently derelict site is located on the opposite side of the road to the WwTP site, and supports similar colonising vegetation. To the north, Amenity grassland **GA2** includes recreational facilities and extends to Seaview Avenue; part of this area is included in the planning boundary (Refer to **Figure 11.1 in Volume 3**). Taller, occasionally mown, and more species rich grassland occurs on the revetment slope. Dominant grass species are Red Fescue, Cock's-foot, and False Oat-grass. Ribwort, Wild Carrot, and Common Knapweed *Centaurea nigra* occur on this slope, with occasional patches of Gorse and Bramble. Sea Beet *Beta vulgaris* occurs on the upper slopes of the revetment.

Arklow Pond (Refer to **Figure 11.1 in Volume 3**), within the area zoned as Open Space, was included in the Wicklow Wetlands Survey¹⁵, and is described as an eroded and much modified dune system, still retaining typical dry and wet areas, one of which runs into a lagoonal lake at the south end¹⁶. The site evaluation for the Arklow Pond site by Wilson *et al* is C+; i.e. County Conservation Value.

The main area of open water at Arklow Pond is surrounded by Reed and large sedge swamp **FS1** dominated by Common reed *Phragmites australis*. The protected plant species¹⁷ *Equisetum x moorei* occurs at a number of sites in the Ferrybank area (Curtis and Wilson¹⁸), including at the northern end of Arklow Pond. This area was surveyed in 2017, and *Equisetum x moorei* was confirmed to continue to be present at this location, c. 700m north of the proposed WwTP site. This species was not found at the WwTP site, or within the section of the revetment proposed to be upgraded.

An area of Dune scrub and woodland **CD4** occurs to the north of the Reed and large sedge swamp **FS1** at Arklow Pond. Scattered Oak, Sycamore, Grey Willow and Hawthorn trees grow over a shrub layer of Bramble, Burnet Rose *Rosa pimpinellifolia*, Gorse, and Bracken, with Bluebell. A number of footpaths traverse this area, connecting to Sea Road and Seaview Avenue.

11.3.2.6 Evaluation of Flora and Habitats

The planning boundary of the proposed development lies entirely within the Arklow LAP. In the context of the urban area of Arklow, the flora and habitats present within the planning boundary provide locally important biodiversity and ecological connectivity. Biodiversity along the Avoca River corridor is higher upstream of Arklow Bridge than it is downstream, because of the presence of natural (although modified by regular mowing of amenity grassland) river banks along most of River Walk. Mature trees along River Walk also provide feeding and commuting corridors for bats (see **Section 11.3.5.1**).

15 Wilson, F., Crushell, P. Curtis, T. & Foss, P.J. (2011). The County Wicklow Wetland Survey I. Report prepared for Wicklow County Council and The Heritage Council.

16 Data from Arklow Pond: Wicklow County Council & The Heritage Council 2012, held by Wetland Surveys Ireland – map of Irish Wetlands, www.WetlandSurveysIreland.com , 20 May 2018)

17 Flora Protection Order, 2015)

18 Curtis, Dr. Tom & Faith Wilson (2008), Field Survey Of Rare, Threatened And Scarce Vascular Plants In County Wicklow. Data provided by NPWS

Biodiversity within the planning boundary of the proposed development is assessed as being of high local importance upstream of Arklow Bridge, and of low local importance downstream of Arklow Bridge along both the south and north quays.

The habitats present in the Alps SWO and Stormwater Storage Tank site, and its immediately adjoining temporary construction area, on the south side of the Avoca River are species poor, include the non-native invasive plant species Buddleia and Cherry Laurel (see **Section 11.3.3**), and are assessed as being of low local ecological importance.

The habitats within the WwTP site and the immediately adjoining working areas included within the planning boundary are assessed as being of low local ecological importance.

11.3.3 Invasive plant species

A total of five plant species listed in Part 1 of the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011 – 2015 were recorded in the study area (Refer to **Figure 11.7 in Volume 3**):

- Japanese knotweed *Fallopia japonica*: High risk of impact¹⁹; a linear stand c. 10m long, located on the north bank of the Avoca River, within Arklow Town Marsh pNHA, and not expected to interact with the proposed development because of its location;
- Rhododendron *Rhododendron ponticum*: High risk of impact¹⁹; located at a number of areas within Arklow Town Marsh pNHA, and not expected to interact with the proposed development because of its location;
- Sea-buckthorn *Hippophae rhamnoides*: Medium risk of impact¹⁹: four mature shrubs of Sea buckthorn, of which one is spreading by suckers, in roadside planting at the Harbour on South Quay, there is a potential for the spread of seed or plant parts by machinery or other traffic movement between the Contractor's Compound and works areas associated with the proposed development. A further stand of Sea buckthorn was recorded at the northern end of the study area, to the north of Arklow Pond;
- Spanish Bluebell *Hyacinthoides hispanica*: Low risk of impact¹⁹; located within Working Area TSN1, and occurring along a footpath linking to River Walk; and
- In addition, Himalayan Balsam *Impatiens glandulifera* was recorded at intervals along the northern bank of the Avoca River, upstream of the proposed development, during baseline studies for the proposed Arklow Flood Relief Scheme (by the project ecologist - Richard Nairn, Natura Consultants). This species is listed as High risk of impact¹⁹, it is not expected to interact with the proposed development because of its location, although as a species that spreads by seed it may spread downstream into working areas.

¹⁹ National Biodiversity Centre (2018) Species Profile Browser. Available from: <https://species.biodiversityireland.ie/> [Accessed 18 August 2018]

Two additional non-native invasive plant species, listed in the NRA guidelines²⁰ were recorded in the immediate vicinity of the proposed development:

- Buddleia / Butterfly Bush *Buddleja davidii*: Medium risk of impact¹⁹; present in many areas as a mature shrub and as seedlings, not mapped;
- Montbretia (*Crocsmia X crocosmiiflora*); a single stand recorded on the coastal revetment adjoining the WwTP site; and
- Laurel (Cherry Laurel) *Prunus laurocerasus* is listed by the National Biodiversity Data Centre as a non-native invasive species with a High risk of impact; this plant occurs in the vicinity of works associated with the proposed development at the Alps.

Management recommendations for non-native invasive plant species potentially interacting with the proposed development are included in **Appendix 11.2**.

11.3.4 Birds

11.3.4.1 Waterbirds

Peak numbers of waterbirds and seabirds recorded during baseline bird surveys, are given in Table 11.4 at each of the three survey areas. Data for the individual counts are given in **Appendix 11.3**.

Table 11.4: Peak numbers of waterbirds recorded during baseline surveys at Arklow

Species	Birds Directive Annex 1 listed	BOCCI ²¹	1% National level ²²	1% International level ²³	Shoreline and coastal waters	Avoca River estuary	Arklow Pond
Red-throated Diver	yes	Amber (b)	20	3000	1		
Little Grebe		Amber (b/w)	20	4000			4
Cormorant		Amber (b/w)	120	1200	13	9	
Grey Heron			25	2700		3	
Mute Swan		Amber (b/w)	90	-		2	6
Greenland White-fronted Goose	yes	Amber (w)	110	240		1	1
Greylag Goose (feral)			-	-		43	29

²⁰ Transport Infrastructure Ireland (incorporating the National Roads Authority) Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Road Schemes (Revision 1, December 2010)

²¹ Colhoun and Cummins, 2013. Birds of Conservation Concern in Ireland, 2014-2019. b= breeding, w= wintering. Irish Birds 9 (4): 523-544

²² Threshold level for national importance (1% of all-Ireland population of each species or sub-species/flyway) – data not available for gull species

²³ Threshold level for International importance (1% of total population of each species or sub-species/flyway)

Species	Birds Directive Annex 1 listed	BOCCI ²¹	1% National level ²²	1% International level ²³	Shoreline and coastal waters	Avoca River estuary	Arklow Pond
Teal		Amber (b/w)	340	5000			1
Mallard			290	20000		49	51
Moorhen				20000		4	5
Coot		Amber (b/w)	220	17500			1
Oystercatcher		Amber (b/w)	690	8200	3		
Ringed Plover			100	730	1		
Common Sandpiper		Amber (b)	-	-		1	
Turnstone			95	1400	12	12	
Kingfisher	yes	Amber (b)	-	-		1	
Mediterranean Gull		Amber (b)	-	770	3		
Black-headed Gull		Red (b)	-	20000	67	512	101
Common Gull		Amber (b)	-	16400	21	50	
Lesser Black-backed Gull		Amber (b)	-	5500	3	10	
Herring Gull		Red (b)	-	10200	150	390	2
Great Black-backed Gull		Amber (b)	-	4200	4	40	
Guillemot		Amber (b)	-		4		

Overall, 22 waterbird species were recorded, and a single seabird species (Guillemot). The numbers recorded were well below the threshold levels for national and international importance for waterbirds, where these have been determined (As outlined in Table 11.4).

Gulls were the most numerous group, and were recorded in all three survey areas. Five gull species were recorded in the Avoca River estuary. Black-headed Gulls were present during all counts, apart from April 2017 when they would be expected to be away at breeding colonies. Herring Gulls recorded in April 2017 were all immature third to third year birds.

Gulls feed in a range of habitats, including agricultural land and wetlands, and use a range of food sources opportunistically. Relatively little gull feeding behaviour was observed in the Avoca River estuary, although gulls were quick to respond to people arriving to feed birds, both on the river and estuary and at Arklow Pond. Herring Gulls scavenge among fish and bait boxes at the harbour on South Quay.

Most of the gull use of the Avoca River and estuary was by birds roosting, bathing and preening; gulls use the gravel banks upstream and downstream of Arklow Bridge to roost on, and bathe and preen in the fresh water of the river. The highest counts were recorded at low tide and river levels, when the largest areas of gravel are exposed. Downstream of Arklow Bridge, gulls also roosted on the pontoon opposite the Sailing Club, and in small numbers on the slipway and rock armour along the sea wall nearby at South Green. At Arklow Pond, Black-headed Gulls roosted on amenity grass near the pond, and on the pond, with regular flights out over coastal waters and to the Avoca River estuary.

Six gull species were recorded on coastal water surveyed; Common Gull, Lesser Black-backed Gull, Herring Gull, and Great Black-backed Gull numbers were highest on a day when fishing vessels were operating in the area, on 29 November 2017 (Refer to **Table 1 in Appendix 11.3**). Three Mediterranean Gulls were also observed on this date, the only record of this species during the baseline surveys. Black-headed Gulls and Herring Gulls were recorded on coastal waters during most surveys, the other species occurred less frequently. In coastal waters at Arklow, gulls were recorded feeding around the edges of the Avoca River freshwater plume as it enters marine waters, attending fishing vessels, and on one occasion (28 January 2017) mobbing a Harbour Seal that had caught a large fish.

The Greylag Geese that occur at Arklow are a resident feral population²⁴. The origins of feral Greylag Geese in Ireland are uncertain, most flocks are thought to be descendants of released birds. Migratory Greylag Geese that breed in Iceland winter in Ireland and Britain, the closest flocks of Icelandic Greylags use sites in north Wicklow, at Poulaphouca and the North Wicklow Coastal Marshes²⁴. The feral Greylag flock at Arklow use Arklow Pond and the Avoca River and adjoining habitats including amenity grassland, and were recorded feeding on amenity grassland at River Walk, South Green, and at Arklow Pond. They also take food that people bring to give them. A single Greylag gosling was recorded with two adults at Arklow Pond in April 2017. Feral Greylag geese are not of conservation interest.

A single Greenland White-fronted Goose was recorded at both the Avoca River and Arklow Pond, and was first recorded as a juvenile on 8 December 2016, associating with feral Greylag Geese.

This individual was still present, in adult plumage, in February 2018, but was not found in April 2018, and is assumed to have been a straggler from the Wexford flock of this Birds Directive Annex 1 listed sub-species that breeds in Greenland, and winters in Ireland and Scotland²⁵.

Mute swan, Mallard, and Moorhen were recorded on the Avoca River and at Arklow Ponds, with Mute Swan and Moorhen breeding at both sites. There were single records of Teal and Coot at Arklow Ponds. Little Grebe occur as a resident breeding species at Arklow Pond; two pairs were recorded during 2017 and 2018.

24 Boland, H. and Crowe, O. 2012. Irish Wetland Bird Survey: Waterbird status and distribution 2001/02 – 2008/09. BirdWatch Ireland, Kilcoole, Co. Wicklow.

25 Fox, Tony, Ian Francis (Greenland White-fronted Goose Study), David Norriss, and Alyn Walsh (NPWS), 2017. Report of the 2016/2017 International Census of Greenland White-Fronted Geese.

Cormorant were recorded feeding in the Avoca River and estuary, and in coastal waters, with peak counts of 9 and 13 respectively. They also roosted within the river estuary, using fallen timber in the river channel, and built structures and mooring buoys in the estuary.

Grey Heron were recorded feeding and roosting in the Avoca River upstream of Arklow Bridge and at Arklow Pond.

Waders were recorded in small numbers. Turnstone occurred on the South Quay at the harbour, and on the harbour walls. Oystercatcher were recorded only on two occasions along the harbour walls. A single Common Sandpiper was recorded on gravel upstream of Arklow Bridge in April 2017, and was likely to be moving upstream to breeding areas in the upper Avoca catchment.

Single Kingfishers were recorded on three separate occasions, flying along the northern bank of the Avoca River upstream of Arklow Bridge and the drainage channel connecting into Arklow Town Marsh. It is considered likely that there is a Kingfisher breeding territory in this area.

There was a single observation of four Guillemot, feeding in coastal waters off Arklow.

Red-listed and Amber-listed Birds of Conservation Concern in Ireland are noted in Table 11.4.

11.3.4.2 Breeding birds

Passerine bird species recorded as breeding in the vicinity of the Alps were Blackbird, Robin, Blackcap, Chiffchaff, Chaffinch, and Wren. House Sparrow, Starling, Magpie and Wood Pigeon were recorded as present along River Walk and South Quay, and as breeding in the general area. Grey Wagtail and Pied Wagtail were consistently present along the Avoca River banks and feeding on exposed gravels, and were recorded flying south into the town carrying food; these species are likely to nest in buildings or other built structures.

Willow Warbler, Blackcap, Blackbird, Robin and Wren were recorded as breeding in the vicinity of 1 Ferrybank (i.e. the westernmost tunnel shaft and working area on North Quay [working area N1]) on the northern side of the Avoca River.

At the WwTP site, Hooded Crow, Wren, and Barn Swallow were confirmed as nesting in the main derelict building on site in 2017, Starling and feral Pigeon were recorded as possible breeders. Birds recorded in scrub habitat and as probable breeding species within the site were Great Tit, Blue Tit, Chaffinch, Goldfinch, House Sparrow, Wren, Robin, and Blackbird. Two Meadow Pipits were recorded in territorial display over recolonising bare ground in April 2017, one within the site, and another on an adjoining derelict site. Five Linnet were recorded within the site in August 2017, but were not recorded as a breeding species within the site.

Passerine bird species recorded as breeding in Reeds swamp and Dune scrub and woodland habitats in the vicinity of Arklow Pond included Sedge Warbler, Willow Warbler, Reed Bunting, Chiffchaff, Bullfinch, Chaffinch, Robin, Wren, Blackbird, Blue Tit, Coal Tit, and Long-tailed Tit. Stonechat and Linnet were also recorded in the area, but breeding was not confirmed.

Meadow Pipit and Grey Wagtail are Red listed as breeding birds of Conservation Concern in Ireland, Barn Swallow, Robin, Stonechat, Starling, House Sparrow and Linnet are Amber listed (Colhoun and Cummins, 2013²⁶).

11.3.5 Mammals

11.3.5.1 Bats

Introduction

Bats constitute a total of nine of the most widespread resident protected mammal species in Ireland. Eleven species of bat have been identified to date in Ireland, of which two were considered to be vagrant. Bats occur in the rural and the urban environment. They feed upon insect fauna at night and during the day, they occupy buildings and occasionally trees for short or long periods. Buildings are a vital element of the annual cycle of all Irish bat species and at no time more so than the period May to August, but many bats may also avail of buildings as hibernation sites. Changes to a site may reduce the lands available to bats as a feeding site and in some cases may even destroy their dwelling place through or during the partial or total demolition, restoration and renovation of buildings, bridges, clearance activities and the subsequent construction.

Bats are protected by Irish and EU²⁷ law and to prevent unlawful injury or death, it is essential that a full understanding of the site is available in advance to protect the resident bats from unintentional disturbance and to create a pathway by which a legal derogation and exemption may be designed in consultation with the NPWS.

Previous evaluations in the Arklow area including house visits, ad hoc observations and survey data recorded by Bat Conservation Ireland have determined the presence of common pipistrelles, soprano pipistrelles, Daubenton's bats, Natterer's bats, brown-longed eared bats and Leisler's bats.

Other species in surrounding areas include one of the first records of Nathusius' pipistrelles and a roost of this species in Wexford town 58km to the south-west. This species was first reported from this area on the Blessington Reservoir 20 years ago, 42 km to the north-west. Additionally, the only record of Brandt's bat in Ireland was recorded in Glendalough approximately 27 km to the north-west. While these would appear considerable distances, these are two species that show high migratory habits in other European countries. Nathusius' pipistrelle have been recorded in England, having been ringed in Latvia and Lithuania.

26 Colhoun, K. and S. Cummins, 2014. Birds of Conservation Concern in Ireland 2014-2019. Irish Birds 9 (4): 523-544

27 All species of Microchiroptera are listed as species of Community interest in need of strict protection in Annex IV of the Habitats Directive

Bat roosts

There is historic evidence of use of the ruins of Arklow Castle including information provided by the resident of the house adjacent to the Castle from childhood and up to recent years. The Castle has been confirmed to be used by roosting bats by the NPWS.

Common pipistrelle activity was the first noted at the ruins of Arklow Castle (19.08 hours) in the survey undertaken in October 2016 and this was followed 12 minutes later by soprano pipistrelle activity. Neither species was seen to return to Arklow Castle prior to dawn. However, on cold mornings, it is possible that bats have returned during the night and have not re-emerged to feed.

In August 2017, no bats emerged or returned to the Castle. A number of bats were noted returning towards the town from the Alps area prior to dawn but not to the Castle. Pipistrelle activity was noted heading to the south-west of the river. A Leisler's bat was noted flying to the south in the vicinity of the Castle (but clearly flying beyond the Castle).

The bat roost that was recorded previously by the NPWS as present within the Castle, would appear to be absent in August 2017 and October 2016. Given that the emergence area is more overgrown than when bats were present previously, it is probable that bats are either scarce or absent from the building.

None of the bat boxes in mature trees along both sides of River Walk along the riverbank had been occupied by bats in 2017. These bat boxes were in clutter and ivy was blocking a number of the box entrances.

Arklow Bridge was found to be the roost site of unidentified bat species, probably Daubenton's bat (*Myotis daubentonii*). There is evidence that bats are availing of crevices in the upriver side of the bridge to roost. This was in the form of clusters and individual droppings below the crevices. These roosting or resting sites are predominantly towards the southern end of the bridge (on the west/upstream side). While the northern end would appear to offer very suitable roosting conditions, there was no evidence of bats within this section. Given the strong association of Daubenton's bats with bridges, it is considered most probable that these sites are used by this species.

Three other species are less commonly encountered in bridges (Natterer's bats, Brown long-eared bats and soprano pipistrelles) while in other European countries a much wider range of species avail of bridges (including species resident in Ireland).

Bats are using Arklow Bridge as a roost site (western side of the southern end of the bridge). This is likely to be individuals roosting rather than a maternity roost and it may be either a transitional roost or simply a night roost used by bats feeding around Arklow along the River Avoca.

Trees at the northern end of Arklow Bridge offer low roost potential, including a Cypress treeline inspected in October 2016 prior to felling. Trees within the hedgerows north of this point have higher roost potential.

No roosts were noted in any of the trees examined prior to dawn and it was considered most probable from pre-dawn activity that bats were heading towards the houses at Ferrybank or further afield.

No bat roosts were recorded in derelict buildings at the WwTP site.

The bat box at Arklow Pond was not checked from a ladder and from an inspection with a torch from ground level, no droppings or bat was visible. This box was reported to be occupied by residents in 2016 but this is unconfirmed.

