## 3.2.2 METHODOLOGY

The current study was carried out as a desk study, and a field assessment. The literature review and field sampling programme was designed primarily as a descriptive study to provide baseline information on the existing ecological status of the area under investigation. An integrated assessment approach was employed. This approach merges biological (effects) and chemical (causes) using a combination of field and desk study evaluations.

### *3.2.2.1 Desktop Review*

A desktop review was carried out to identify features of ecological importance within the study area and surrounding region. A review of areas designated (or being considered) for designation for nature conservation was carried out by consulting the National Parks and Wildlife Service (NPWS). These included Special Areas of Conservation, Special Protection Areas for birds (both internationally important) and proposed Natural Heritage Areas (of national importance). Furthermore, a review of the published literature, including the Cork County Development Plan 2003-2009 was undertaken in order to collate data on species and habitats of conservation concern on and in the immediate environs of the proposed development site. The digital database of the New Atlas of the British and Irish Flora (Preston et *al*, 2002) was consulted to assess the presence of rare plant species recorded from the 10 km square in which the site is located. Likewise, "Exploring Irish Mammals" (Hayden and Harrington, 2000) was used to assess the importance of the study area for mammals. The results of the Irish Wetland Bird Survey (I-WeBS) (Crowe, 2005) were also reviewed. A range of additional sources of information including scientific reports produced by, and information on the websites of the Marine Institute and other agencies were also reviewed. A full bibliography of information sources reviewed is given in the references section. The responses received from statutory and non-statutory consultees consulted directly by Mott McDonald Pettit Consulting Engineers were also reviewed.

The collation of this information, as well as examination of Ordinance Survey Maps 87 and 81 and OS aerial photographs allowed areas of potential ecological importance to be highlighted prior to the field survey.



### *3.2.2.2 Field Survey Work*

#### Terrestrial Ecology

Field survey comprised a systematic walk over of the proposed site, pump stations and collection system. Much of the pipeline route comprises existing road or built ground. A Phase 1 habitat survey of the site and other affected areas was conducted during June 2007 using methodology developed by the Joint Nature Conservation Committee (1993). Habitats were classified and mapped using habitat descriptions and codes published in the Heritage Council's 'A Guide to Habitat Types in Ireland' (Fossitt, 2000). Plant species nomenclature follows Stace's 'New Flora of the British Isles' (1997). All birds encountered during the course of the surveys were noted and the habitats present on the site were assessed as to their suitability for breeding and wintering bird species. The affected areas were also examined for signs of / or the presence of mammals (including potential bat roosts and badger setts).

#### Marine Ecology

The marine field survey also a systematic walk over and boat survey of the areas that would be potential affected by the proposed development (i.e. outfalls, areas adjoining pipeline routes etc.). Habitats were classified and mapped using habitat descriptions and codes published in the Heritage Council's 'A Guide to Habitat Types in Ireland' (Fossitt, 2000) and the JNCC 'Marine Habitat Classification for Britain and Ireland' (O'Connor, 2004). A marine fauna assessment of the affected areas was undertaken using JNCC Marine Monitoring methods (Davies *et al*, 2001).

Areas were examined during the low water of spring tides and also from a hired charter boat. Shore (littoral) and sub-littoral sampling was undertaken at 23 stations during low spring tides with a further 4 stations sampled from a boat. The location (including NOS grid references) and methodology used at the 27 stations is given in Tables 3, 4 and 5. Sampling involved the use of quadrates (quadrate area 0.25m$^2$), cores (0.01m$^2$) and a hand held grab (AMS type, 0.023 m$^3$) and conformed to JNCC methodology. Specimens were identified to the lowest possible taxonomic level, counted and weighed. Marine fauna nomenclature follows Barnes' 'The brackish-water fauna of North-western Europe' (1994).