Bat fauna feeding and commuting within and through the study area

Bat species recorded in the study area are as follows:

- Common pipistrelle *Pipistrellus pipistrellus*
- Soprano pipistrelle *Pipistrellus pygmaeus*
- Leisler's bat *Nyctalus leisleri*
- Daubenton's bat *Myotis daubentonii*

Areas of high bat activity are shown in **Figure 11.8 in Volume 3**. Further records are shown in **Appendix 11.4**.

Common pipistrelles were noted at all times throughout the survey period and throughout Arklow town. This is the most widespread species in Europe and is most often the most commonly encountered bat species. Common pipistrelles were widespread in Arklow in summer in 2016 and 2017. In October 2016, males of this species were noted calling along the riverbank south of the river. Common pipistrelles were also noted along the lands along the eastern boundary of Arklow Town Marsh. This species was heard within the fields adjacent to Brigg's Lane behind Ferrybank around a derelict house and along the disused railway line.

Closer to freshwater, soprano pipistrelles are often more numerous, and this species was certainly very evident along the Avoca River and in marshy areas close to the northern bank of the river. This was the first bat to be noted around the mature trees along the river and one individual was present along the disused railway line to the north of the river for several minutes as well as feeding and calling around the derelict house.

Soprano pipistrelles were seen and heard along the southern riverbank and were the only species noted prior to dawn on 18 October 2016. Similarly, in August 2017, soprano pipistrelles were the most commonly encountered bat species prior to dawn.

The SM2 bat detector was used north of the river on 19 October 2016 revealed the presence of three species of bat; Leisler's bat, common and soprano pipistrelle. Each bat only occurred on one occasion between 18.15 and 21.30.

Daubenton's bats were heard over several hours along the river and were also noted flying from the rear of the houses north of the Avoca River towards the river channel.

Daubenton's bats were present close to water in almost all encounters, with some Daubenton's bat activity in Arklow Town Marsh, and at Arklow Pond. Daubenton's bat activity was noted along the Avoca River from the Arklow Bridge to Arklow Castle and onwards to the M11 flyover.

Ireland is considered to be a stronghold for Leisler's bats and this species is encountered throughout Leinster and the east coast. Leisler's bats were very briefly present along the northern bank of the Avoca River on 19 October 2016 at 19:31 and otherwise there was very little activity. This species was present in August 2017 but was less in evidence than all other species. A Leisler's bat was seen and heard flying over the Main Road of Arklow close to the Castle ruins prior to dawn away from any areas within the study area. Leisler's bats were noted on occasion in the study area but were much less common than other species.

Bat fauna feeding and commuting within and through the WwTP site

The most commonly encountered bats within the proposed WwTP site were common pipistrelles (Refer to Figure 11.1). There were no greater than three common pipistrelles at any given time. Activity within the buildings was predominantly common pipistrelle with occasional soprano pipistrelle activity around and possibly within the main building.

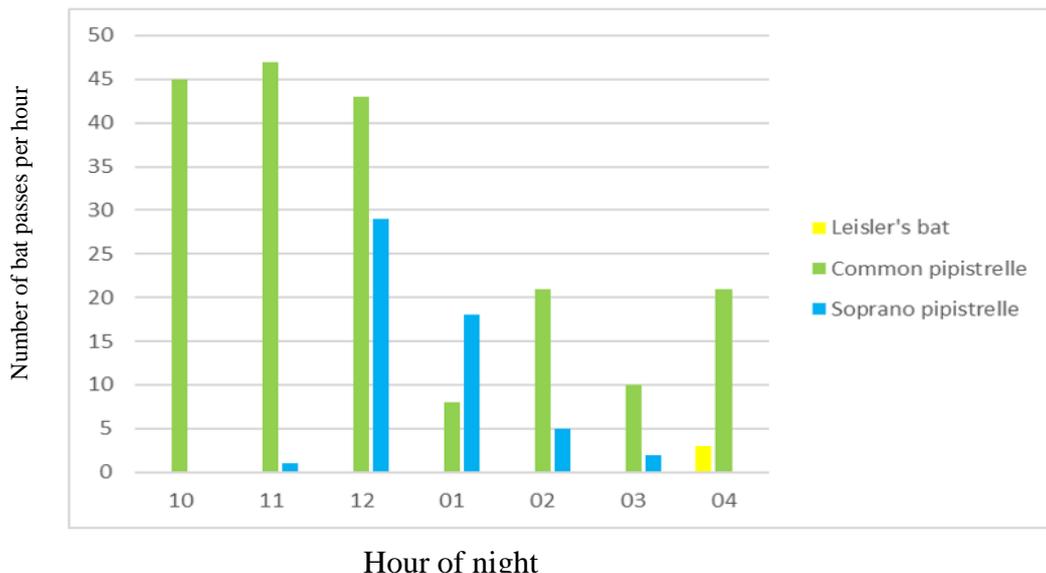


Figure 11.1: Bat activity recorded by the SM2 bat detector within the WwTP site in 2016

Ireland is considered to be a stronghold for Leisler's bats and this species is encountered throughout Leinster and the east coast. Leisler's bat fed over the proposed waste water treatment site while moving to and from a roost site that was not within the site itself in June 2016. The final bat observed prior to dawn was last noted flying towards the Avoca River in a south-westerly direction and it is probable that this individual was crossing towards the town over the river.

Bat fauna at Arklow Pond

Bat activity over the Arklow Ponds during an evaluation in 2017 was high (Refer to **Figure 11.8 in Volume 3**) and included Daubenton's bats, Leisler's bats, soprano and common pipistrelle. During consultation, the NPWS indicated that several bat boxes around the Ponds are known to be in use and noted that there is a pipistrelle roost in a building near Arklow Bay Hotel (west of Arklow Pond), and another bat roost in the Office of Public Works building in Arklow town.

11.3.5.2 Other terrestrial mammals

Otter *Lutra lutra* signs (spraints) were recorded along the banks of the Avoca River during aquatic ecology and terrestrial habitat surveys (Detailed description is given in **Section 11.3.6.3**). This species is listed in Annex II and in Annex IV of the Habitats Directive.

Fox *Vulpes vulpes* signs and scats were recorded at the Alps and at the WwTP site. Other terrestrial mammals likely to occur include Pygmy shrew *Sorex minutus* and the rodent species Wood Mouse *Apodemus sylvaticus*, House Mouse *Mus domesticus*, and Brown Rat *Rattus norvegicus* are likely to occur.

11.3.5.3 Marine Mammals

General information on marine mammal distribution in relation to Arklow

Marine mammals listed on Annex II of the Habitats Directive occur in coastal and marine waters off Arklow. The proposed outfalls lie within 10km square T27 (Refer to Figure 11.2).

Harbour Porpoise (Common Porpoise) *Phocoena phocoena* and Bottle-nosed Dolphin *Tursiops truncatus* have been recorded in 10km square T27. Records held by the National Biodiversity Data Centre include several databases compiled by the Irish Whale and Dolphin Group²⁸: Records for coastal and offshore 10km squares to the north and south of Arklow T26, T27, T36, T37, T38, T39, T46, T47, T48 and T49 include the following additional cetacean species: Common Dolphin *Delphinus delphis*, Striped Dolphin *Stenella caeruleoalba*, Risso's Dolphin *Grampus griseus*, and Minke Whale *Balaenoptera acutorostrata*²⁹.

28 IWDG Cetacean Strandings Database, IWDG Casual Cetacean Sightings, and IWDG Ferry Survey sightings Data.

29 (Data from the Irish Whale and Dolphin Group held by the National Biodiversity Data Centre www.biodiversityireland.ie (downloaded from Biodiversity Maps on 26.04.2016 and 31 May 2018)

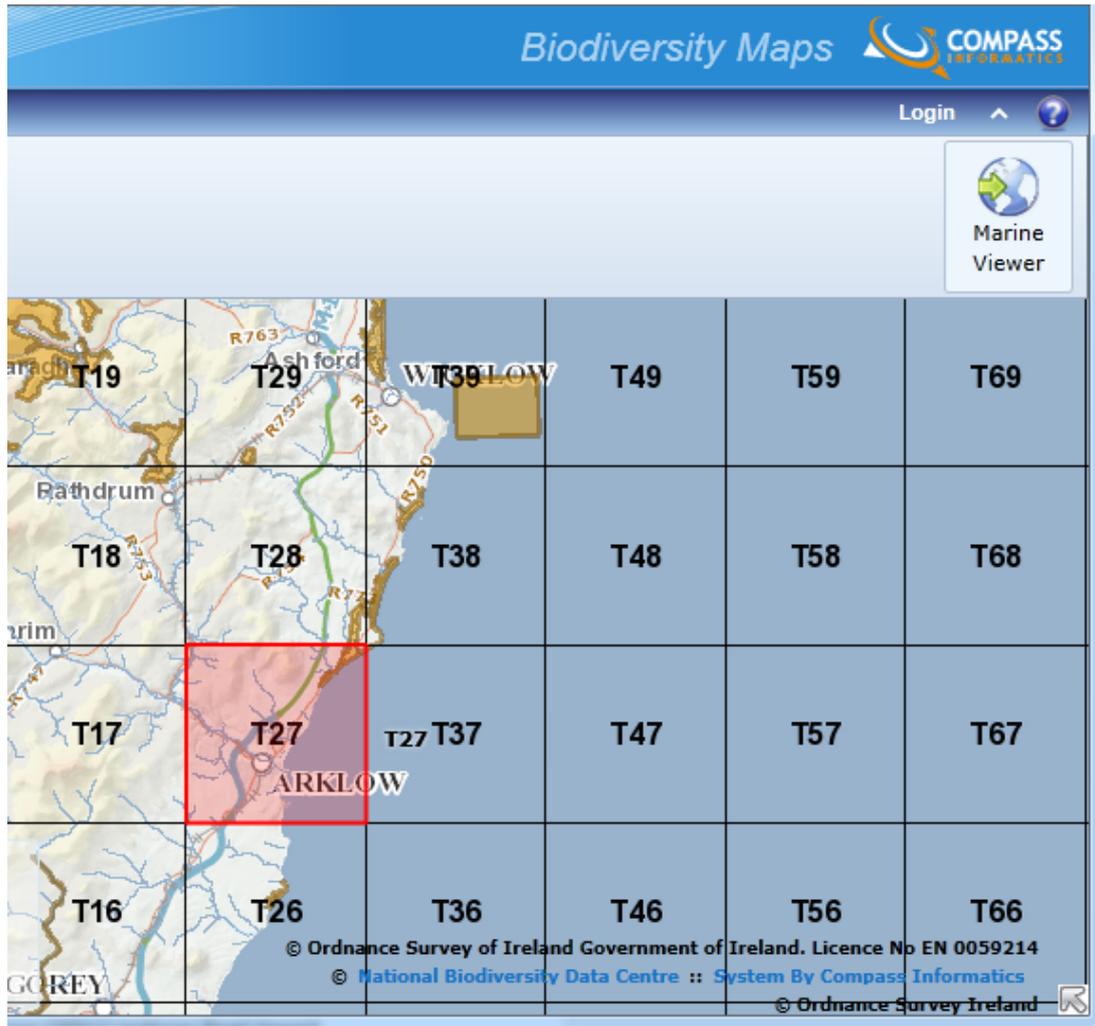


Figure 11.2: Coastal and offshore 10km grid squares in the Arklow area. SACs are also shown in orange

The Harbour Porpoise *Phocoena phocoena* is the smallest cetacean species that occurs in Irish waters, and is the most frequently reported and widespread cetacean species. It occurs throughout the year in continental shelf waters, and is frequently recorded in shallow bays, estuaries and tidal channels, in waters less than 20m deep. Line transect cetacean surveys in the Irish Sea in 2011 recorded a total of 57 sightings in Block A in the northern Irish Sea (Refer to Figure 11.3); 51 Harbour Porpoise sightings and six sightings of individual Minke Whales. In Block B in the southern Irish Sea (Refer to Figure 11.3), 14 cetacean sightings were recorded, all Harbour Porpoise sightings. This provided sighting rates of Harbour Porpoise of 0.29 sightings per km or 5.24 sightings per hour in Block A, and 0.10 Harbour Porpoise per km or 1.91 sightings per hour in Block B (Berrow *et al*, 2011³⁰). There are three marine coastal areas where high numbers of Harbour Porpoise have been recorded (Refer to Figure 11.4), one off Co. Dublin on the east coast, and two off the south west coast of Ireland.

30 Berrow, Simon, Joanne O'Brien, Conor Ryan, Enda McKeogh and Ian O'Connor (2011) Inshore Boat-based Surveys for Cetaceans – Irish Sea. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group, pp.24.

Three SACs include Harbour Porpoise as a Qualifying Interest: Rockabill to Dalkey Island SAC off the east coast (more than 50km to the north of Arklow), and Blasket Islands SAC and Roaringwater Bay and Islands SAC in the south west of Ireland.

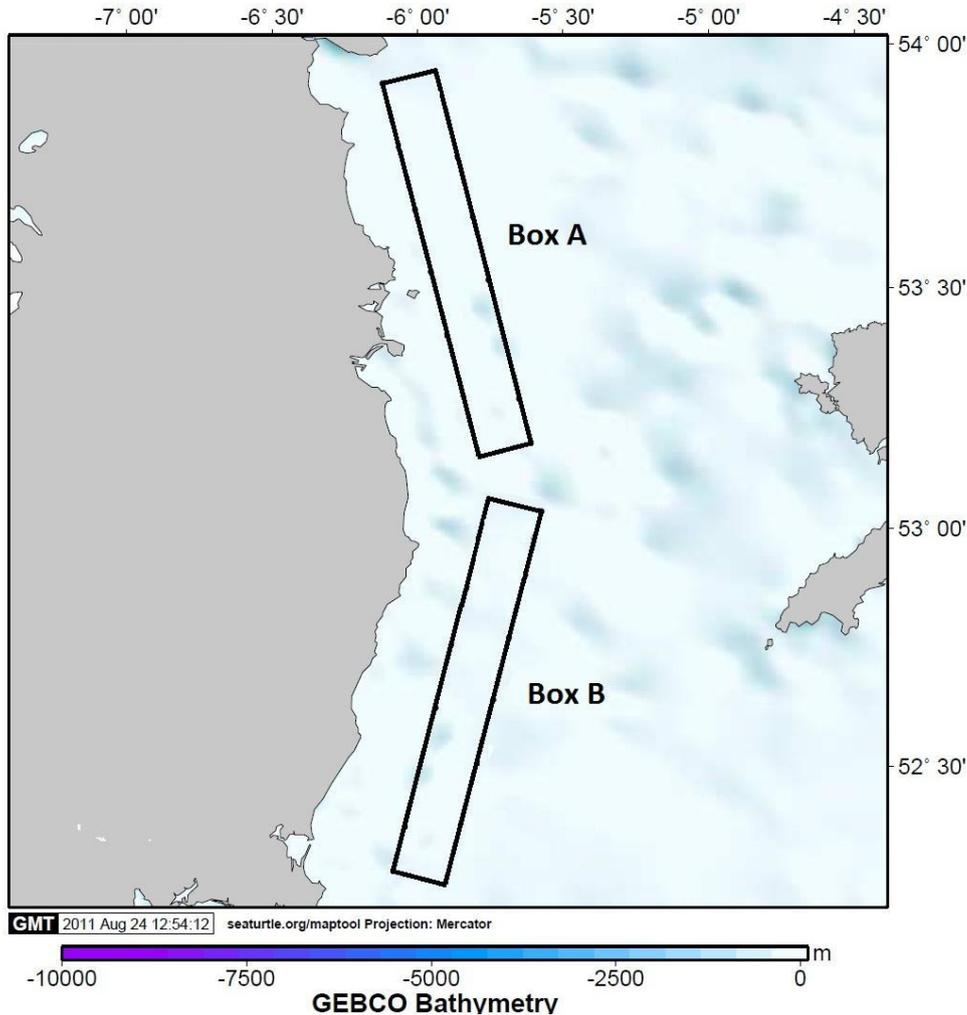


Figure 11.3: Map of Ireland showing the locations of survey blocks surveyed for cetaceans in 2011 (Reproduced from Berrow et al, 2011)

Bottle-nosed Dolphins have been seen in all Irish waters, particularly along the west coast, where three distinct populations are now recognised: the offshore, inshore and Shannon Estuary populations (Refer to Figure 11.4). One of the most important resident populations in Europe is the group of 120-140 Bottle-nosed Dolphins living year round in the Shannon; the species is included as a Qualifying Interest of the Lower River Shannon SAC. Bottle-nosed Dolphin is the Qualifying Interest of West Connacht Coast SAC, in Galway and Mayo. Since 2010, the Irish Whale and Dolphin Group (IWDG) has recorded an increase in sightings along the Irish east coast extending into the North Irish Sea and Ulster coast.

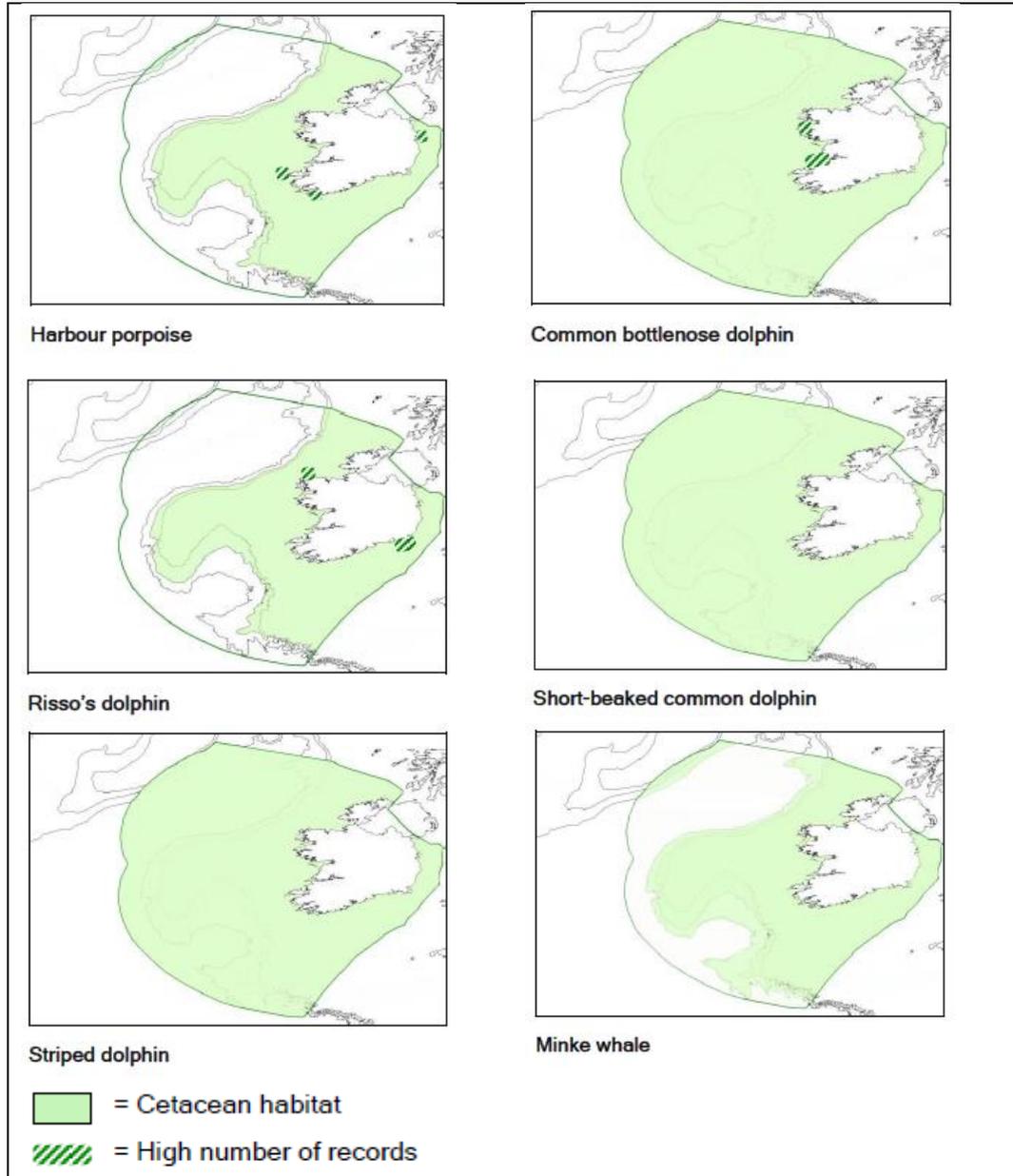


Figure 11.4: Generalised distribution of cetacean species that have been recorded in coastal waters in the Arklow area. (Reproduced from the Department of Arts, Heritage and the Gaeltacht³¹)

Common Dolphins are the most frequently recorded dolphin species in Irish waters.