### *3.2.2.3 Impact Assessment Methodology*

The impact significance is a combined function of the value of the affected feature (its ecological importance), the type of impact and the magnitude of the impact. It is necessary to identify the value of ecological features within the study area in order to evaluate the significance and magnitude of possible impacts.

The results of the ecological survey were evaluated to determine the significance of identified features located in the study area on an importance scale ranging from international-national-county-local. The local scale is approximately equivalent to one 10 km square but can be operationally defined to reflect the character of the area of interest. Because most sites will fall within the local scale, this is sub-divided into high local importance to local importance-local value. The criteria used are shown in Table 6.

The means of assessing impact significance is based on the Institute of Ecological and Environmental Management draft guidelines on Ecological Impact Assessment (IEEM 2002). The evaluation methodology used in this assessment is presented in full in Appendix 1. The significance of impacts was assessed on a combined basis of the value of the feature being affected and the magnitude of the impact. Impacts on features of less than local value are not considered to be potentially significant. The terminology used to define impact significance is also described in Appendix 1. Impacts during both Construction and Operation of the proposed development are considered, as are impacts in the Short, Medium and Long term (as per EPA methodology).



**Table 3** Locations and descriptions of the JNCC Core sampling stations. A total of 5 cores were taken at each station. Locations are also shown in Appendix 6.

| Site Code | Location | Distance from LWMMT | Substrate | Grid reference |
|---|---|---|---|---|
| C1 | Carrigaline. Downstream of bridge. On the north side of the channel. | 0 | Mud | W 73428 62420 |
| C2 | Carrigaline. Downstream of bridge. On the north side of the channel. | 3 m below | Mud | W 73751 62349 |
| C3 | Carrigaline. Further Downstream of bridge. On the north of the channel. | 2 m below | Mud | W 73996 62328 |
| C4 | Crosshaven. East of town centre on the southern shore. | 10 m above | Mud | W 78312 61361 |
| C5 | Glenbrook, Passage West. | 7 m below | Mud | W 77180 67863 |
| C6 | Great Island. South of River Ferry on east of R. Lee. | 3 m below | Mud | W 77569 67318 |
| C7 | Rushbrook, Great Island. | 5 m below | Mud | W 77520 66606 |
| C8 | Cobh. South facing mudflat at Whitepoint. | 7 m below | Mud | W 78342 65604 |

LWMMT = Low water mark of medium tides.

**Table 4** Locations and descriptions of the JNCC quadrate sampling stations. A total of 1 $m^2$ was sampled at each station. Locations are also shown in Appendix 6.

| Site Code | Location | Distance from LWMMT | Substrate | Grid reference |
|---|---|---|---|---|
| Q1 | Crosshaven. North of town centre on the southern shore. | 15 m above | Mud/cobble | W 78849 61302 |
| Q2 | Crosshaven. Just east of the town centre on the southern shore. | 10 m above | Rock, cobble, gravel, mud | W 79926 61534 |
| Q3 | Ringaskiddy. East-facing beach. | 0 | Rock, cobble | W 79081 63244 |
| Q4 | Ringaskiddy. East-facing beach. | 0 | Bedrock, boulder, cobble | W 79197 63603 |
| Q5 | Ringaskiddy. North-facing beach. Opposite Whitepoint, Cobh. | 2 m above | Cobble, gravel, sand | W 78179 64636 |
| Q6 | Monkstown. Northern end of town on the western shore. North of pier. | 1 m below | Mussels, sand, mud | W 77230 66451 |
| Q7 | Monkstown. Just south of River Ferry. | 3 m below | Gravel, sand mud | W 77170 67427 |
| Q8 | Monkstown / Passage West. North of River Ferry. | 5 m below | Rock, mud | W 77152 67695 |
| Q9 | Passage West. Near slipway at bottom of public green. | 0 | Rock, cobble | W 76620 69187 |
| Q10 | Great Island. Just north of River Ferry on east of R. Lee. | 2m above | Cobble, gravel, mud | W 77587 67778 |
| Q11 | Great Island. South of River Ferry on east of R. Lee. | 0 | Gravel, cobble | W 77555 67495 |
| Q12 | Whitepoint, Cobh. | 0 | Cobble, gravel, mud | W 78544 65775 |
| Q13 | East Beach, Cobh. Bottom of the steps to the east of Lynch's Quay. | 1 m below | Gravel | W 80071 66447 |
| Q14 | Cobh. East of red chimney stack. | 3m below | Cobble, shingle | W 80420 66534 |
| Q15 | Cobh. Just east of fishing quay. | 2m below | Cobble, bedrock | W 80877 66565 |