31 Department of Arts, Heritage and the Gaeltacht (2014) Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters – January 2014.

They are recorded in their largest concentrations over the continental shelf and in deeper waters, but are also frequently observed in shallow inshore waters off the south and southwest coasts of Ireland and around the Aran Islands, and in the southern Irish Sea^{32,33}.

Risso's Dolphins are fairly abundant with a world-wide distribution in tropical and temperate seas, but do not generally penetrate far into high latitudes. They are sighted regularly around the Irish coast, with sightings and strandings concentrated on the south-west and west coast of Ireland, with occasional sightings in the Irish Sea. Risso's Dolphins appear to prefer deep offshore waters but on occasion can be seen close inshore around the Irish coast (Irish Whale and Dolphin Group).

Striped Dolphins are not common in Irish waters, occurring mainly further south in warmer waters. They are recorded annually, mainly off the south west coast of Ireland³²

Evidence from multi-annual surveillance programmes indicate that Minke Whales occur widely in Irish continental shelf and slope waters, and may do so throughout the year. They have also been recorded in the Celtic Sea and the Irish Sea^{32,30}.

Information on cetacean distribution, movements and seasonal occurrence in Irish and international waters is relatively recent, and currently concentrations of individual species have been identified in Irish waters only for Harbour Porpoise and Bottle-nosed Dolphin (Refer to Figure 11.4).

Grey Seal *Halichoerus grypus* and Harbour (Common) Seal *Phoca vitulina vitulina* have both been recorded in small numbers in inshore coastal waters in the Arklow area. Both species are listed in Annex II of the Habitats Directive. Important sites for these species are shown in Figure 11.5. Grey Seals are listed as a Qualifying Interest in ten SACs, of which two are on the east/south east coast: Lambay Island SAC, and Saltee Islands SAC. Harbour Seals are listed as a Qualifying Interest in thirteen SACs of which two are on the east/south east coast: Lambay Island SAC, and Slaney River Valley SAC. These SACs are located at distances in excess of 50km from Arklow.

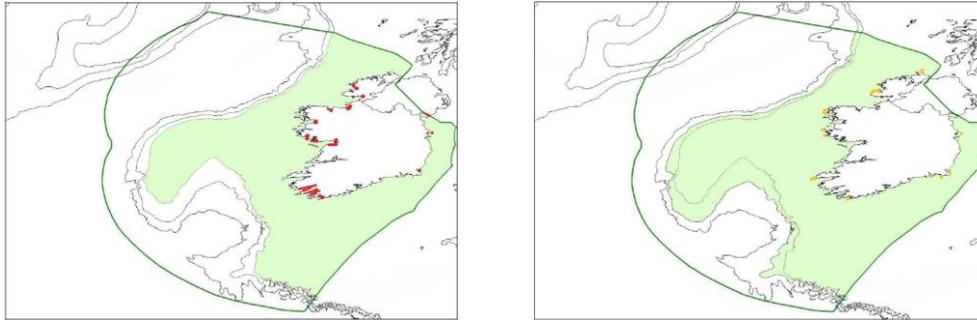
There is a small Grey Seal breeding site at Wicklow Head³⁴, with seals using small beaches and caves; there are no recent published census data for this colony.

32 NPWS (2013) The Status of EU Protected Habitats and Species in Ireland.

Species Assessments Volume 3, Version 1.0. Unpublished Report, National Parks & Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

33 Ryan, Conor, Simon Berrow, Alessandro Pierini, Joanne O'Brien, Ian O'Connor and David McGrath (2010) Inshore Boat-based Surveys for Cetaceans. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group. pp.33.

34 Ó Cadhla, Oliver, Denis Strong, Ciarán O'Keeffe, Mary Coleman, Michelle Cronin, Callan Duck, Tony Murray, Pascal Dower, Richard Nairn, Paul Murphy, Pat Smiddy, Cyril Saich, David Lyons, Lex Hiby (2008). An assessment of the breeding population of grey seals in the Republic of Ireland, 2005. Irish Wildlife Manuals No. 34. National Parks & Wildlife Service



Harbour Seal; generalised distribution and key breeding and non-breeding haul-out locations

Grey Seal; generalised distribution and key breeding and non-breeding haul-out locations

Figure 11.5: Generalised distribution and key breeding and non-breeding haul-out locations for Harbour Seal (left) and Grey Seal (right). ((Reproduced from the Department of Arts, Heritage and the Gaeltacht³²)

Marine mammals recorded during baseline surveys

Site investigation works have been carried out in the Avoca River estuary and in Arklow Bay, to inform the proposed development (refer to **Chapter 14** for further detail) and a qualified Marine Mammal Observer (MMO) was appointed to monitor for marine mammals and to log all relevant events during those works. A total of 30 MMO watches were carried out during the 30 minutes prior to, and during site investigation works. No marine mammals were recorded. The MMO records are given in **Appendix 11.5**.

There were three sightings of seals during bird surveys of coastal waters in Arklow Bay as outlined in Table 11.5. A single Harbour Seal was recorded on 28 January 2017, approximately 500m offshore opposite the caravan park; it had caught a large fish and was being mobbed by two Lesser Black-backed Gulls, 15 Herring Gulls, and up to 30 Black-headed Gulls.

A single Grey Seal was recorded on 24 February 2017, feeding approximately 80m offshore opposite the southern end of Arklow Pond. Five Grey Seals were recorded on 29 November 2017 at low tide, between 50 and 300m offshore opposite Arklow Pond; these animals appeared to be resting, their bodies including their heads held vertically in the water.

Table 11.5: Seal records in coastal waters in Arklow Bay during baseline bird surveys

Species/ count date	24.11.16	8.12.16	28.01.17	24.02.17	29.11.17	13.02.18
Harbour Seal			1			
Grey Seal				1	5	

11.3.6 Aquatic Ecology

11.3.6.1 General

The Avoca River is formed by the joining of the Avonmore and Avonbeg rivers. The Avonmore River flows from Lough Dan, just west of Roundwood, and flows in a generally south-eastern direction for approximately 30 km before meeting the Avonbeg River (which rises near Table Mountain at the top of Glenmalure valley), just north of the village of Avoca, and becoming the Avoca River. The Avoca River is located within Hydrometric Area 10 (HA10) along with the Vartry River and the Dargle River.

The Avoca River continues to be one of the most seriously polluted rivers in Ireland due to acid mine drainage at Avoca Mines, just upstream of the village of Avoca³⁵. This pollution has had, and continues to have, serious impacts on the macroinvertebrate and fish populations of the river. These impacts are most severe closest to the Avoca Mines site and are having a lesser effect downstream; an effect that appears to be diminishing over time³⁶.

The effects of the acid mine drainage from the Avoca Mines extends all the way to the estuary of the Avoca River. The Avoca River Estuary is the only transitional or coastal waterbody in Ireland to fail for chemical status under the Water Framework Directive (WFD) assessment due to the levels of substances that are not ubiquitous in the water environment³⁵.

The rehabilitation of the Avoca Mines site is an on-going issue, with a feasibility study completed in 2008³⁷, and is under the authority of the Department of Communications, Climate Action and Environment.

In addition to the acid mine drainage impacting on the Avoca River for much of its length, the lack of a waste water treatment plant for Arklow and its environs has resulted in untreated wastewater being discharged into the Avoca River Estuary. This is impacting water and sediment quality within the estuary and is likely to be having an impact outside the mouth of the estuary also.

11.3.6.2 Fish

The Avoca River catchment is an important salmonid water with excellent populations of Salmon, Sea Trout and Brown Trout throughout.

35 Fanning, A. Craig, M., Webster, P., Bradley, C., Tierney, D., Wilkes, R., Mannix, A., Treacy, P., Kelly, F., Geoghegan, R., Kent, T. and Mageean, M. (2017) Water Quality in Ireland 2010-2015. Environmental Protection Agency, Johnstown Castle, Co. Wexford.

36 Gray, N.F. and Delaney, E. (2010) Measuring community response of benthic macroinvertebrates in an erosional river impacted by acid mine drainage by use of a simple model. *Ecological Indicators* 10: 668-675.

37 CDM (2008) Feasibility Study for Management and Remediation of the Avoca Mining Site. Investigative Reports: Volume 1. Report prepared by CDM for The Department of Communications, Energy and Natural Resources.

It is a large mainly upland catchment, with many varying habitats for fish, excellent species diversity and a good fishery potential. According to the Central Fisheries Boards³⁸, a total of 261 discrete migratory salmonid ‘fishery systems’ were identified nationally, of which 173 are recorded as ‘salmon and sea trout’ and 88 as sea trout only. The Avoca River system ranked 17th overall with regard to the fluvial habitat accessible to Salmon.

Despite the negative impacts on the Avoca River from the acid mine drainage and the release of untreated sewage, the river and estuary continue to support a diverse fish population. Surveys of the Avoca River Estuary carried out by Inland Fisheries Ireland^{39,40,41} under the Water Framework Directive (WFD) recorded a total of 15 species across the two earlier sampling periods (2008 and 2010), and a total of 16 species recorded in 2015, with some variation in the species recorded during each of the surveys (Refer to Table 11.6).

The outcome of the above sampling was the Avoca River Estuary being classed as ‘Moderate’ status for the fish populations in both the 2008³⁹ and 2010⁴⁰ sampling periods. The Avoca River Estuary was classified as ‘Good’ status for fish populations in 2015⁴¹. The overall WFD status of the Avoca Estuary for the period 2010 to 2015 is moderate (Refer to **Chapter 15** for further detail - EPA data, Site Code IE_EA_150_0100).

In the course of the current survey, Minnow were recorded at stations S4-6, Three-spined stickleback at stations S4, S6 and S7, while two lamprey ammocoetes (larva) were recorded at S6.

A number of the species recorded in the WFD sampling are particularly notable, in that they are listed under Annex II of the Habitats Directive, namely Atlantic Salmon *Salmo salar* and River Lamprey *Lampetra fluviatilis*, while the European Eel is listed as Critically Endangered. Though not recorded in the course of the IFI surveys, Sea Lamprey (*Petromyzon marinus*) are also known from the Avoca River, and are also listed under Annex II of the Habitats Directive.

38 McGinnity, P., Gargan, P., Roche, W., Mills, P. & McGarrigle, M. 2003. Quantification of the Freshwater Salmon Habitat Asset in Ireland using data interpreted in a GIS platform. Irish Freshwater Fisheries, Ecology and Management Series: Number 3, Central Fisheries Board, Dublin, Ireland.

39 Kelly, F., Harrison, A., Connor, L., Wightman, G., Matson, R., Morrissey, E., O’Callaghan, R., Feeney, R., Hanna, G., Lordan, M. and Rocks, K. (2009). Sampling Fish for the Water Framework Directive – Transitional Waters 2008. Avoca Estuary. The Central and Regional Fisheries Boards.

40 Kelly, F., Harrison, A., Connor, L., Matson, R., Morrissey, E., O’Callaghan, R., Feeney, R., Wögerbauer, C., Hanna, G., Gallagher, K. and Rocks, K. (2011). Sampling Fish for the Water Framework Directive – Transitional Waters 2010. Avoca Estuary. Inland Fisheries Ireland.

41 Ryan, Diarmuid, Roisin O’Callaghan, Will Corcoran, John Coyne & William Roche (2015). Water Framework Directive Fish Stock Survey of Transitional Waters in the Eastern River Basin District – Avoca Estuary 2015. Inland Fisheries Ireland

Table 11.6: Results of Inland Fisheries Ireland sampling carried out in 2008, 2010, and 2015 (Source: Kelly et al, 2009; 2011, Ryan et al, 2015), with Red List status (IUCN, 2018, King et al, 2011⁴²)

Scientific name	Common name	2008	2010	2015	Global status *	Irish status *
<i>Chelon labrosus</i>	Thick-lipped Grey Mullet	225	31	2	LC	-
<i>Platichthys flesus</i>	Flounder	36	97	152	LC	-
<i>Anguilla anguilla</i>	European Eel	20	9	12	CR	CR
<i>Ciliata mustela</i>	Five-bearded Rockling	6	-	11	LC	-
<i>Lampetra fluviatilis</i>	River Lamprey	5	9	1	LC	LC
<i>Gasterosteus aculeatus</i>	Three-spined Stickleback	5	2	3	LC	LC
<i>Salmo trutta</i>	Brown/Sea Trout	3	4	2	LC	LC
<i>Melanogrammus aeglefinus</i>	Haddock	2	1		VU	-
<i>Merlangus merlangus</i>	Whiting	2	-		LC	-
<i>Pomatoschistus minutus</i>	Sand Goby	1	21	258	LC	-
<i>Sprattus sprattus</i>	Sprat	1	-		DD	-
<i>Salmo salar</i>	Atlantic Salmon	1	-	16	LC	VU
<i>Spinachia spinachia</i>	Fifteen-spined Stickleback	-	2		LC	-
<i>Gadus morhua</i>	Cod	-	1	1	VU	-
<i>Syngnathus acus</i>	Greater Pipefish	-	1		LC	-
<i>Ammodytes tobianus</i>	Lesser sandeel	-	-	14	DD	-
<i>Taurulus bubalis</i>	Long-spined sea scorpion	-	-	1	LC	-
<i>Pleuronectes platessa</i>	Plaice	-	-	2	LC	-
<i>Pollachius pollachius</i>	Pollack	-	-	7	LC	-
<i>Trisopterus minutus</i>	Poor cod	-	-	1	LC	-
<i>Atherina presbyter</i>	Sand smelt	-	-	28	LC	-

Note: Results are not directly comparable between years owing to differences in the survey methodology employed – e.g. beam trawl used in 2010, but not 2008. CR = Critically Endangered, VU = Vulnerable, LC = Least Concern, and DD Data Deficient.

42 King, J.J., Marnell, F., Kingston, N., Rosell, R., Boylan, P., Caffrey, J.M., Fitzpatrick, Ú., Gargan, P.G., Kelly, F.L., O'Grady, M.F., Poole, R., Roche, W.K. and Cassidy, D. (2011) Ireland Red List No. 5: Amphibians, Reptiles and Freshwater Fish. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

The deep and slow flowing nature of the Avoca River within the surveyed study area does not provide suitable spawning habitat for salmon or lamprey species, which require shallower, faster flowing water over suitable spawning gravels. The presence of lamprey ammocoetes just upstream of the M11 flyover, suggests they may also be present downstream of the bridge. After hatching, ammocoetes inhabit silt beds for a number of years, feeding by filtering organic particles out of the water column, before transforming into an adult migrating to the river estuary or to sea⁴³. Very slow-flowing or still areas of the Avoca River within the in-river working areas may support such habitat.

Salmon and trout require passage through the lower reaches of the Avoca River to reach spawning grounds further up the system and the area may also support smolts and adults for a period of time on their way to sea or upriver, respectively. The Avoca River supports a spring and summer salmon run, with adults returning from sea, passing through the estuary and moving upstream during this period. Sea trout adults return to the Avoca River in summer. Following hatching, salmon and trout develop through a number of stages over the course of a number of years before undergoing physiological change (smoltification) to become smolts and be ready to go to sea. There are a range of factors that determine the exact timing of the movement of smolts to sea, including water temperature and photoperiod^{44,45} however, the seaward migration takes place over the spring to summer period.

Following metamorphosis to adults, River Lamprey migrate to estuaries and the sea, where they spend one to two years feeding.

In Ireland, migration of adults back upstream for spawning takes place over a protracted period from late summer to autumn⁴⁶, while downstream movement of newly metamorphosed adults peaks in March-April⁴⁷.

Sea Lamprey migrate into rivers for spawning in spring⁴³, while the seaward movement of newly metamorphosed adults takes place in autumn and into winter⁴⁶.

European Eels also require passage through the lower reaches of the Avoca River on their migration from spawning grounds at sea to rivers where they spend most of their lives.

43 Maitland, P.S. (2003) Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

44 McCormick, S.D., Hansen, L.P., Quinn, T.P. and Saunders, R.L (1998) Movement, migration, and smolting of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 55(suppl. 1): 77-92.

45 Byrne, C.J., Poole, R., Dillane, M., Rogan, G. and Whelan, K.F (2004) Temporal and environmental influences on the variation in sea trout (*Salmo trutta* L.) smolt migration in the Burrishoole system in the west of Ireland from 1971 to 2000. Fisheries Research 66(1): 85-94.

46 Kelly, F.L. and King, J.J. (2001) A review of the ecology and distribution of three lamprey species, *Lampetra fluviatilis* (L.), *Lampetra planeri* (Bloch) and *Petromyzon marinus* (L.): a context for conservation and biodiversity considerations in Ireland. Biology and Environment: Proceedings of the Royal Irish Academy 101B(3): 165 – 185.

47 Hardisty, M.W., Potter, I.C. and Sturge, R. (1970) A comparison of the metamorphosing and macroph-thalmia stages of the lampreys, *Lampetra fluviatilis* and *Lampetra planeri*. Journal of Zoology (London) 162: 383-400.

Adult European Eels move to sea in the autumn⁴⁸, while glass eels (young eels migrating from the spawning grounds to rivers) move upstream in spring⁴⁹.

Inland Fisheries Ireland⁵⁰ notes the following fish in coastal waters in the vicinity of Arklow: off-shore sandbanks dogfish, ray, codling, whiting and tope; shore angling bass, dabs, sole, flounder, plaice, Sea Trout and Mackerel further south off Clogga. Commercial fishing by boats based in Arklow Harbour is mainly for whelk.

11.3.6.3 Otter

Otters are listed under Annex II and Annex IV of the Habitats Directive and are protected under the Wildlife Acts 1976 to 2018.

Evidence of otter activity was noted within the study area in the course of the current survey. Otter spraint was recorded at two locations along the south bank of the Avoca River (Refer to Plate 1 in **Appendix 11.6**) between the M11 flyover and the start of the built-up banks in Arklow Town.

The area is prone to disturbance from human activity and dogs due to the path that runs along the river.

11.3.6.4 Freshwater Macroinvertebrates

The macroinvertebrate community of the Avoca River was sampled at six locations on the main channel and at one location on the channel that runs in a south-easterly direction through Arklow Town Marsh (Refer to **Figure 11.2 in Volume 3** and **Appendix 11.6**).

The most downstream sample station on the Avoca River (S1) shows the estuarine influence on the macroinvertebrate community with a high abundance of the shrimp *Gammarus chevreuxi*, while the high numbers of the worm *Lumbriculus variegatus* present at this site point towards issues of organic pollution. This site also had the lowest species richness, with eight species or higher taxa recorded.

Conversely, the most upstream site on the Avoca River (S6) had the highest species richness, with 21 species or higher taxa recorded.

This site supported high numbers of the cased caddisfly larva *Mystacides azurea*, with two other cased caddisfly species present (*Sericostoma personatum* and *Potamophylax latipennis*). Cased caddisfly larvae are considered ‘Less sensitive’ or Group B on the EPA scale of sensitivity to organic pollution that runs from ‘Sensitive’ (Group A) to ‘Most tolerant’ (Group E). The larvae of two damselfly species were also recorded (Beautiful demoiselle *Calopteryx virgo* and Large Red Damselfly *Pyrrosoma nymphula*), which are also Group B.

48 Sandlund, O.T., Diserud, O.H., Poole, R., Bergesen, K., Dillane, M., Rogan, R., Durif, C., Thorstad, E.B., Asbjørn Vøllestad, L. (2017) Timing and pattern of annual silver eel migration in two European watersheds are determined by similar cues. *Ecology and Evolution* 7:5956–5966.

49 Anonymous (2008) National Report for Ireland on Eel Stock Recovery Plan Including River Basin District Eel Management Plans. Report prepared by the Inland Fisheries Division of The Department of Communications, Energy and Natural Resources, Dublin

50 Dunlop, Norman (2009). A Guide to Sea Angling in the Eastern Fisheries Region. Inland Fisheries Ireland

The sample station within the channel through Arklow Town Marsh (S7) was dominated by mollusc species including the Wandering Pond Snail (*Radix peregra*) and the Common Bladder Snail (*Physa fontinalis*). This reflects the very slow-flowing or still nature of the water at this site, which was dominated by aquatic plants including Branched Bur-reed (*Sparganium erectum*), Fool's-water-cress (*Apium nodiflorum*) and Reed Canary-grass (*Phalaris arundinacea*).

A full list of freshwater macroinvertebrate species and abundances recorded in the survey is presented in **Appendix 11.6** (Refer to Table A1, with field data in Table A2).

There are no records of the protected White-clawed Crayfish (*Austropotamobius pallipes*) from the Avoca River catchment, due to the low pH and alkalinity conditions created by the underlying geology⁵¹.

Three Margaritifera Sensitive Areas lie upstream of the proposed development:

- Avoca - Aughrim; catchment of extant population;
- Avoca – Upper Avonmore; catchment of extant population; and
- Avoca – Lower Avonmore; catchments with previous records of Margaritifera, but current status unknown.

The Freshwater Pearl Mussel *Margaritifera margaritifera* is listed in Annex II of the Habitats Directive, and has been recorded in the Aughrim and Avonmore tributaries as noted above, but not in the Avoca River.

11.3.6.5 Intertidal Habitat

The intertidal habitats of the Avoca River Estuary are highly modified. The estuary banks comprise sheet piles, rock armour and concrete retaining walls (Refer to Plate 8 in **Appendix 11.6**). The intertidal habitat is limited to these surfaces and to a narrow strip of cobble, pebble and occasional sand, with abundant rubble on both sides of the estuary and the gravel banks in the river channel downstream of the bridge (Refer to Plate 9 and 10 in **Appendix 11.6**). Green algae (*Enteromorpha* spp.) and brown filmy algae coat the lower zone of the rock armour, with yellow and white lichens present in the upper zone (Refer to Plate 11 in **Appendix 11.6**). No marine invertebrate epifauna were noted within the estuary.

Evidence of pollution by sewage was present in the form of sewage fungus at a flap valve on the South Quay and an accumulation of toilet paper and sanitary towels nearby (Refer to Plate 12 and 13 in **Appendix 11.6**).

The location of the proposed outfall comprises a shore protected by rock armour at the revetment.

51 Lucey, J. and McGarrigle, M.L. (1987) The distribution of the crayfish *Austropotamobius pallipes* (Lereboullet) in Ireland. Irish Fisheries Investigations Series A (Freshwater), No. 29.

The lower section of the rock armour supports a limited biotope of green algae (often bleached white), below which occurs a zone of carrageen (*Chondrus crispus*), spiral wrack (*Fucus spiralis*), common limpet (*Patella vulgata*) and barnacles, above a zone supporting kelp (*Laminaria digitata*), sugar kelp (*Saccharina latissima*) and red algae (Refer to Plate 7 in in **Appendix 11.6**).

In summary, the intertidal habitat of the study area is highly modified by human activity and supports very few species, constituting habitats of low ecological value.

11.3.6.6 Estuarine and marine benthic macroinvertebrates

There is limited published information on the benthic ecology of the waters around Arklow; however, the habitats along the east coast of Ireland are similar along much of the coastline. A benthic survey was carried out as part of the EIA of the proposed Arklow Waste Water Treatment Works in the late 1990s⁵².

This survey noted that an *Abra alba*-dominated community accounts for the majority of the sample stations surveyed, resembling similar communities recorded in the Irish Sea^{53,54}. A number of other molluscs, polychaete worms and crustaceans were also recorded in the course of the survey. It was found that species richness and abundance were low close to the mouth of the Avoca River, with the presumed cause to be the high contamination content due to the Avoca Mines upstream. Metal contamination is known to be impacting the riverine fauna^{55,37} and so the effect is likely to extend into the estuary and surrounding waters.

The benthic survey carried out as part of the current study recorded a total of 1077 individuals represented by 49 species or higher taxa (Refer to **Figure 11.3 in Volume 3**, Table A3 and Table A4 in **Appendix 11.6**). Major invertebrate groups present included Annelida (23 taxa), Mollusca (8 taxa), Crustacea (8 taxa) and Echinodermata (4 taxa), with Nemertea, Ascidiacea, Hexacorallia and Insecta also present. The white furrow shell (*Abra alba*) was the most common species and was present in all but one of the samples taken outside the estuary.

Sample Station 7 was the most species rich of the stations sampled with 19 species, while Station 11 was the least species rich with 1 species as outlined in Table 11.7; Station 11 was located within the estuary. Station 9 scored the highest in terms of diversity and evenness (due to the fact that only a single specimen of each species was present). No diversity or evenness score could be calculated for Station 11 as only a single specimen of a single species was recorded. Stations with lower diversity and evenness scores tended to be those with a high proportion of a single taxon, such as *Abra alba* or Enchytraeidae.

52 Anonymous (1999) Arklow Waste Water Treatment Works Environmental Impact Statement. Arklow Urban District Council/P.H. McCarthy & Partners. 90pp.

53 Anonymous (2015) Proposed Cruise Terminal, Dún Laoghaire, Co. Dublin. Environmental Impact Statement, prepared by Stephen Little & Associates on behalf of Dún Laoghaire Cruise Stakeholder Group.

54 Walker, A.J.M. and Rees, E.I.S. (1980) Benthic ecology of Dublin Bay in relation to sludge dumping. Irish Fisheries Investigation Series B 22:1-59.

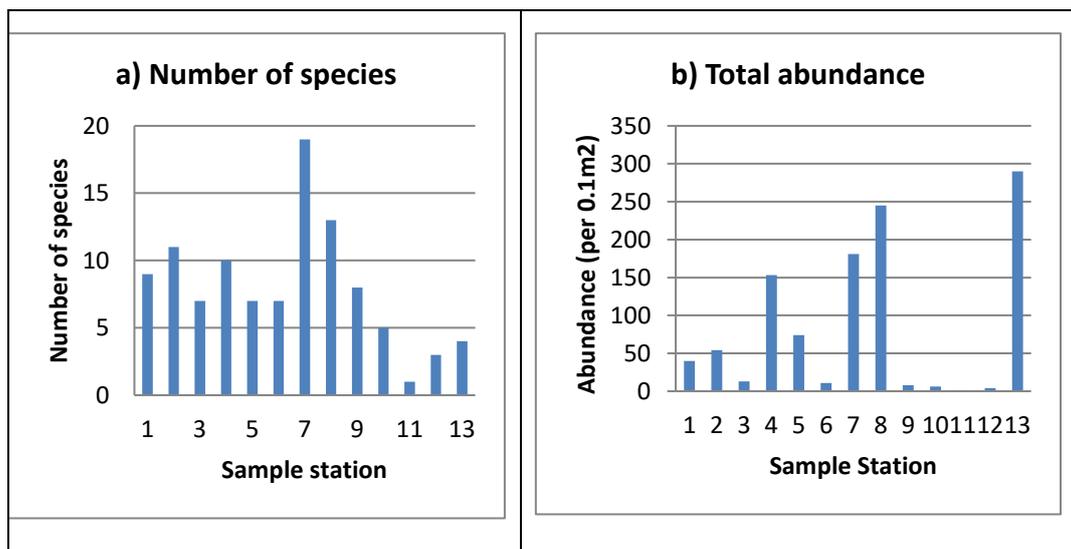
55 Gray, N.F. (1998) Acid mine drainage composition and the implications for its impact on lotic systems. Water Research 32(7): 2122-2134.

Table 11.7: Univariate ecological indices based on macroinvertebrate community.

Station	Number of species	Abundance (per sampling area)	Pielou's evenness	Shannon-Wiener diversity (natural logarithm base)
1	9	40	0.69	1.52
2	11	54	0.72	1.73
3	7	13	0.95	1.84
4	10	153	0.52	1.20
5	7	74	0.52	1.01
6	7	11	0.93	1.80
7	19	181	0.61	1.80
8	13	245	0.44	1.14
9	8	8	1.00	2.08
10	5	6	0.97	1.56
11	1	1	N/A*	N/A*
12	3	4	0.95	1.04
13	4	290	0.29	0.40

*No diversity or evenness score could be calculated for Station 11 as only a single specimen of a single species was recorded.

The univariate statistics scores are represented graphically in Figure 11.6. The three groups of sample stations, based on the statistical analysis of the macroinvertebrate species present, were stations 1-8, stations 9 and 10, and stations 11-13. Stations 1-8 represent the sand communities from outside the estuary, stations 9 and 10 represent the slightly gravelly sands outside the estuary, while stations 11-13 represent the sites within the estuary that are heavily influenced by the freshwater of the Avoca River (and the low species diversity caused by pollution from the mines upstream and the untreated wastewater from Arklow town).



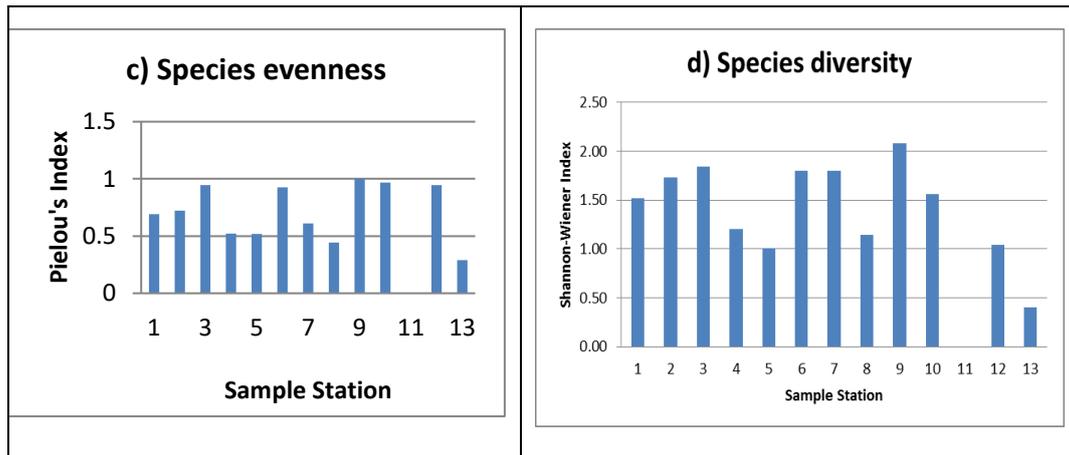


Figure 11.6: Univariate ecological indices based on macroinvertebrate community

The benthic macroinvertebrate community of Avoca River Estuary and the surrounding waters is largely dependent on the salinity and sediment type (Refer to Table A5 in **Appendix 11.6**). Within the estuary, where the salinity was low (≤ 1.3 PSU) and where the sediment was classed as mud (with leaf debris), the community is quite different from those outside the harbour where more sandy sediment is recorded. The sediment analysis revealed a pattern broadly similar to the macroinvertebrates, as would be expected, with four grouping: stations 11 and 12, stations 1, 4, 5, 7, and 8, stations 3 and 6, and stations 2, 9 and 10, with Station 13 very different from the others. Station 13, in the upstream part of the estuary, stands out from the rest of the samples on the basis of species and sediment as illustrated in Figure 11.7 and Figure 11.8.

The sediment was considerably more gravelly than any of the other samples, likely to be the result of higher current flows just downstream of Arklow Bridge. While stations 11 and 12 separated out together, this was on the basis of total organic carbon, as the sample at Station 12 was comprised entirely of tree leaves and the sample at Station 11 was comprised of mud and leaves. While stations outside the estuary were more sandy than those inside, silt & clays did still occur. This is due to localised variations in current flows due to bottom and/or coastal topographical variation.

The *Abra alba*-dominated community present at stations 1-8 is classified as ***Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (SS.SSa.CMuSa.AalbNuc)** (Connor *et al.*, 2004). Stations 9 & 10 could not be defined further than **Infralittoral fine sand (SS.SSa.IFiSa)**, while stations 11-13, within the Avoca River Estuary are so heavily influenced by freshwater input and lacking in marine fauna, that no biotope was assigned.

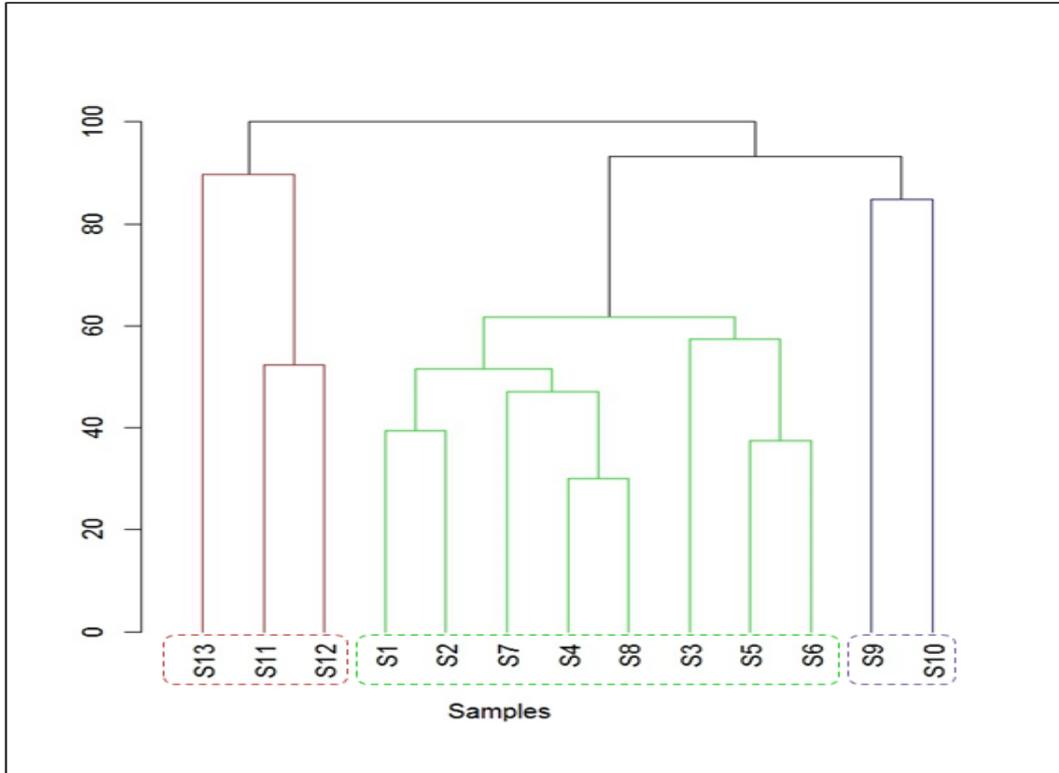


Figure 11.7: Cluster analysis showing significant (SIMPROF, $P < 0.05$) invertebrate community structure groupings among sampling sites (indicated with broken lines) based on Bray-Curtis similarities

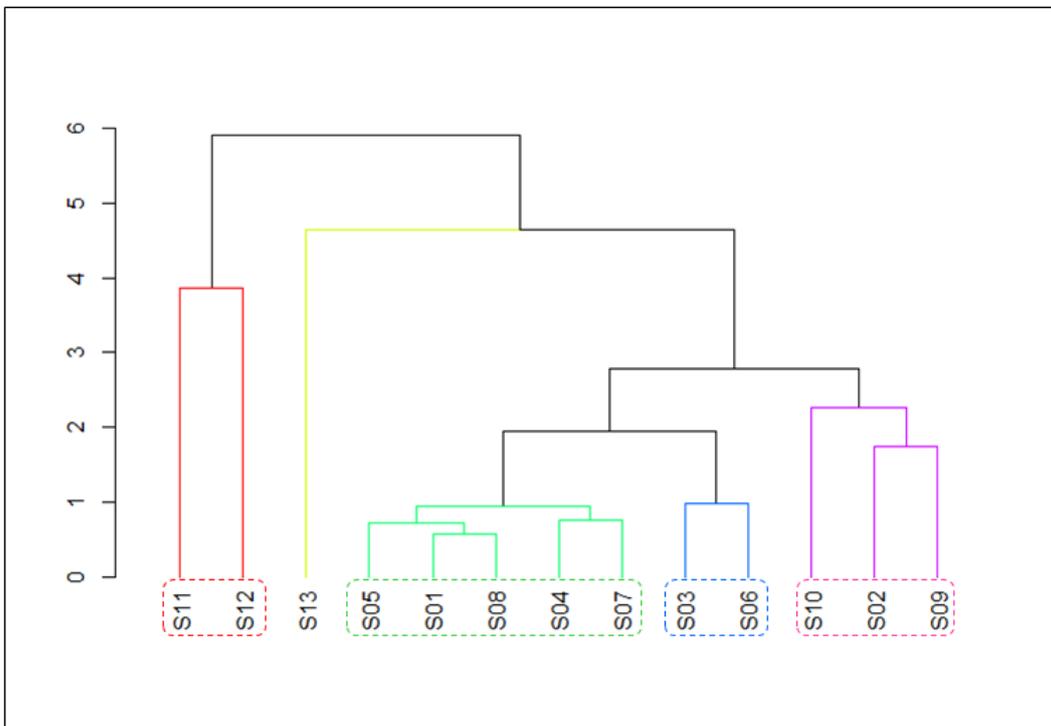


Figure 11.8: Cluster analysis showing significant (SIMPROF, $P < 0.05$) sediment characteristics groupings among sampling sites (indicated with broken lines) based on Euclidian distances.

11.3.6.7 Conclusion

The freshwater, estuarine and marine ecology in the vicinity of the proposed development has been described through field survey and desk study. The area is highly modified by human activity through the construction of retaining walls, breakwaters and stretches of rock armour, with the river impacted by acid mine drainage from the Avoca Mines upstream and the estuary also influenced by the input of untreated wastewater.

The species richness of the freshwater macroinvertebrate community is somewhat reduced at most of the sites as compared to what might be expected in a river such as the Avoca. This is due to the fact that the Avoca River is still recovering from the effects of acid mine drainage, which continues to have an influence on water quality. No rare or protected macroinvertebrate species were recorded in the course of the surveys or desk study.

Otters occur within the study area and are likely to make use of both banks of the river. The north bank is less prone to disturbance than the south bank and so is likely to provide better opportunities for otters in terms of resting up areas or the location of holts.

The three sample stations within the estuary (stations 11-13) lacked marine species and, with the exception of the oligochaete worms, the few animals recorded are likely to have washed down from upstream.

The low salinity of the estuary would likely play a factor in the low species richness and abundance, but the pollution caused by metals washed down from the Avoca mines upstream and the input of untreated wastewater into the estuary from Arklow town are likely to be combining to cause the depauperate benthic community of the Avoca River estuary, with the effect extending out into the Irish Sea.

The benthic community outside the Avoca Estuary has a depressed species richness compared to what might be expected from the habitat present. It is likely that the discharge of the Avoca River is having an influence in terms of contaminant load, as suggested in the previous benthic survey⁵². The area is dominated by a single biotope *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment, which is present at stations 1-8 and tallies with the findings of the previous survey⁵². This biotope is common and widespread along the east coast of Ireland.

Sample stations 9 and 10 were assigned to the higher category Infralittoral fine sand due to the lack of defining species. The separation of these stations from the other marine stations is likely to be due to the sediment type and their more inshore location.

While the intertidal and estuarine habitats of the study area are of low ecological value, the estuary does continue to support a fish community and provides a corridor for fish that may successfully migrate through to cleaner waters upstream of the polluting influence of the mines^{40,56}.

11.4 Likely Significant Effects

11.4.1 Do-Nothing Scenario

If the proposed development were not carried out, significant adverse effects on aquatic ecology and biodiversity in the Avoca River and Estuary in Arklow, and in adjoining coastal waters arising from the discharge of untreated wastewater would continue to occur.

11.4.2 Assessment of Effects during Construction

11.4.2.1 Terrestrial Biodiversity Habitats and Flora

Southern side of the Avoca River

Alps and River Walk

Construction of the Alps SWO and stormwater storage tank will require the removal of existing vegetation, and rock breaking. This will impact on Gorse and Bramble dominated **Scrub WS1** and **Exposed Siliceous Rock ER1**, species poor Bramble and Buddleia dominated **Scrub WS1 and WS3**, and on Ash and Sycamore regrowth. There is a potential for ground disturbed in this area to re-vegetate with Buddleia, which would tend to develop a dominant tall scrub cover within which native plant species would be suppressed, reducing biodiversity in the short, medium and long term with significant negative local effects (Refer to **Appendix 11.2**).