**Table 5** Locations and descriptions of the grab sampling stations. A total of 5 grabs were taken at each station. Locations are also shown in Appendix 6.

| Site | Location | Depth(m) LWMT | Substrate | Grid Reference |
|---|---|---|---|---|
| G1 | IDA outfall pipe, to the west of Carlisle fort. | 7.0 | Sand | W 81576 63060 |
| G2 | IDA outfall pipe, to the west of Carlisle fort. | 7.6 | Sand | W 80927 62810 |
| G3 | Proposed pipeline crossing at West Passage. North side. | 7.0 | Silt / mud | W 77535 67616 |
| G4 | Proposed pipeline crossing at West Passage. South side. | 8.2 | Silt / mud | W 77184 67277 |

**Table 6** Criteria used in assessing the ecological importance of ecological features.

| Importance | Criteria |
|---|---|
| International | An internationally designated site or candidate site (SPA, pSPA, SAC, pSAC, Ramsar Site, Biogenetic Reserve). Also Sites which qualify for designation as SACs or SPAs – this includes sites on the NGO shadow list of SAC's. |
| National | A nationally designated site or candidate site (NHA, pNHA) (unfortunately there is no published criteria used in selecting these areas).<br>Sites which hold Red Data Book (Curtis and McGough, 1988) plant species. |
| County | Sites which hold nationally scarce plant species (recorded from less than 65 10 km squares), unless they are locally abundant.<br>Sites which hold semi-natural habitats likely to be of rare occurrence within the county.<br>Sites which hold the best examples of a semi-natural habitat type within the county. |
| High Local Importance | Sites which hold semi-natural habitats and/or species likely to be of rare occurrence within the local area.<br>Sites which hold the best examples of a high quality semi-natural habitat type within the local area. |
| Local Importance | Sites which hold high quality semi-natural habitats |
| Local Value | Any semi-natural habitat |

## 3.2.3 EXISTING ENVIRONMENT

### *3.2.3.1 Background*

It is proposed to develop a new wastewater treatment plant on an area of 7.36 ha to the northeast of the town of Carrigaline. This new wastewater treatment will facilitate the towns of Carrigaline, Monkstown, Passage West, Cobh and Ringaskiddy.

Foul effluent from these areas will be pumped to the new site of the proposed treatment plant via pipes located underneath roads or pipelines located through fields. With regard to the town of Cobh, all effluent will be pumped to the western shore of Great Island before being pumped to Monkstown via a pipe extending across the channel. From Monkstown the effluent will be pumped by means of a series of pipelines to the wastewater treatment plant. The construction will involve the excavation of many roadways throughout these areas in addition to the excavation of sections of green fields within the vicinity. The layout of the proposed development is shown in Figure 1.

### *3.2.3.2 Receiving Environment*

#### Designated Areas

Designated areas in the vicinity of the proposed development works are shown in Figure 2 and Appendix 2. NPWS site synopses for these sites are also provided in this appendix. Parts of the proposed development are located within the Cork Harbour Special Protection Area (SPA) for birds (Site Code 004030). The Cork Harbour SPA is an internationally important wetland site, regularly supporting in excess of 20,000 wintering waterfowl. Several of the species which occur regularly within Cork Harbour are listed on Annex I of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover, Bar-tailed Godwit, Ruff and Common Tern. Proposed works associated with the development are located within 2km of the Great Island channel Special Area of Conservation (SAC) (Site Code: 0001058). The Great Island Channel stretches from Little Island to Midleton. It is designated due to the presence of the Annex I habitats; mudflats and Atlantic salt meadows.