Temporary sheet piling at the southern end of this working area has the potential to cause root severance of a mature Sycamore tree, however this tree will be removed to facilitate construction.

The interceptor sewer will be constructed using open cut methods on the upstream, land based sections on River Walk (i.e. between MHS1-MHS8) and construction activities on River Walk (Working areas S8 – S10) will occur during October to March following consultation with Wicklow County Council. Interceptor sewer invert levels are between 2m - 4m below existing ground level in this section, therefore it is likely that the roots of mature trees growing in a semi-continuous **Treeline WL2** within a narrow strip (maximum width 7m) of mown amenity grassland along River Walk will be severed during these works. It is therefore assumed that in the reasonable worst case scenario almost all of the existing trees along the Avoca River bank within the planning boundary of the proposed development will be removed during construction.

⁵⁶ Fahy, E. and Reynolds, J. (1987) The Avonmore Brown Trout Fishery at Rathdrum, Co. Wicklow. Fishery Leaflet No. 137. Department of the Marine, Dublin.

Three mature trees will be retained along River Walk near the Alps; two weeping willow and one mature Hawthorn (Refer to **Chapter 13** for further detail). Likely significant effects on trees during construction are assessed as negative locally significant.

Mown **Amenity grassland GA2** along the Avoca River bank is likely to be removed during construction in working areas S2 and S3. Working areas S7, S8 and S11 along River Walk extend marginally into the Avoca River channel and are required to facilitate traffic movements around the adjoining working areas on the landside of River Walk. A temporary trafficable surface will be installed as part of the enabling works requiring the removal of **Amenity grassland GA2**, young trees planted within the amenity grassland, and of two Silver birch trees growing on the edge of the river bank. Likely significant effects during construction are assessed as negative locally significant.

The interceptor sewer will be constructed within the existing tarmac surface **Buildings and artificial surfaces BL3** of River Walk.

Direct effects on terrestrial habitats and flora at the Alps SWO and stormwater tank site and along River Walk to Arklow Bridge are assessed as being of negative local significance during construction, because biodiversity along the Avoca River corridor is higher upstream of Arklow Bridge than it is downstream, and because mature trees supporting high levels of bat feeding activity, will be removed. The amenity value of this area is separately in **Chapters 13 and 17** (Refer to **Appendix 13.2** for the tree survey report).

South Quay

Downstream of Arklow Bridge, the construction of interceptor sewers within terrestrial habitats will impact on **Buildings and artificial surfaces BL3**, **Amenity grassland GA2**, and on young trees planted in a narrow strip of amenity grassland along the south quay wall; these will be removed. **Amenity grassland GA2** and some mature ornamental trees at South Green are likely to be removed during construction. Likely significant effects on these habitats are assessed as being of moderate negative local significance during construction, because biodiversity is lower downstream of Arklow Bridge, and most of the trees that would be removed are young. The amenity value of this area is discussed separately in **Chapters 13 and 17** (Refer to **Appendix 13.2** for the tree survey report).

Existing vegetation of **Spoil and bare ground ED2** and **Recolonising bare ground ED3** at the temporary construction area to the south of the Harbour at South Quay (working area S19) will be removed. This direct effect is assessed as being of moderate negative local significance during construction because biodiversity is lower downstream of Arklow Bridge and the area has been recently used as a compound for other developments.

Assessment of effects on aquatic habitats in this area during construction are discussed in **Section 11.4.2.6**.

Northern side of the Avoca River

The working area to the west of Arklow Bridge (Working area N1), includes **Scrub WS1** growing on steeply sloping ground along the north bank of the Avoca River, which will be used temporarily to support construction works located within an area vegetated with sparse colonising vegetation of **Spoil and bare ground ED2**. All vegetation will be cleared to facilitate construction. This direct effect is assessed as being of moderate negative local significance for terrestrial flora and habitats. Likely significant effects on aquatic ecology in this area during construction are discussed in **Section 11.4.2.6**.

To the east of Arklow Bridge, a **Treeline WL2**, mainly of young ornamental trees planted in a 2m wide strip of ground between the road and the quay wall will be removed, together with occasional patches of Bramble, Gorse, grass and herbaceous vegetation. This direct effect is assessed as being of slight negative local significance for terrestrial flora and habitats, since this vegetation is subject to existing disturbance arising from maintenance of the quay wall and is in poor condition.

Habitats and flora at the WwTP site and adjoining working areas

All of the existing vegetation on this site as described in **Section 11.3.2.4** will be removed. This direct effect is assessed as being of moderate negative local significance for terrestrial flora and habitats.

11.4.2.2 Invasive Plant Species

Two non-native plant species listed in Part 1 of the Third Schedule of the European Communities (Birds and Natural Habitats Regulations 2011-2015) were recorded within the planning boundary in working areas:

- Sea-buckthorn *Hippophae rhamnoides*, a medium risk of impact, non-native plant species listed in Part 1 of the Third Schedule of S.I No.477 of 2011 occur in roadside planting at the Harbour on the South Quay (see **Figure 11.7 in Volume 3**). There is a potential for this species to spread during construction if seeds or plant parts are transported from this area by construction machinery, in the absence of management measures given in **Appendix 11.2**, and
- Spanish bluebell, a low risk of impact, non-native plant species listed in Part 1 of the Third Schedule of S.I No.477 of 2011 (see **Figure 11.7 in Volume 3**).

Two additional non-native invasive plant species, listed in the Guidelines¹⁰, were recorded in, and in the immediate vicinity of the proposed development:

- Buddleia / Butterfly Bush *Buddleja davidii*: Medium risk of impact; present in many areas as a mature shrub and as seedlings, not mapped; and
- Montbretia *Crocasmia X crocosmiiflora*; a single stand recorded on the revetment adjoining the WwTP site.

Management measures for these species are given in **Appendix 11.2**.

11.4.2.3 Birds

There is limited potential for disturbance, displacement, or habitat loss arising from the proposed development to affect the distribution of waterbirds recorded during baseline surveys, as construction activities will not extend to the main area of gravel banks within the Avoca River and Estuary used primarily by roosting, bathing and preening gull species. Waterbird numbers recorded were well below the threshold levels for national and international importance, where these have been determined. Gull species are not considered likely to be displaced from any of the areas in which they have been recorded during construction, either in estuarine or coastal waters. Likely effects during construction are assessed as not significant.

Amenity grassland along the south bank of the Avoca River at River Walk is used by Mallard and feral Greylag geese; this habitat will be largely removed during construction, and these waterbirds will be displaced to other areas in the vicinity including the Avoca River channel and estuary, and to Arklow Pond, which will not be affected by construction activities. Feral Greylag geese are not considered to be of conservation interest. Likely effects during construction are assessed as not significant.

Three species listed on Annex 1 of the Birds Directive were recorded during baseline surveys. A single Red-throated Diver was recorded on one occasion in coastal waters off Arklow. A single Greenland White-fronted Goose was recorded as a juvenile in December 2016, the presumed same bird remained in the area and was last recorded in February 2018. It is not expected that individual birds of either species will be affected by the proposed development, since their main areas of distribution are not located in the Arklow area. Single Kingfishers were recorded flying along the north bank of the River on three occasions during baseline surveys, and it is considered likely that there is a Kingfisher breeding territory in the area.

The river banks within the planning boundary are not suitable for Kingfisher nesting as Kingfishers prefer vertical or near vertical banks at least 1-2m high⁵⁷ and the river banks within the planning boundary are substantially lower than this. Potentially suitable banks were noted upstream along the Avoca River in the general vicinity of the M11 flyover. It is not expected that Kingfishers will be displaced from any breeding territory in the immediate area during construction of the proposed development. Likely effects on Annex 1 listed bird species during construction are assessed as not significant.

⁵⁷ Cummins, Sinéad, Jennifer Fisher, Ruth Gaj McKeever, Laura McNaghten, and Olivia Crowe (2010). Assessment of the distribution and abundance of Kingfisher *Alcedo atthis* and other riparian birds on six SAC river systems in Ireland. A report commissioned by the National Parks and Wildlife Service and prepared by BirdWatch Ireland.

Loss of mature trees and scrub within the planning boundary and the demolition of existing buildings at the WwTP site, have the potential to result in the loss of active nests of passerine bird species, and mortality of eggs and nestlings, if felling and clearance works are carried out between 1 March and 31 August, however construction along River Walk will occur during October to March. Likely effects are assessed as significant negative during construction, in the absence of mitigation.

11.4.2.4 Bats

The modifications or features introduced by the proposed development that are relevant to bats are:

- Vegetation clearance;
- Bridge underpinning and grouting works;
- Lighting;
- Building demolition at the WwTP site; and
- New building and vegetation screening.

These modifications have the potential to affect bat roosts, and bat feeding and commuting. A Derogation Licence (No. DER/BAT 2018 – 73) has been issued for the proposed development (Refer to **Appendix 11.7**).

Bat roosts

There will be tree felling and some scrub removal along the river including at the Alps SWO and stormwater storage site to the south of the Avoca River. It is likely that some of the mature trees along River Walk between the Alps and Arklow Bridge will be removed during the construction of the interceptor sewer, thus there is also the removal of the existing bat boxes along the riverfront. These offer roosting opportunities specifically geared towards bats.

The tree felling at The Alps also creates the risk of roost loss and injury to bats if not examined prior to such operations. The removal of a mature Sycamore near the ruins of Arklow Castle may facilitate access by bats to this known roost site.

Underpinning and associated repairs to the southernmost two arches of Arklow Bridge will remove crevices used by bats as roost sites. In addition to roost loss, there is the possibility of death or injury to roosting bats if repair work were to be undertaken without an examination for bats in advance of repairs. Likely direct effects would be significant negative in the absence of mitigation.

On the north side of the Avoca River immediately upstream of Arklow Bridge, there will be some tree loss at working area N1 (i.e. TSN1 adjacent to 1 Ferrybank). The mature conifers with low roost surveyed in 2016 at this site have already been removed as part of a separate development, but there may be some further tree removal here to accommodate the proposed development. There is low roost potential considered for the remaining trees at this location.

The existing buildings at the Old Wallboard site at Ferrybank are within the WWTP site and will be demolished. These buildings offer some roost potential albeit that they have not been proven to be roost sites during the two surveys undertaken in 2016 and 2017. It is probable that at most this is a transitional roost for individual bats (most probable species common pipistrelle, followed by soprano pipistrelle and Leisler's bat). In addition to roost loss, there is the possibility of death or injury to roosting bats if buildings are removed without an examination for bats in advance of demolition.

Reduced feeding

There will be reduced feeding opportunities for bats around trees currently growing at The Alps, along River Walk, and in other areas of good tree and scrub cover close to the Avoca River that will be felled or otherwise removed during the construction (Refer to **Figure 11.8 in Volume 3**). Mature trees and scrub provide suitable sheltered sites for insects, and their removal consequently reduces the value of the area within the planning boundary for foraging bats, with long-term moderately negative effects upon bats during construction.

Disturbance from lighting

Lighting of the Avoca River corridor along River Walk will be increased by the loss of mature vegetation that assists in restricting illumination especially in summer. This may affect bat species, in particular, the light-intolerant bat species Daubenton's bat during foraging, and if directed at emergence points would affect all bat species, even those that will feed in illuminated areas.

Given the existing knowledge of the bat fauna, illumination will only affect commuting rather than roosting as there are no known tree roosts to date. Species such as common pipistrelle and Leisler's bat are less affected than all other Irish bat species (but are less common in lit sites than in dark sites of similar habitat) and this would not be a significant impact overall in the current situation. At worst, it would be a permanent slight negative effect during construction.

11.4.2.5 Protected Marine Mammals Risk Assessment

Marine mammal sensory systems are adapted to life in the water or, in the case of seals, both in water and on land. The sound receiving systems of marine mammals have become specialised to meet the physical demands of water and to diving to considerable depth, while retaining many of the characteristics of land mammals (e.g., ear canal, air-filled middle ear, spiral cochlea of the inner ear). Marine mammals rely on sound to navigate, to communicate with one another and to sense and interpret their surroundings.

Cetacean species may currently be distinguished by three groupings related to their known auditory ability and functional frequencies. Seal species that occur in Irish waters, and other pinniped species occurring elsewhere, demonstrate differing auditory ability in air and in water, so from a functional point of view they may be subdivided into two groups: (i) pinnipeds in water, and (ii) pinnipeds in air (Table 11.8). Further information on marine mammal noise exposure criteria for permanent injury and for disturbance/behavioural response is given in **Appendix 11.5**.

Table 11.8: Functional frequency ranges in Cetacean and Seal species (Reproduced from Department of Arts, Heritage and the Gaeltacht)

Cetaceans			Pinnipeds in water	Pinnipeds in air
Low Frequency 7 Hz-22 kHz	Mid-frequency 150 Hz-160 kHz	High Frequency 200 Hz – 180kHz	75 Hz – 75 kHz	75 Hz – 30 kHz
Baleen Whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
<i>Species – Ireland</i> Humpback whale Blue whale Fin whale Sei whale Minke whale	<i>Species – Ireland</i> Sperm whale Killer whale Long-finned pilot whale Beaked whale species Dolphin species	<i>Species – Ireland</i> Pygmy sperm whale Harbour porpoise	<i>Species – Ireland</i> Grey seal Harbour seal	<i>Species – Ireland</i> Grey seal Harbour seal

Due to the concern regarding levels of anthropogenic sound associated with human activities in the marine environment, there is a growing body of literature and metrics describing the sound pressure level (SPL), sound exposure level (SEL) and other acoustic characteristics associated with specific machinery, vessels and operations, examples of which are given in **Appendix 11.5**.

With reference to the guidance², the proposed development construction activities of relevance to marine mammals include the following.

- Construction of the SWO at the WwTP, within a temporary cofferdam requiring the insertion and removal of sheet piles. A sheet piling method has not been specified, but can be expected to be carried out either by impact hammer or by vibrating head (including low vibration piling). These two piling methods have different sound generating characteristics, with impact hammer pile driving representing a worst case scenario. Pile driving strikes have generally been reported to produce low frequency pulse sounds of several tens of Hz to several thousand Hz (and up to approximately 20 kHz), with some technologies introducing underwater sound at comparatively high sound pressure levels exceeding 220 dB re: 1 µPa (Refer to Appendix 11.5 and Appendix C1 of the guidance²). This presents the possibility of permanent hearing injury (i.e., PTS), temporary hearing loss (i.e., TTS) or other injury for some marine mammals in close proximity to such operations (Refer to Appendix 11,5 and Appendix C2 of the guidance²).
- Construction of the long sea outfall will include works from both the land and sea and vessels and diving support is likely to be required at times. Three possible methodologies have been identified to construct the outfall as described in detail in **Chapter 5**:
- Horizontal directional drilling method;
- Flood and float method; and
- Bottom-pull method.

Of which the latter two methods require dredging of a trench within which the outfall will be laid. All three methods require works to attach the diffuser to the end of the outfall pipe, located approximately 900m offshore. Pile driving may be also required to construct a temporary cofferdam to facilitate this work. A sheet piling method has not been specified, but can be expected to be carried out either by impact hammer or by vibrating head (including low vibration piling). These two piling methods have different sound generating characteristics, with impact hammer pile driving representing a worst case scenario. Pile driving strikes have generally been reported to produce low frequency pulse sounds of several tens of Hz to several thousand Hz (and up to approximately 20 kHz), with some technologies introducing underwater sound at comparatively high sound pressure levels exceeding 220 dB re: 1 μ Pa (Refer to Appendix 11.5 and Appendix C1 of the guidance²). This presents the possibility of permanent hearing injury (i.e., PTS), temporary hearing loss (i.e., TTS) or other injury for some marine mammals in close proximity to such operations (Refer to Appendix 11.5 and Appendix C2 of the guidance²).

In addition to the sound from attendant vessels, dredging operations (required to construct the trench required as part of the flood and float and open cut methods) have been reported to produce low frequency omnidirectional sound of several tens of Hz to several thousand Hz (and up to approximately 20 kHz) at sound pressure levels of 135-186 dB re: 1 μ Pa. Some coastal dredging operations can therefore be detected at received levels (RL) exceeding ambient sound more than 10km from shore. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.

Drilling is generally acknowledged to produce moderate levels of continuous omnidirectional sound at low frequency (several tens of Hz to several thousand Hz and up to c.10 kHz). Source sound pressure levels have generally been reported to lie within the 145-190 dB re: 1 μ Pa range. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.

The revetment upgrade will require the removal of the existing rock revetment and its subsequent realignment and replacement of the rock armour. Construction of the revetment upgrade will be carried out from toe to crest by using suitable excavators located on the WwTP site. As a worst case scenario, noise levels are expected to be similar to those arising from dredging works.

In addition to the works in marine waters listed above, sheet piling is also likely to be required within the Avoca River estuary to construct the interceptor sewer in the river channel.

Occurrence of marine mammals in the vicinity of the proposed works

Harbour Porpoise, Bottle-nosed Dolphin, Harbour Seal and Grey Seal have been recorded occasionally in the vicinity of the proposed development, and in small numbers (see **Section 11.3.5.3**). This area is not known to hold important concentrations of these species.

Identified areas of importance for these species are located at a distance of at least 50km from the working areas. A total of 30 MMO watches, with a total duration of 268 hours of observations, were carried out during the 30 minutes prior to, and during site investigation works conducted in respect of the proposed development. No marine mammals were recorded.

The risk of cetaceans and seals being present in coastal waters during works is therefore assessed as low.

Additional marine mammal species recorded in coastal and offshore waters near Arklow are Common Dolphin, Striped Dolphin, Risso's Dolphin, and Minke Whale. This area is not known to hold important concentrations of these species.

Activities with the potential for cumulative effects include existing boat traffic entering and leaving Arklow Port, and existing activities at the quarry at Arklow Head. The proposed Arklow Flood Relief Scheme works will also include dredging works within the Avoca River both upstream and downstream of Arklow Bridge.

The lack of observations of marine mammals by the MMO during site investigation works indicates that risk is low, and arises with regard to the noise generating activities associated with particular construction activities in the Irish sea and Avoca River that are part of the proposed development. The Arklow area is not identified as a sensitive area for marine mammals, and the Arklow coastal area is not known to be used by important concentrations of marine mammals.

Notwithstanding that marine mammals do occur in the area, it is not possible to rule out a risk of injury or a disturbance/behavioural response to protected marine mammals; in the absence of mitigation there is a potential for direct significant adverse effects on individual marine mammals listed on Annex II of the Habitats Directive within their natural range.

11.4.2.6 Aquatic Ecology

Overview

While the intertidal and estuarine habitats of the study area are of low ecological value, the Avoca River estuary does continue to support a fish community and provides a corridor for fish that migrate through to cleaner waters upstream of the polluting influence of acid mine drainage (i.e. upstream of the proposed development). A number of the species recorded in the WFD sampling are particularly notable, in that they are listed under Annex II of the Habitats Directive, namely Atlantic Salmon *Salmo salar* and River Lamprey *Lampetra fluviatilis*. The planning boundary lies within transitional and coastal waters and River Lamprey adults have been recorded in transitional waters, and ammocoetes were recorded just upstream of the M11 flyover. Whilst not recorded in the course of the Inland Fisheries Ireland surveys^{39, 40, 41}, Sea Lamprey *Petromyzon marinus* are also known from the Avoca River, and are also listed under Annex II of the Habitats Directive.

None of these species are listed as Qualifying Interests in any of the SAC sites located upstream of the proposed development in the Avoca River catchment.

However, in the absence of mitigation, there is a potential for direct and indirect significant adverse effects on Atlantic Salmon *Salmo salar*, River Lamprey *Lampetra fluviatilis*, Sea Lamprey *Petromyzon marinus*, the Critically Endangered European Eel, and on other typical species within their natural range in the Avoca River catchment. The considerations potentially giving rise to these direct and indirect significant adverse effects are detailed below.

Temporary and permanent habit loss of aquatic habitat in the Avoca River and estuary

There will be a permanent loss of aquatic habitat arising from the southern interceptor sewer of which approximately 300m will be constructed in the Avoca River estuary from Arklow Bridge eastwards (River Working Area S1). An adjoining temporary causeway will be installed within the estuary (River Working Area S1) to facilitate these works. As described in detail in **Chapter 5**, the temporary causeway will be up to 10m wide and approximately 330m in length. The narrowest section of the estuary at South Green is approximately 96m wide. During construction, when the temporary haul road is in place, estuary width will reduce to 80m. 83% of the estuary width will therefore remain open to the passage of fish at this narrow point and no barrier to fish migration will arise during construction.

Working Areas S7, S8, S10 and S11 will be located on River Walk and extend marginally into the river channel. River Working Area S2 will be located in the river channel, in the vicinity of the proposed river crossing at tunnel shaft (TSS3) on South Quay. Working Area N1 will be located at No. 1 Ferrybank to support the construction of the interceptor sewer on North Quay. This working area includes a steeply sloping river bank and extends into tidal waters at the base of the bank.

The temporary working areas that directly overlap with the Avoca River required during construction of the proposed development will give rise to the direct and indirect effects described below.

Aquatic habitat alteration and degradation in the Avoca River and estuary

Construction activities including the construction and operation of temporary causeway and associated activities including transport of excavated materials and construction materials, will give rise to the potential for silt and soil to enter into the Avoca River and estuary. Increases in suspended sediment in a waterbody can cause stress and also affect the gills of fish, resulting in injury or mortality in a worst case scenario. Migratory fish movement through affected waters may also be adversely affected.

Construction works could potentially result in spillages and leakages entering the watercourse. Spills of construction materials may include concrete and cement, and leaks from construction equipment may include fuel, oils, lubricants and hydraulic fluids. These construction materials are toxic to aquatic fauna.

Disturbance of the existing Avoca River and estuary bed has a potential to mobilise existing contaminants including wastewater derived contaminants.

The resuspension of fine sediment can also remobilise heavy metals such as copper, zinc and lead that have settled in the river from the Avoca Mines and other sites upstream⁵⁸. These metals could impact on freshwater and marine aquatic fauna.

Bentonite will be used during tunnelling of the sewers and during underpinning works at Arklow Bridge. This material is not toxic, but can have a smothering effect on vegetation and benthic fauna if released in quantity. Aquatic vegetation is not present at the Arklow Bridge, and the benthic macroinvertebrate community is species poor and of low ecological value. Bentonite would contribute to turbidity and an increase in suspended sediments if unintentionally released into water.

The temporary causeway within the estuary (River Working Area S1) will be contained on the river side to mitigate against silt and spill migration into the Avoca River (Refer to **Chapter 5** for further detail). The two most likely methods to achieve this containment would either be an additional row of sheet piles on the river side of the causeway or alternatively a row of stone gabions wrapped in a geotextile membrane. Either method would require that the containing material (i.e. the sheet piles or the gabion walls) are extended (i.e. to a height above the surface of the haul road) to be effective. Similar containment of all other temporary working areas extending into the Avoca River and estuary is detailed in **Section 5.6.3.3 of Chapter 5**. In the absence of this mitigation, there is a potential for direct and indirect significant adverse effects on Atlantic Salmon *Salmo salar*, River Lamprey *Lampetra fluviatilis*, Sea Lamprey *Petromyzon marinus*, the Critically Endangered European Eel, and on other typical species within their natural range in the Avoca River catchment during construction.

The insertion and removal of sheet piling or gabions can contribute to a temporary increase in sediment entering the waterbody, although it must be noted that the main function of these barriers is the separation of working areas from the waterbody and the reduction of risk of habitat alteration and degradation.

Effects associated with dewatering – contamination of surface waters in the Avoca River and estuary

Working areas may be liable to accumulate water through rainfall and also through infiltration of groundwater. Dewatering will be required to remove this water, which may potentially include traces of in-situ fresh concrete and cement products, fuels, oils, lubricants and hydraulic fluids, and by silts and soils and organic materials arising from excavations. In the absence of mitigation, there is a potential for these contaminants to reach the adjoining waterbody within the Avoca River and estuary, resulting in habitat alteration and degradation as described above. In the absence of mitigation, there is a potential for direct and indirect significant adverse effects on Atlantic Salmon *Salmo salar*, River Lamprey *Lampetra fluviatilis*, Sea Lamprey *Petromyzon marinus*, the Critically Endangered European Eel, and on other typical species within their natural range in the Avoca River catchment during construction.

⁵⁸ Yau, H. and Gray, N.F. (2005) Riverine Sediment Metal Concentrations of the Avoca-Avonmore Catchment, South-East Ireland: A Baseline Assessment. *Biology and Environment: Proceedings of the Royal Irish Academy* 105B(2): 95-106.

Effects associated with dewatering– entrapment of fish in the Avoca River and estuary and in coastal waters

There is a potential for fish, including Annex II listed migratory species to become trapped in working areas in aquatic habitats when these are enclosed by sheet piles or geotextile wrapped gabions. This risk arises in the Avoca River and estuary, and also within the sheet piling to be provided to facilitate the construction of the SWO at South Quay.

In the absence of mitigation, there is a risk of injury and mortality to Atlantic Salmon *Salmo salar*, River Lamprey *Lampetra fluviatilis*, Sea Lamprey *Petromyzon marinus*, the Critically Endangered European Eel, and on other typical fish species within their natural range in the Avoca River catchment during excavation and dewatering activities.

Temporary and permanent benthic habitat alteration and loss in coastal and marine waters

The removal of the existing revetment during the revetment upgrade will result in the removal of a limited biotope of green macroalgae growing above a zone of Carrageen in the upper level to kelp species at depth. As described in **Section 11.3.6.5** and **Appendix 11.6**, this habitat is highly modified by human activity and has been assessed as being of low ecological value. Since a similar habitat is likely to colonise the revetment upgrade once in place, this likely significant effect is assessed as moderate negative, local, and of short to medium term in duration.

The construction of the SWO, terminating at the toe of the upgraded revetment, will not result in any additional loss of marine and marine benthic habitat, which would be excavated within a coffer dam to facilitate laying of the SWO. A concrete apron will also be placed around the outfall location, to protect against scour, but this will not result in the loss of any habitat as it will be within the footprint of the proposed upgraded revetment.

As described in detail in **Chapter 5**, the likely methods that can be undertaken to construct the long sea outfall, based on current practice and site restraints/characteristics, are:

- Horizontal directional drilling method;
- Flood and float method; and
- Bottom-pull method.

Construction of the outfall would include works from both the land and sea. It is expected that several vessels may be required during the construction of the outfall and that diving support is likely to be required at times.

Horizontal directional drilling

In the event of a blow-out during boring (required to enlarge the hole for the outfall as part of the horizontal directional drilling method), there is a potential for increased turbidity in marine waters with slight to moderate negative temporary effects on the existing depauperate benthic community and any fish that may be in the vicinity.

Benthic habitat loss will not arise from the horizontal directional drilling method of installing the outfall, because the construction and installation occurs at depth within the marine sediments, and no excavation is required within the surface of the sea bed, thus benthic communities would not be affected. No additional impacts on fauna arise.

Float and flood method and Bottom-pull method

The use of the float and flood method would require the formation of trenches and the placement of suitable material to support and protect the long sea outfall once it is in position. The use of the bottom-pull method would, in a similar manner to the flood and float method, require the formation of trenches and the placement of suitable bedding material to support and protect the positioned pipeline.

Trench excavation will impact directly on the existing benthic community in the habitat **Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment**, and would be likely to result in some localised mortality to common species with slight negative temporary effects.

Diffuser assembly

Once the long sea outfall has been laid, by whichever construction method (HDD, float and flood or bottom-pull), the diffuser will be assembled on the seaward end of the outfall to construct the diffuser arrangement of up to 6 diffusers of approximately 0.16m diameter at a spacing of approximately 10m intervals.

The diffuser will be prefabricated on land and placed on the seabed by barge as one complete unit. The exact procedure and depths of backfill required will depend on the detailed design and equipment available from the contractor along with programme and cost considerations, however it is anticipated that this will likely require open excavation of the seabed, around the diffuser.

The diffuser structures will be likely to colonise with a different marine biotope over a period of time. Once operational, the diffuser will be subject to routine inspection and maintenance by Irish Water to ensure their proper functioning.

11.4.2.7 Potential Effects on Coastal Processes

Overview

The assessment on coastal processes is provided in detail in **Chapter 15** and **Appendix 15.5**. The following items are of relevance for the biodiversity assessment:

- The uniform units identified in the vicinity of the area of study of coastal processes are Kilmichael Point to Mizen Head and Mizen Head to Wicklow Head.
- Each uniform unit incorporates smaller sub-physiographic units, also defined by changes in coastline orientation and local headland features, which also have the effect of limiting sediment exchange between adjoining units.
- The direction of longshore drift along the Wexford and Wicklow coasts is from South to North, therefore uniform units and their constituent physiographic sub-units along sandy shores tend towards sediment starvation and erosion at their southern end, and towards sediment accretion at their northern end. This effect is noted in the Buckroneys-Brittias Dunes and Fen SAC (site code: 000729) Conservation objectives supporting document - Coastal habitats (NPWS 2017⁵⁹).
- A smaller sub-physiographic unit is identified within the Kilmichael Point to Mizen Head uniform unit, in the stretch of coastline that is limited to the South by the breakwaters and piers which guard the entrance to Arklow Harbour, and to the North by the headland at Seabank, located at the North end of the Arklow North Beach. For clarity, this feature is referred to as the Arklow North sub-physiographic area of interest in this chapter.
- Three coastal SACs that are located at least 4km from the proposed development, are listed for Qualifying Interests with a potential to be affected by changes in coastal processes with regard to the single relevant attribute contributing to conservation status: Physical structure: functionality and sediment supply (Table 11.9). These European sites could be affected by ex situ activities that may impede longshore drift, and/or impede and alter sediment movement, to the extent of causing indirect effects on the Conservation Status of the Qualifying Interests listed in Table 11.8.

Table 11.8: Qualifying Interests of the European sites potentially affected by changes in coastal processes

European site	Buckroneys – Brittias Dunes and Fen SAC (Site Code 000729)	Kilpatrick Sandhills SAC (Site Code 001742)	Magharabeg Dunes SAC (Site Code 001766)
Relevant Qualifying Interest	Annual vegetation of drift lines [1210]	Annual vegetation of drift lines [1210]	Annual vegetation of drift lines [1210]
* indicates a priority habitat under the Habitats Directive	Perennial vegetation of stony banks [1220]		
	Mediterranean salt meadows (<i>Juncetalia maritimi</i>) [1410]		
	Embryonic shifting dunes [2110]	Embryonic shifting dunes [2110]	Embryonic shifting dunes [2110]
	Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes) [2120]	Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes) [2120]	Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes) [2120]

⁵⁹ NPWS (2017) Buckroneys-Brittias Dunes and Fen SAC (site code: 000729) Conservation objectives supporting document- Coastal habitats. Version 1 March 2017. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs.

European site	Buckronev – Brittas Dunes and Fen SAC (Site Code 000729)	Kilpatrick Sandhills SAC (Site Code 001742)	Magharabeg Dunes SAC (Site Code 001766)
	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*
	Dunes with Salix repens ssp. argentea (Salicion arenariae) [2170]		
	Humid dune slacks [2190]		

The Qualifying Interest habitats listed in Table 11.8 for Kilpatrick Sandhills SAC lie to the south of Kilmichael Point, and are outside the Kilmichael Point to Mizen Head uniform unit.

Part of Buckronev-Brittas Dunes and Fen SAC lies within the Kilmichael Point to Mizen Head uniform unit (Pennycomequick and Buckronev lie to the south of Mizen Head).

Magharabeg Dunes SAC lies within the Mizen Head to Wicklow Head uniform unit

Coastal processes potentially affected by the upgraded revetment

The extent of the proposed revetment upgrade is approximately 350m. Construction along the existing revetment will involve excavation in coastal waters along the toe of the existing revetment and removal of existing rock armour. The revetment upgrade may mobilise sand and silt.

As outlined in **Chapter 15** and **Appendix 15.3**, the only likely effect that the upgrade works could have on the existing coastal dynamics is the dispersion of material at the location of the revetment works during construction. The excavation of material from the seabed is limited at the toe of the proposed revetment and the volume of material is expected to be small.

Mobilised sand and silt is expected to be naturally deposited within the Arklow North sub-physiographic area of interest, and generally limited by both the harbour entrance at the south and the natural headland at the north at Seabank.

The likely indirect effects of the construction of the revetment upgrade on European sites (Kilpatrick Sandhills SAC -Site Code 001742; Buckronev – Brittas Dunes and Fen SAC - Site Code 000729, and Magharabeg Dunes SAC - Site Code 001766) are assessed as neutral (i.e. no effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error). No likely significant direct effects will arise during construction of the revetment upgrade.

Coastal processes potentially affected by the SWO

Mobilised sand and silt is expected to be naturally deposited within the Arklow North sub-physiographic area of interest, and generally limited by both the harbour entrance at the south and the natural headland at the north at Seabank. The likely effects of constructing the SWO on European sites (Kilpatrick Sandhills SAC -Site Code 001742; Buckronev – Brittas Dunes and Fen SAC - Site Code 000729, and Magharabeg Dunes SAC - Site Code 001766) are assessed as neutral. No likely significant direct or indirect effects will arise during construction of the SWO at the WwTP site.

Coastal processes potentially affected by the long sea outfall

Horizontal directional drilling method

Effects on coastal processes and sediment transport do not have a potential to arise with regard to the horizontal directional drilling method of installing the long sea outfall, because the construction and installation occurs at depth within the marine sediments, and no excavation is required at the surface of the sea bed.

The likely effect of the Horizontal directional drilling method of the long sea outfall during the construction phase on European sites (Kilpatrick Sandhills SAC -Site Code 001742; Buckronev – Brittas Dunes and Fen SAC - Site Code 000729, and Magharabeg Dunes SAC - Site Code 001766) is assessed as neutral. No likely significant direct or indirect effects would arise during construction of the outfall via the horizontal directional drilling method.

Flood and float and Bottom-pull methods

It is estimated that up to approximately 18,000 m³ of seabed material may be excavated if the flood and float or bottom pull methods are used to construct the outfall in order to form a trench into which the outfall would be laid.

As described in detail in **Chapter 15** and **Appendix 15.5**, the marine environment is dynamic and there is a continuous process of sedimentation and deposition naturally occurring. In this context, the volumes of excavated material from the long sea outfall trench are considered to be relatively small and it is expected that up to around 50% of the excavated material will be reused to backfill the trench.

The likely effect of the float and flood method, and the bottom-pull method during is therefore assessed as neutral, with regard to the Conservation Objectives of Buckronev – Brittas Dunes and Fen SAC (site code: 000729).

Applying the precautionary principle, potential effects on the Conservation Objectives of Buckronev – Brittas Dunes and Fen SAC (site code: 000729) could be slight or moderate temporary adverse, because of the location of Pennycomequick dunes and Buckronev dunes within the Kilmichael Point to Mizen Head uniform unit, within which adverse effects on existing coastal processes could have a potential to occur during construction in the event of the construction phase of the long sea outfall interacting with a strong gale, storm or extreme weather event, in the absence of mitigation applied in accordance with the precautionary principle.

The likely indirect effect of the float and flood or bottom-pull methods of the long sea outfall during the construction phase on Kilpatrick Sandhills SAC (Site Code 001742) and Magharabeg Dunes SAC (Site Code 001766) are assessed as neutral. Direct effects on these European sites will not arise.

Diffuser assembly

Once the long sea outfall has been laid, by whichever method, the diffuser will be assembled at the seaward end of the outfall. The diffuser arrangement will include up to 6 diffusers of approximately 0.16m diameter at a spacing of approximately 10m intervals.

The diffuser will be prefabricated on land and placed on the seabed by barge as one complete unit. The exact procedure and depths of backfill required would depend on detailed design and the equipment available from the contractor along with programme and cost considerations, however it is anticipated that this will be undertaken from the barges and likely require open excavation of the seabed, around the diffusers.

The extent of excavation may be approximately 60m long and 6m wide, in a water depth of approximately 11m. The likely effects of the diffuser assembly during on European sites (Kilpatrick Sandhills SAC -Site Code 001742; Buckronev – Brittas Dunes and Fen SAC - Site Code 000729, and Magharabeg Dunes SAC - Site Code 001766) are assessed as neutral, because of the small scale of the works involved. Following the precautionary principle, mitigation is provided to ensure this outcome. No likely significant direct effects arise will arise during construction and assembly of the diffuser.

11.4.2.8 Cumulative

The proposed Arklow Flood Relief Scheme design is being developed currently and hydrological investigations are in progress to inform the final design.

The proposed Arklow Flood Relief Scheme which is still at design stage and in respect of which no planning application has yet been submitted would likely comprise the construction of direct flood defences, including flood defence walls, embankments and gates within Arklow town to improve resilience to flooding, as well as conveyance improvements in the Avoca River as described in **Section 2.6 of Chapter 2**.

As currently envisaged and understood given the information provided by the design team, dredging would take place as part of the proposed Arklow Flood Relief Scheme within the estuary (Transitional waterbody) in Arklow, both upstream and downstream of Arklow Bridge, and may extend into the Surface waters of the Avoca River also. Based on the current level of information available, the debris trap and gravel trap for the proposed Arklow Flood Relief Scheme are likely to be constructed in the Avoca River, subject to the final design details. Based on the current level of information available, it is not envisaged that the proposed Arklow Flood Relief Scheme would occur in coastal waters.

On the basis of the information currently available, in respect of the proposed Arklow Flood Relief Scheme, which is still at design stage and in respect of which no planning application has yet been submitted, it is not considered likely that the proposed Arklow Flood Relief Scheme would interact with the proposed development as regards potential impacts on the European sites listed in Table 11.2 and outlined below:

- Buckronev – Brittas Dunes and Fen SAC (Site Code 000729);
- Kilpatrick Sandhills SAC (Site Code 001742);
- Magharabeg Dunes SAC (Site Code 001766);
- Wicklow Reef SAC (Site Code 002274);
- Blackwater Bank SAC (Site Code 002953);
- Wicklow Mountains SAC (Site Code 002122);
- Wicklow Mountains SAC (Site Code 002122);
- Vale of Clara (Rathdrum Wood) SAC (Site Code 000733); and
- Wicklow Mountains SPA (Site Code 004040).

Because Buckronev – Brittas Dunes and Fen SAC (site code: 000729) is the only European site that has been identified for the provision of mitigation, following the precautionary principle, to ensure neutral effects during construction of the proposed development, and because it is not envisaged that any works for the proposed Arklow Flood Relief Scheme would occur in coastal waters, potential cumulative effects of the two developments on European sites are assessed as neutral.

Since the proposed development and the proposed Arklow Flood Relief Scheme overlap within the Avoca River and Estuary, the same baseline Annex II listed species occur in the footprint for both schemes. With reference to Table 11.2, Otter *Lutra lutra* is listed as a Qualifying Interest for Wicklow Mountains SAC (Site Code 002122).

Otters will utilise freshwater habitats from estuary to headwaters. No aquatic habitat severance will arise to Otters moving between the upper Avoca River catchment and coastal waters, since water will continue to flow through the river and estuary during construction works undertaken for both the proposed development and the proposed Arklow Flood Relief Scheme.

The operation of plant and machinery, and the presence of workers on the site, will result in some level of disturbance to Otters using the area. Otters are predominantly nocturnal and therefore would not overlap greatly with construction activities. Further, Otters are also quite tolerant of human disturbance and are often recorded in urban areas, so this impact is unlikely to be significant. Disturbance arising from cumulative construction works may have some potential to result in brief displacement of Otters to unaffected areas of the river channel and banks in the Arklow area, but since works are not anticipated to continue throughout 24 hours each day, cumulative effects are assessed as slight negative and restricted to the Arklow area. Ex situ cumulative effects on Otter in Wicklow Mountains SAC are assessed as neutral.

Fish species listed on Annex II of the Habitats Directive i.e. Atlantic Salmon and River Lamprey, occur in the Avoca River catchment and estuary, while Sea Lamprey are known to occur but have not been recorded in recent surveys of the estuary. The estuary area has been highly modified by human activity through the construction of estuarine retaining walls, harbour breakwaters, and a stretch of coastal rock armour revetment, with the river impacted by acid mine drainage from the Avoca Mines upstream and the estuary also influenced by the input of untreated wastewater.

While the estuarine habitats of the study area are of depressed species richness and low ecological value, the estuary does continue to support a fish community and provides a corridor for fish including Habitats Directive Annex II listed species. Since these species are not listed as Qualifying Interests for any upstream Natura 2000 sites, no cumulative ex situ effects arise. However, potential cumulative direct and indirect effects arise on Habitats Directive Annex II listed Atlantic Salmon *Salmo salar*, River Lamprey *Lampetra fluviatilis*, and Sea Lamprey *Petromyzon marinus*, the Critically Endangered European Eel and on other typical species within their natural range in the Avoca River catchment, in the absence of mitigation should the construction of the proposed development and proposed Arklow Flood Relief Scheme occur simultaneously.

Aquatic ecology

Dredging in the river channel as part of the proposed Arklow Flood Relief Scheme has the potential to impact on the aquatic environment in a number of ways. These impacts may include habitat loss, habitat alteration, impacts on species populations, increased suspended solids, and the risk of hydrocarbon pollution. This can impact on fish species by clogging gills, reducing visibility when foraging, and clogging spawning gravels (though it should be noted that there is no evidence of salmonid or lamprey spawning within the proposed dredge area).

The resuspension of fine sediment can also remobilise heavy metals such as copper, zinc and lead that have settled in the river from the Avoca Mines and other sites upstream⁶⁰. These metals could impact on freshwater and marine aquatic fauna.

⁶⁰ Yau, H. and Gray, N.F. (2005) Riverine Sediment Metal Concentrations of the Avoca-Avonmore Catchment, South-East Ireland: A Baseline Assessment. *Biology and Environment: Proceedings of the Royal Irish Academy* 105B(2): 95-106.

Bats

Four Habitats Directive Annex IV listed bat species have been recorded within the proposed development and proposed FRS combined works areas:

- Common pipistrelle - *Pipistrellus pipistrellus*
- Soprano pipistrelle - *Pipistrellus pygmaeus*
- Leisler's bat - *Nyctalus leisleri*
- Daubenton's bat - *Myotis daubentonii*

Individual Bat Derogation Licences will be required for each project in respect of works at Arklow Bridge. A Derogation Licence (No. DER/BAT 2018 – 73) has been issued in respect of the proposed development (Refer to Appendix 11.7) and it is anticipated that the proposed Arklow Flood Relief Scheme would also obtain their own derogation license in due course.

Likely potential effects of the proposed Arklow Flood Relief Scheme on bats are outlined below:

- There will be the removal of suitable crevices from Arklow Bridge during underpinning works. In addition to potential roost loss, there is the possibility of death or injury to roosting bats if works were to be undertaken without an appropriate examination for bats in advance of works.
- Tree felling behind Brigg's Lane may be required to allow the construction of the flood protection berms which also creates the risk of roost loss and injury to bats if not examined prior to such operations.
- There will be reduced feeding as mature trees are felled and suitable sheltered sites for insects are removed that consequently reduces the value of the site for foraging bats. The feeding opportunities within the footprint of the proposed Arklow Flood Relief Scheme provided by the trees to the rear of Brigg's Lane and Ferrybank.

In the absence of mitigation, this creates a long-term moderately negative impact upon bats.

Generally, the changes within Arklow, if following current trends, would see a loss in green space, increase in lighting and increase in modern buildings with an associated removal of old buildings for some developments associated with those developments identified in Chapter 2. These would all create a permanent moderate negative effect if not appropriately mitigated in each project.

11.4.3 Assessment of Effects during Operation

11.4.3.1 Terrestrial Biodiversity, Habitats, Flora, and Fauna

In the absence of mitigation, the effects of the proposed development will be similar to those described in **Sections 11.4.2.1 to 11.4.1.4**, with the following exceptions:

- loss of bird's nests and mortality or injury to nestlings would not arise; and
- mortality or injury to Annex IV listed bat species would not arise.

11.4.3.2 Bats

External lighting will be installed around the WwTP for the safety and security of staff on the site during for operational reasons. The lighting will be kept close to the buildings and only operate when there is movement. Operational lighting will be designed in accordance with the relevant street light standards. LED flood lighting with glass lenses will be provided on the WwTP site, located within some parts of the louvered building façade, and would be switched rather than motion activated. This may lead to the disturbance of light intolerant or shy species while the more urban-adapted species will be affected only over a short-term period. Of the species noted on and around the WwTP site, no bats would be considered light-intolerant as they will generally avoid direct illumination but are not usually fully excluded by the presence of light.

Pipistrelles, the main species within the WwTP site, are negatively affected by lighting but to a lesser extent than most Irish species. Leisler's bats are the most tolerant of light of the three species noted. This species will feed around lighting in car parks as the night progresses. There are no roosts directly illuminated by changes to the site as there were no roosts noted within the site in June 2016 or in August 2017.

Once constructed, the proposed WwTP buildings may have a positive impact as they may have future roost potential for bats.

The planting of vegetation within the WwTP site provides feeding and commuting potential for bats.

11.4.3.3 Marine Mammals

During operation, it is not envisaged that noise generating activities associated with the proposed development would have a potential to affect cetacean species listed in Annex IV of the Habitats Directive and/or Harbour Seal and Grey Seal listed in Annex II of the Habitats Directive.

11.4.3.4 Aquatic Ecology

The commissioning of a WwTP at Arklow will have positive impact on aquatic ecology. Currently, untreated wastewater is entering the river, as evidenced by the accumulation of toilet paper and sanitary towels in parts of the estuary.

The input of untreated wastewater affects water quality can result in elevated nutrient levels, increased turbidity, changes to pH and reduced oxygen levels; all of which can impact on aquatic ecology. In addition, the Avoca Estuary is being impacted by the acid mine drainage from upstream and so the two pollution sources may be acting cumulatively or synergistically, resulting in serious impacts on the aquatic environment.

Freshwater, estuarine and marine macroinvertebrate communities are sensitive to nutrient and dissolved oxygen levels, as well as other chemicals and metals, and so the elimination, in so far as possible of untreated wastewater discharges will result in a change to a more natural community structure, indicative of cleaner waters. This will benefit the aquatic environment and biodiversity generally and have a positive impact on the status of the river, estuary and coastal waters from the perspective of the Water Framework Directive. The negative impact wastewater is currently having on the macroinvertebrate community is evidenced by the dominance of the worm *Lumbriculus variegatus* downstream of the Arklow Bridge (Refer to Table A1 in **Appendix 11.6**).

Many fish species are also sensitive to reduced water quality, and serious pollution incidents involving substances that reduce dissolved oxygen (such as untreated wastewater) can result in fish kills, while chronic exposure to sub-lethal levels of pollutants can impact on overall health and reproduction. The Avoca Estuary provides habitat for adult and juvenile marine species and is also an important pathway for important migratory species, such as the Habitats Directive Annex II listed Atlantic Salmon, River Lamprey, and Sea Lamprey, the critically endangered European Eel, and on other typical fish species within their natural range in the Avoca River catchment, and in the Estuary. Physiological changes required to move between freshwater and seawater mean that certain migratory species have to spend some time in the estuarine environment before moving on, which, in the case of the Avoca Estuary, exposes them to elevated pollution levels associated with raw wastewater. The improvement in estuarine water quality that will result from the proposed development will positively impact on the fish species that use the estuary for short or long periods of time.

The proposed development does not have a potential to affect marine mammals during the operational phase, therefore likely significant effects are imperceptible.

11.4.3.5 Coastal Processes

The scour protection concrete mattress over the long sea outfall may create a 900m long linear artificial reef habitat, which would be likely to colonise with a different marine biotope over a period of time.

Assuming a base width of approximately 6m, the scour protection, if exposed above the sea bed level, would cover an area of approximately 0.54ha of sea bed, where the existing habitat is classified as **Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment**. This biotope is common and widespread along the east coast of Ireland. It would be replaced by c.0.54ha of scour protection, effectively creating a 900m long linear artificial reef habitat, which would be likely to colonise with a different marine biotope over a period of time.

Colonisation of the scour protection would be by a range of subtidal marine algae and sessile animals, such as kelps and other seaweeds, molluscs such as mussels, crustaceans such as barnacles, bryozoa and sponges, as well as mobile invertebrates. The colonisation would begin as soon as the scour protection is in place, with a succession of species taking advantage of the unoccupied surface until it reaches an equilibrium over a number of years. The scour protection and the associated sessile species would also provide cover and foraging for larger mobile species such as fish, crabs and lobsters. This effect is assessed as slight positive, because species diversity will increase.

Otherwise, the long sea outfall during the operation of the proposed development is assessed as neutral on the Conservation Objectives of Buckronev – Brittas Dunes and Fen SAC (site code: 000729), with regard to the relevant attribute Physical structure: functionality and sediment supply, for which the target is to maintain the natural circulation of sediment and organic matter throughout the entire dune system, without any physical obstructions. Direct effects on European sites will not arise from the proposed development.

Further north, within the Mizen Head to Wicklow Head uniform unit, the effects of the outfall during operation is assessed as neutral on the Conservation Objectives of Magharabeg Dunes SAC (Site Code 001766), because of distance from the proposed development and location to the North of Mizen Head and another headland at Ballynacarrig. Direct effects on this European site will not arise from the proposed development.

11.4.3.6 Cumulative

It is noted that a Public Realm Plan would be developed as part of the proposed Arklow Flood Relief Scheme and that this will include tree planting along River Walk, along the South Quay and adjacent to the Town Marsh pNHA in Arklow. Planting of mature trees may therefore be implemented as part of the proposed Arklow Flood Relief Scheme along the southern banks of the Avoca River and Estuary. This is considered a positive effect on biodiversity during operation of the proposed development and the proposed Arklow Flood Relief Scheme.

11.5 Mitigation Measures and Monitoring

11.5.1 Mitigation

11.5.1.1 Mitigation During Construction

Terrestrial biodiversity, habitats, and flora

Overview

The mitigation measures for habitats and flora aim to implement Objective NH12 of County Development Plan (Refer to **Section 11.3.1.3**), in the context of the ecological baseline conditions recorded within the planning boundary of the proposed development.

Chapter 5 provides for top-soiling and seeding of existing areas of Amenity grassland **GA2** within the planning boundary of the proposed development, where these are removed or damaged during the construction phase. The species listed in Table 11.9 are suitable for seeding in these areas, and managed as short meadow. **Section 13.5 of Chapter 13** makes recommendations in relation to the planting of replacement trees in these locations.

Table 11.9: Native grasses and wild flowers to be included in short and long meadow habitat

Common name	Scientific name	Habitat / management notes
Grasses		
Red Fescue	<i>Festuca rubra</i>	Dominant grass species on existing site. Common widespread species, also salt tolerant. Suitable for use in short and long meadow habitat
Common Bent/Brown Top	<i>Agrostis capillaris</i>	Component species of wild flower seed mix
Flowering herbaceous plants for inclusion in wild flower mix. All these native species occur on site or in the Arklow coastal area, are pollinated by insects and will enhance biodiversity and habitat for bats and birds		
	Apiaceae	
Wild Carrot	<i>Daucus carota</i>	Biennial. Tolerates coastal conditions, calcareous substrate, suitable for use in long meadow habitat
	Asteraceae	
Common knapweed	<i>Centaurea nigra</i>	Perennial. Suitable for use in long meadow habitat
Hawkbit	<i>Leontodon spp.</i>	Suitable for use in short and long meadow habitat
Sea Mayweed	<i>Tripleurospermum maritimum</i>	Biennial or perennial of coastal rock, shingle and waste ground. Suitable for use in small gravel or reinforced surface with light use, or in meadow
Yarrow	<i>Achillea millefolium</i>	Perennial, suitable for use in short and long meadow habitat
Legumes; Clovers and Vetches	Fabaceae	
Bird's foot trefoil	<i>Lotus corniculatus</i>	Perennial. Suitable for use in short meadow habitat
Common vetch	<i>Vicia cracca</i>	Perennial. Suitable for use in long meadow habitat
Hare's-foot Clover	<i>Trifolium arvense</i>	Annual of coastal habitats. Suitable for use in small gravel or reinforced surface and in meadow

Common name	Scientific name	Habitat / management notes
Kidney vetch	<i>Anthyllis vulneraria</i>	Perennial, coastal habitats. Suitable for use in short and long meadow habitat
Meadow vetchling	<i>Lathyrus pratensis</i>	Suitable for use in long meadow habitat
White clover	<i>Trifolium repens</i>	Suitable for use in reinforced grass surface and in short meadow habitat
Red clover	<i>Trifolium pratense</i>	Suitable for use in reinforced grass surface and in short and long meadow
Black medick	<i>Medicago lupulina</i>	Suitable for use in short and long meadow
	Lamiaceae	
Selfheal	<i>Prunella vulgaris</i>	Perennial, suitable for use in short and long meadow
	Rubiaceae	
Lady's bedstraw	<i>Galium verum</i>	Perennial of dry sandy and coastal areas, suitable for use in short and long meadow

Wildflower grassland management

Initially, sown areas will need to be monitored for germination and establishment, and any unwanted species removed manually. Subject to monitoring, mowing may not be required during the first year after seeding. After the meadow is established, the following regime is recommended:

Short meadow will generally be mown five times per year, with cut material removed:

- First cut after the 15 April
- Second cut at end of May
- Third cut in mid-late July (maximises growth of Clovers and other wildflowers)
- Fourth cut at the end August
- Fifth cut after mid-October.

Long meadow will be mown once a year, in late September or October, with cut material removed.

For both short and long meadow, a high cut setting of >8-10cm is recommended during mowing or strimming.

At the Alps SWO and storm water storage tank site, Honeysuckle will be planted at 2m centres along the western and eastern sides of the perimeter fence. This measure will provide shelter and habitat for insects and feeding habitat for bats at a small site where tree and shrub planting would be inappropriate.

The grass and wildflower seed mix listed in Table 11.9 will be seeded within and adjoining the temporary construction site as part of completion works and managed initially as short meadow, to implement measures to control Buddleia are required in this area as identified in **Appendix 11.2**.

Landscaping around the four buildings at the WwTP site will follow a basic grid, derived from the primary geometries of the site. This grid will include hard landscaping between the buildings in addition to soft landscaping that will be planted around the site perimeter. This landscaping will be provided as part of the completion works, as illustrated in **Drawing No. 247825-00-L002 in Volume 3**.

Planting of trees, shrubs and climbers, and seeding with the bespoke mix of native grasses and wild flowers listed in Table 11.9 to be managed as short and long meadow, will be carried out in areas agreed with the project architect Clancy Moore within the WwTP site, and also along the site road frontage where a 5m setback to be provided will allow space for planting of groups of trees and short meadow, with Honeysuckle provided at intervals along the WwTP site boundary fence. Irish native species are proposed throughout, as specified in Table 11.9 and Table 11.10, with the exception of Scot's pine for which a cultivar is likely to be more suitable for this coastal location.

Table 11.10: Trees, shrubs and climbers to be included in planting at the WwTP site

Common name	Scientific name	Habitat / management notes
Colonising / established trees and shrubs recommended for planting		
Silver Birch	<i>Betula pendula</i>	Requires some shelter. Birch provides light shade, suitable for under-planting with Bluebell <i>Hyacinthoides non-scripta</i> . Bluebell leaves will emerge in autumn, flowers in April and May, leaves will die back in June. Wildflower meadow species from adjoining planting will colonise. Any maintenance of herbaceous ground flora required in areas planted with Silver birch should be carried out in July and August.
Autumn Gorse	<i>Ulex gallii</i>	Tolerates exposure. Mature plants up to 0.8m tall, little management required. Not suitable for under-planting with grasses or wild flowers
Honeysuckle	<i>Lonicera periclymenum</i>	Climber, suitable for planting at intervals along the site boundary fence, may need some support until established. Little management required
Scot's pine	<i>Pinus sylvestris</i>	A cultivar, <i>Pinus sylvestris</i> Glauca Nana that appears to do well in coastal windy locations is recommended, it will grow to 12m in height after 20-50 years

Birds

Tree felling, removal of scrub and other tall vegetation will be carried out between 1 September and 28 February, to avoid any risk to breeding birds and their habitats.

At the WwTP site, depending on the schedule of demolition of existing buildings, the sequence of demolition works may require to be modified to take account of a small number of breeding birds that may be present within structures, in the event of works occurring from 1 March to 31 August.

Nesting boxes for the Red-listed species Grey Wagtail, and for Pied Wagtail will be provided in alternate arches of Arklow Bridge, on ledges above high-water level in the existing concrete structure on the upstream side of the Arklow Bridge (because existing ledges are not secure from predation), in order to provide nesting habitat for these species that feed extensively along the river channel.

Bats

A Derogation Licence (No. DER/BAT 2018 – 73) has been issued for the proposed development (Refer to **Appendix 11.7**).

As all bat species recorded within the planning boundary of the proposed development are protected under Annex IV of the Habitats Directive, the works to be carried out to the two southernmost arches of Arklow Bridge and their associated piers require the aforementioned derogation license from the NPWS to allow works that would create a risk to bats and would remove existing roosting options. The following measures were proposed as part of the application for the derogation licenses and will be implemented during construction to meet the requirements for protecting the bats availing of Arklow Bridge:

- Examination of the bridge prior to works by the licensed bat specialist for evidence of bats.
- Exclusion of bats if necessary with one-way valves devised by the bat specialist.
- Capture of any bats that are still present prior to works and retention until the risk of injury or re-entry to the bridge has been removed.
- Provision of 4 x 2FR Schwegler woodcrete bat tubes for each modified arch (i.e. 12 x 2FR bat tubes). These bat boxes must be attached to the bridge in an unlit area above high-water mark.
- The boxes should be attached upright unless there is insufficient clearance above the river and the lower section would be immersed. Two boxes should be attached together to form a large cavity suitable for a large population of bats.

Examination of all mature trees, and bat boxes along River Walk with roost potential prior to removal

All mature trees at the Alps, along River Walk, and along the south and North quays in Arklow shall be examined for bats prior to felling.

This may be achieved through a bat detector assessment if undertaken in the active season (prior to November and after March) or alternatively may require supervision at the time of felling. Any mature trees will require survey prior to felling.

All buildings within the WwTP site shall be examined for bats prior to removal. This may be achieved through a bat detector assessment if undertaken in the active season (prior to November and after March) or alternatively may require supervision at the time of removal.

Lighting at the WwTP site

External lighting will be installed around the WwTP for the safety and security of staff on the site. The specimen lighting required during construction has been designed in consultation with the licenced bat expert. The detailed lighting required will be designed in consultation with the licenced bat expert, using emerging lighting technologies and having regard to best practice.

Mitigation for bats proposed as part of the application for the derogation licenses and required to be implemented during construction includes the following additional lighting considerations:

- Floodlighting is required for two of the external yards, and will be located within the building facade, and screened from broader light spillage by the louvered elements of the facade. Floodlights will be LED, as these have glass lenses which can be used to direct the light to the working area and reduce light spillage;
- Floodlights for working areas will make use of multiple lights to produce a more uniform light output and to lower the individual output from a single source – these will however still be quite high output;
- The site lighting incorporates the use of street lights to light the roadway around the building. The street lights will be selected to minimize upward lighting spill, hoods, louvres, shields or cowls would be fitted on the lights to reduce light spillage, and will incorporate the use of presence detection;
- Perimeter fence lighting will also incorporate presence detection, and will be off by default until motion is detected;
- Low level (~ 1m high) bollard lighting is being used in selected areas (refer to architect's landscape plans);
- Lights should be of low intensity. It is better to use several low intensity lights than one strong light spilling light across the entire area. The source of light should be Light Emitting Diodes (LEDs) as this is a narrow beam highly directional highly energy efficient light source. The lighting should allow for a light level of 3 lux at ground level. This low lighting is thus easier to control both the direction but also the actual light level because it is so close to the target area (if using bollard lighting);
- Narrow spectrum lighting should be used with a low UV component. Glass also helps reduce the UV component emitted by lights.

In the event of security lighting being required, it is recommended that infra-red lighting and infra-red cameras are employed to record anti-social activity to assist in crime solving and prevention. This will not raise the visible light levels that would affect mammals and birds to a much greater extent.

Additional habitat creation measures for bats

It is envisaged that the façade of the new buildings at the WwTP will provide roosting opportunities for bats. As part of the detailed design of the proposed development, the appointed bat specialist shall review the buildings and advise on an appropriate location for of a purpose-built bat box such as the Improved Roost-Maternity Bat Box; likely to be located on the southern facade of both Process and Inlet works Buildings at about 4.5m off the ground. These locations will not be directly illuminated.

Planting of trees, shrubs, climbers, and species rich grassland within the planning boundary of the proposed development is detailed in the flora and habitats mitigation **Section 11.5.1.1**.

Marine mammals

The Standard Management Conditions for the contractor will include a requirement to consider alternative construction methodologies during the development of the detailed design, including confirmation of the sound generation characteristics (in air and in water) of all methodologies and all the equipment intended to be used in coastal and marine environments (i.e. in all areas east of Arklow Harbour at South Quay). The contractor will also be required to apply the appropriate risk minimisation measures outlined in the guidance². These risk minimisation measures include the following as a minimum²:

- A6.1 - Minimise the duration over which the sound-producing activity is intended to take place;
- A6.2 - Minimise the individual and cumulative sound pressure and exposure levels delivered into the environment by the activity. If necessary the use of alternative, lower impact equipment and methods could be explored (e.g., vibratory hammer, gravity base piles).
- A6.3 - Incorporate the use of clear “ramp-up” (i.e., “soft-start”) procedures, whereby sound energy input to the marine environment is gradually or incrementally increased from levels unlikely to cause significant behavioural impact on marine mammals to the full output necessary for completion of the activity.
- A6.4 - Incorporate the use of fully enclosing or confined bubble curtains, encircling absorptive barriers (e.g., isolation casings, cofferdams) or other demonstrably effective noise reduction methods at the immediate works site, in order to reduce underwater sound propagation from on-site operations. Studies have shown that such methods can provide a significant reduction in sound input to the wider aquatic environment in the order of 10-30 dB.

- A6.5 - Use trained and experienced marine mammal observers (MMOs) to provide effective means of detecting marine mammals in the vicinity of coastal and marine plans or projects. Associated operational considerations must also be taken into account (see Section 4.2 of the guidance²).

Implementation of these measures during construction will ensure that no risks of injury to, or of a disturbance/behavioural response by marine mammals from man-made sound will arise during construction.

Aquatic ecology

The contractor will submit a detailed programme of work to the client and to Inland Fisheries Ireland showing the order of procedure and the method by which it is proposed to carry out the authorised works, together with a timetable for completion of such work, in compliance with the guidance⁶¹.

The seasonal restriction contained in the guidance⁶¹ has been modified in consultation with Inland Fisheries Ireland, in respect of the proposed development, to take account of the presence and seasonal passage on migration of Habitats Directive Annex II listed fish species Atlantic Salmon, River Lamprey, and potentially also Sea Lamprey in the Avoca River and Estuary. All instream works including the installation and removal of sheet piling or geotextile wrapped gabions required to provide barriers between the in-river working areas (including the temporary causeway) and aquatic habitats will be carried out during the July to September inclusive.

The following mitigation measures will apply:

- Four weeks' notice shall be given in writing to the Employer's Representative and Inland Fisheries Ireland before the authorised works commence;
- A suitably qualified Environmental Clerk of Works shall be appointed to oversee and monitor all measures taken to protect the aquatic environment;
- The contractor shall pay all statutory fees associated with the works;
- The contractor will be responsible for maintaining flows in the river at all times. The contractor will be permitted to construct temporary causeway, however the flow must be maintained throughout this period to enable free passage of fish. The details of the all temporary works in and immediately adjoining the Avoca River shall be subject to approval by the Employer's Representative and by Inland Fisheries Ireland;
- The contractor shall take all practicable measures to prevent the deposition of silt or other material in, and the pollution or damage to the Avoca River;
- Any construction equipment and vehicle which in the opinion of the Employer's Representative presents a risk of affecting the Avoca River shall be removed from site;

⁶¹ IFI (2016) Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters

- Instream machine works shall be minimised, and any machines working in the watercourse must be protected against leakage or spillage of fuels, oils, greases and hydraulic fuels;
- Instream earthworks must be executed so as to minimise the suspension of solids. Construction activities, especially ones involving the pouring of concrete, must be conducted in the dry;
- Dewatering of any in-stream or marine sheet piled areas will be via a screened water intake pipe, to avoid injury or mortality to any fish that may be present;
- Search for and safe removal to safe waters of any fish trapped in enclosed working areas in the aquatic environment will be carried out by suitably qualified and licenced personnel, using methodologies to be agreed with Inland Fisheries Ireland;
- Discharge from the dewatering process will be passed to a suitably sized settlement pond or a proprietary silt removal system, before discharge to the Avoca River or the local sewer network. Back-up equipment will be required to be maintained ready for use at all working areas. Any discharge to either sewer or watercourse will be subject to a discharge licence;
- In order to minimise the volumes of water required to be removed from contained working areas in which in-situ cement works and/or excavation are required, working areas will be covered overnight and when works are not in progress therein, in order to minimise infiltration of rainfall;
- To minimise the risk of spills and/or leaks, standard good practice will be followed with regard to pollution prevention as part of the detailed CEMP(s);
- All in-situ cement works will be monitored by the appointed Environmental Manager to ensure that spill prevention and remediation measures are in place, to minimise the risk and extent of spills and to rapidly deploy clean up equipment;
- Machinery maintenance work, re-fuelling of construction equipment and the addition of hydraulic oil or lubricants to vehicles/equipment will take place in designated bunded areas within the construction compounds. All waste oil, empty oil containers and other hazardous wastes will be disposed of in compliance with the requirements of the Waste Management Acts 1996, as amended. All of the construction machinery operating near any watercourse will be systematically checked in order to avoid leaks of oils, hydraulic fluids and fuels; and
- Spill-kits and hydrocarbon absorbent packs will be stored in the cabin of each vehicle and operators will be fully trained in the use of this equipment.

Coastal processes

Relevant mitigation measures for coastal processes are described in **Section 15.5.1 of Chapter 15** and in **Appendix 15.5**.

11.5.1.2 Mitigation during Operation

Subject to the implementation of the monitoring provided in **Section 11.5.2 in Chapter 15** and **Appendix 15.2**, no further mitigation will be required with respect to biodiversity effects during the operation of the proposed development.

11.5.2 Monitoring

11.5.2.1 Monitoring during Construction

The following monitoring would be carried out during construction:

- Monitoring of new seeding and planting provided as habitat and flora mitigation will be carried out during implementation of these measures;
- Monitoring of the effectiveness of implementation of bat mitigation measures, including occupancy of bat roost boxes and bat responses to WwTP site lighting, will be carried out during the construction of the proposed development; and
- Monitoring and reporting of marine mammals will be provided by MMO as referred to in **Section 11.5.1.1**.

11.5.2.2 Monitoring during Operation

The following monitoring would be carried out during operation of the proposed development:

- Monitoring of new seeding and planting provided as habitat and flora mitigation will be carried out during the first two years of operation.
- Monitoring of the effectiveness of implementation of bat mitigation measures, including occupancy of bat roost boxes, and bat responses to WwTP site lighting, will be carried out during the first two years of operation.

11.6 Residual Effects

11.6.1 Residual Effects during Construction

With the implementation of mitigation measures included, following in **Section 11.5.1.1**, residual indirect effects on the European site Buckronev – Brittas Dunes and Fen SAC (site code: 000729), in respect of the Qualifying Interests listed in Table 11.8, are assessed as neutral. No likely significant direct residual effects arise.

With the implementation of the mitigation measures specified in **Section 11.5.1.1**, residual effects on the Habitats Directive Annex II listed fish species Atlantic Salmon, River Lamprey and Sea Lamprey during construction are assessed as neutral.

With the full implementation of the mitigation measures specified in **Section 11.5.1.1**, residual effects on Habitats Directive Annex IV listed bat species (Common pipistrelle, Soprano pipistrelle, Leisler's bat and Daubenton's bat) are assessed as neutral.

With the full implementation of the mitigation measures specified in **Section 11.5.1.1**, residual effects on Habitats Directive Annex IV listed cetacean species, and Habitats Directive Annex II listed Harbour Seal and Grey Seal, are assessed as neutral.

With the implementation of seasonal mitigation measures specified in **Section 11.5.1.1**, residual effects on breeding birds and their nests, eggs and nestlings, are assessed as neutral.

Local effects on terrestrial flora and habitats within the planning boundary, (providing locally important biodiversity and ecological connectivity through the urban environment of Arklow), are assessed as short term, slight, and reversible, in the context of the urban area of Arklow.

11.6.2 Residual Effects during Operation

With the implementation of mitigation measures included in **Section 11.5.1.2**, residual indirect effects on the European site Buckronev – Brittas Dunes and Fen SAC (site code: 000729), in respect of the Qualifying Interests listed in Table 11.8, are assessed as neutral. No likely significant direct residual effects arise during operation.

With the implementation of the mitigation measures specified in **Section 11.5.1.2**, and from the considerations given in **Section 11.4.3.4**, residual effects on the Habitats Directive Annex II listed fish species Atlantic Salmon, River Lamprey and Sea Lamprey are expected to be positive during operation.

With the implementation of the mitigation measures specified in **Section 11.5.1.2**, local residual effects on terrestrial flora and habitats within the planning boundary, providing locally important biodiversity and ecological connectivity through the urban environment of Arklow, and residual effects on species including Habitats Directive Annex IV listed bat species (Common pipistrelle, Soprano pipistrelle, Leisler's bat and Daubenton's bat), are assessed as not significant during operation.

With the implementation of the mitigation measures specified in **Section 11.5.1.2**, residual effects on Habitats Directive Annex IV listed cetacean species, and Annex II listed Harbour Seal and Grey Seal, are assessed as neutral during operation.

Arising from the implementation of seasonal mitigation measures specified in **Section 11.5.1.2**, residual effects on breeding birds and their nests, eggs and nestlings, are assessed as neutral. The provision of nesting boxes for Grey Wagtail and Pied Wagtail at Arklow Bridge is assessed as slight positive during operation.

As detailed in **Section 11.4.3.4**, the proposed development will have positive effect on aquatic ecology.

11.7 References

- Anonymous (2015) Proposed Cruise Terminal, Dún Laoghaire, Co. Dublin. Environmental Impact Statement, prepared by Stephen Little & Associates on behalf of Dún Laoghaire Cruise Stakeholder Group.
- Anonymous (2008) National Report for Ireland on Eel Stock Recovery Plan Including River Basin District Eel Management Plans. Report prepared by the Inland Fisheries Division of The Department of Communications, Energy and Natural Resources, Dublin.
- Anonymous (1999) Arklow Waste Water Treatment Works Environmental Impact Statement. Arklow Urban District Council/P.H. McCarthy & Partners. 90pp.
- Berrow, Simon, Joanne O'Brien, Conor Ryan, Enda McKeogh and Ian O'Connor (2011) Inshore Boat-based Surveys for Cetaceans – Irish Sea. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group. pp.24.
- Boland, H. and Crowe, O. 2012. Irish Wetland Bird Survey: Waterbird status and distribution 2001/02 – 2008/09. BirdWatch Ireland, Kilcoole, Co. Wicklow.
- Byrne, C.J., Poole, R., Dillane, M., Rogan, G. and Whelan, K.F (2004) Temporal and environmental influences on the variation in sea trout (*Salmo trutta* L.) smolt migration in the Burrishoole system in the west of Ireland from 1971 to 2000. Fisheries Research 66(1): 85-94.
- CDM (2008) Feasibility Study for Management and Remediation of the Avoca Mining Site. Investigative Reports: Volume 1. Report prepared by CDM for The Department of Communications, Energy and Natural Resources.
- Clarke, K.R. (1993) Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18: 117-143.
- Colhoun, K. and S. Cummins, 2014. Birds of Conservation Concern in Ireland 2014-2019. Irish Birds 9 (4): 523-544
- Connor, D.W, Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. and Reker, J.B. (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. In: JNCC (2015) The Marine Habitat Classification for Britain and Ireland Version 15.03 [Online]. [31/05/2017]. Available from: jncc.defra.gov.uk/MarineHabitatClassification ISBN 1 861 07561 8.
- Cummins, Sinéad, Jennifer Fisher, Ruth Gaj McKeever, Laura McNaghten, and Olivia Crowe (2010). Assessment of the distribution and abundance of Kingfisher *Alcedo atthis* and other riparian birds on six SAC river systems in Ireland. A report commissioned by the National Parks and Wildlife Service and prepared by BirdWatch Ireland.
- Curtis, Dr. Tom & Faith Wilson (2008), Field Survey of Rare, Threatened and Scarce Vascular Plants in County Wicklow. Data provided by NPWS
- Dunlop, Norman (2009). A Guide to Sea Angling in the Eastern Fisheries Region. Inland Fisheries Ireland

- Fahy, E. and Reynolds, J. (1987) The Avonmore Brown Trout Fishery at Rathdrum, Co. Wicklow. Fishery Leaflet No. 137. Department of the Marine, Dublin.
- Fanning, A. Craig, M., Webster, P., Bradley, C., Tierney, D., Wilkes, R., Mannix, A., Treacy, P., Kelly, F., Geoghegan, R., Kent, T. and Mageean, M. (2017) Water Quality in Ireland 2010-2015. Environmental Protection Agency, Johnstown Castle, Co. Wexford.
- Fossitt, Julie A (2000). A Guide to Habitats in Ireland. The Heritage Council.
- Fox, Tony, Ian Francis (Greenland White-fronted Goose Study), David Norriss, and Alyn Walsh (NPWS), 2017. Report of the 2016/2017 International Census of Greenland White-Fronted Geese.
- Gray, N.F. (1998) Acid mine drainage composition and the implications for its impact on lotic systems. *Water Research* 32(7): 2122-2134.
- Gray, N.F. and Delaney, E. (2010) Measuring community response of benthic macroinvertebrates in an erosional river impacted by acid mine drainage by use of a simple model. *Ecological Indicators* 10: 668-675.
- Hardisty, M.W., Potter, I.C. and Sturge, R. (1970) A comparison of the metamorphosing and macroph-thalmia stages of the lampreys, *Lampetra fluviatilis* and *Lampetra planeri*. *Journal of Zoology (London)* 162: 383–400.
- IFI (2016) Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters. A report by Inland Fisheries Ireland, Citywest, Dublin. IFI/2016/I-4298. 28pp.
- IUCN (2018) The IUCN Red List of Threatened Species. Version 2017-3. <www.iucnredlist.org>. Downloaded on 15 January 2018. International Union for Conservation of Nature
- Kelleher, C. & Marnell, F. (2006). Bat Mitigation Guidelines for Ireland. Irish Wildlife Manuals, No. 25. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.
- Kelly, F., Harrison, A., Connor, L., Matson, R., Morrissey, E., O’Callaghan, R., Feeney, R., Wögerbauer, C., Hanna, G., Gallagher, K. and Rocks, K. (2011). Sampling Fish for the Water Framework Directive – Transitional Waters 2010. Avoca Estuary. Inland Fisheries Ireland.
- Kelly, F., Harrison, A., Connor, L., Wightman, G., Matson, R., Morrissey, E., O’Callaghan, R., Feeney, R., Hanna, G., Lordan, M. and Rocks, K. (2009). Sampling Fish for the Water Framework Directive – Transitional Waters 2008. Avoca Estuary. The Central and Regional Fisheries Boards.
- Kelly, F.L. and King, J.J. (2001) A review of the ecology and distribution of three lamprey species, *Lampetra fluviatilis* (L.), *Lampetra planeri* (Bloch) and *Petromyzon marinus* (L.): a context for conservation and biodiversity considerations in Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy* 101B(3): 165 – 185.

- King, J.J., Marnell, F., Kingston, N., Rosell, R., Boylan, P., Caffrey, J.M., Fitzpatrick, Ú., Gargan, P.G., Kelly, F.L., O' Grady, M.F., Poole, R., Roche, W.K. and Cassidy, D. (2011) Ireland Red List No. 5: Amphibians, Reptiles and Freshwater Fish. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.
- Lucey, J. and McGarrigle, M.L. (1987) The distribution of the crayfish *Austropotamobius pallipes* (Lereboullet) in Ireland. Irish Fisheries Investigations Series A (Freshwater). No. 29.
- Maitland, P.S. (2003) Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
- Masters-Williams, H., Heap, A., Kitts, H., Greenshaw, L., Davis, S., Fisher, P., Hendrie, M. and Owens, D. (2001) Control of Water Pollution from Construction Sites: Guidance for Consultants and Contractors. CIRIA C532. CIRIA, London.
- McCormick, S.D., Hansen, L.P., Quinn, T.P. and Saunders, R.L (1998) Movement, migration, and smolting of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 55(suppl. 1): 77-92.
- McGinnity, P., Gargan, P., Roche, W., Mills, P. & McGarrigle, M. 2003. Quantification of the Freshwater Salmon Habitat Asset in Ireland using data interpreted in a GIS platform. Irish Freshwater Fisheries, Ecology and Management Series: Number 3, Central Fisheries Board, Dublin, Ireland.
- Natura (2009) Arklow Flood Relief Scheme (SIA) Baseline Ecological Field Survey Data: Interim Report. Unpublished report prepared by Natura Environmental Consultants, Wicklow. 9pp.
- NPWS (2017) Buckroney-Brittias Dunes and Fen SAC (site code: 000729) Conservation objectives supporting document- Coastal habitats. Version 1 March 2017. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs.
- NPWS (2017a) National Parks & Wildlife Service website www.npws.ie accessed 20/04/2017.
- NPWS (2017b) Conservation Objectives: Buckroney-Brittias Dunes and Fen SAC 000729. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, Dublin.
- NPWS (2014). Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters Department of Arts, Heritage and the Gaeltacht (January 2014). Issued by the Minister for Arts, Heritage and the Gaeltacht as official guidelines and codes of practice under Regulation 71 of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011).
- NPWS (2013) The Status of EU Protected Habitats and Species in Ireland. Species Assessments Volume 3, Version 1.0. Unpublished Report, National Parks & Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

NPWS (2013) Conservation Objectives: Wicklow Reef SAC 002274. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin.

NRA (2010) Transport Infrastructure Ireland (incorporating the National Roads Authority) Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Road Schemes (Revision 1, December 2010)

Ó Cadhla, Oliver, Denis Strong, Ciarán O’Keeffe, Mary Coleman, Michelle Cronin, Callan Duck, Tony Murray, Pascal Dower, Richard Nairn, Paul Murphy, Pat Smiddy, Cyril Saich, David Lyons, Lex Hiby (2008). An assessment of the breeding population of grey seals in the Republic of Ireland, 2005. Irish Wildlife Manuals No. 34. National Parks & Wildlife Service

Parnell, John, and Tom Curtis (2012). Webb’s An Irish Flora. Cork University Press

PESI (2017) Pan-European Species directories Infrastructure. Accessed through www.eu-nomen.eu/portal on 2017-05-31.

Ryan, Diarmuid, Roisín O’Callaghan, Will Corcoran, John Coyne & William Roche (2015). Water Framework Directive Fish Stock Survey of Transitional Waters in the Eastern River Basin District – Avoca Estuary 2015. Inland Fisheries Ireland

Ryan, Conor, Simon Berrow, Alessandro Pierini, Joanne O’Brien, Ian O’Connor and David McGrath (2010) Inshore Boat-based Surveys for Cetaceans. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group. pp.33.

Sandlund, O.T., Diserud, O.H., Poole, R., Bergesen, K., Dillane, M., Rogan, R., Durif, C., Thorstad, E.B., Asbjørn Vøllestad, L. (2017) Timing and pattern of annual silver eel migration in two European watersheds are determined by similar cues. *Ecology and Evolution* 7:5956–5966.

Scannell, Mary J.P, and Donal M. Synnott (1987). Census catalogue of the Flora of Ireland. Stationery Office, Dublin.

Walker, A.J.M. and Rees, E.I.S. (1980) Benthic ecology of Dublin Bay in relation to sludge dumping. *Irish Fisheries Investigation Series B* 22:1-59.

Wilson, F., Crushell, P. Curtis, T. & Foss, P.J. (2011). The County Wicklow Wetland Survey I. Report prepared for Wicklow County Council and The Heritage Council.

Wilson, F., Crushell, P. Curtis, T. & Foss, P.J. (2012). The County Wicklow Wetland Survey II. Report prepared for Wicklow County Council and The Heritage Council.

Yau, H. and Gray, N.F. (2005) Riverine Sediment Metal Concentrations of the Avoca-Avonmore Catchment, South-East Ireland: A Baseline Assessment. *Biology and Environment: Proceedings of the Royal Irish Academy* 105B(2): 95-106.