Two nationally important designated areas are also directly affected by the proposed development. These are Monkstown creek Natural Heritage Area (NHA) (Site Code 001979) and the Owenboy River NHA (Site Code 001990). Sections of pipeline associated with the proposed scheme would run along the boundary of these sites (within the above SPA). Both of these designated areas are of national importance to wintering water birds. Table 6 provides a list of designated areas within the study area and indicates their distance from areas affected by the proposed development.

Evaluation: Sites designated as SAC's and SPA's are recognised as being of international importance. The study area includes areas designated as an SPA and NHA. The study area is of international importance due to the abundance of important bird species and also the presence of internationally important coastal habitats.

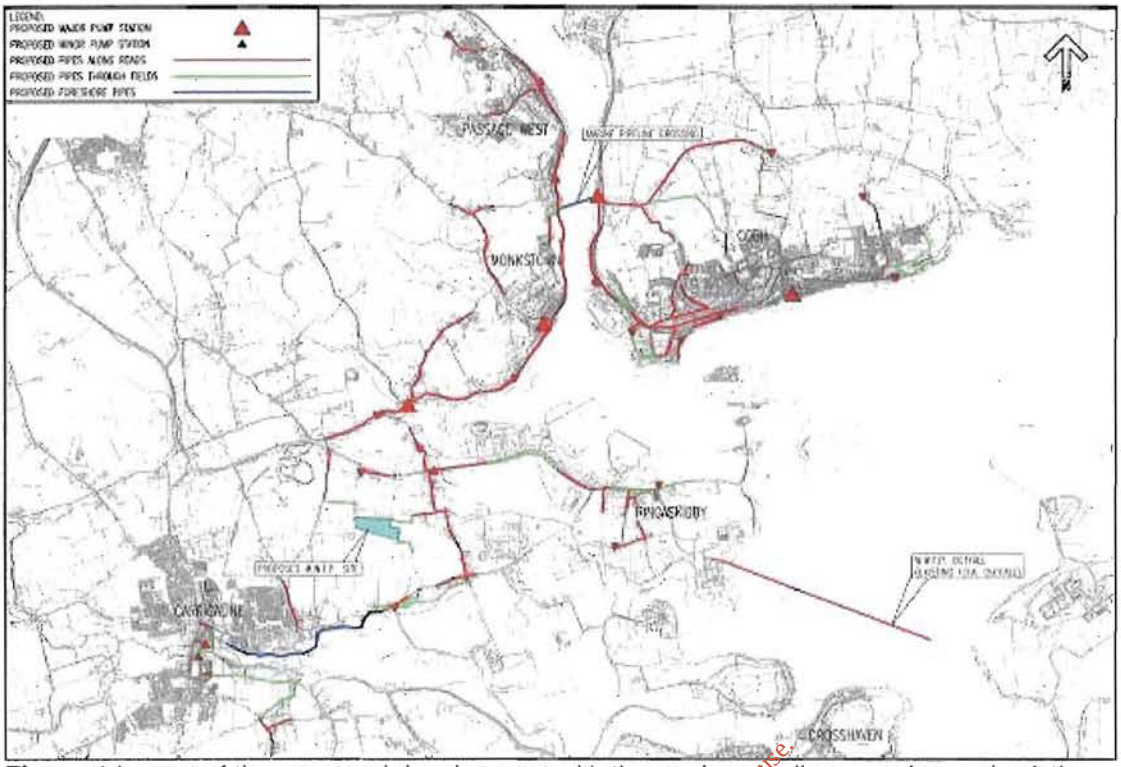


**Figure 1** Layout of the proposed development with the marine pipeline crossing and existing outfall indicated.



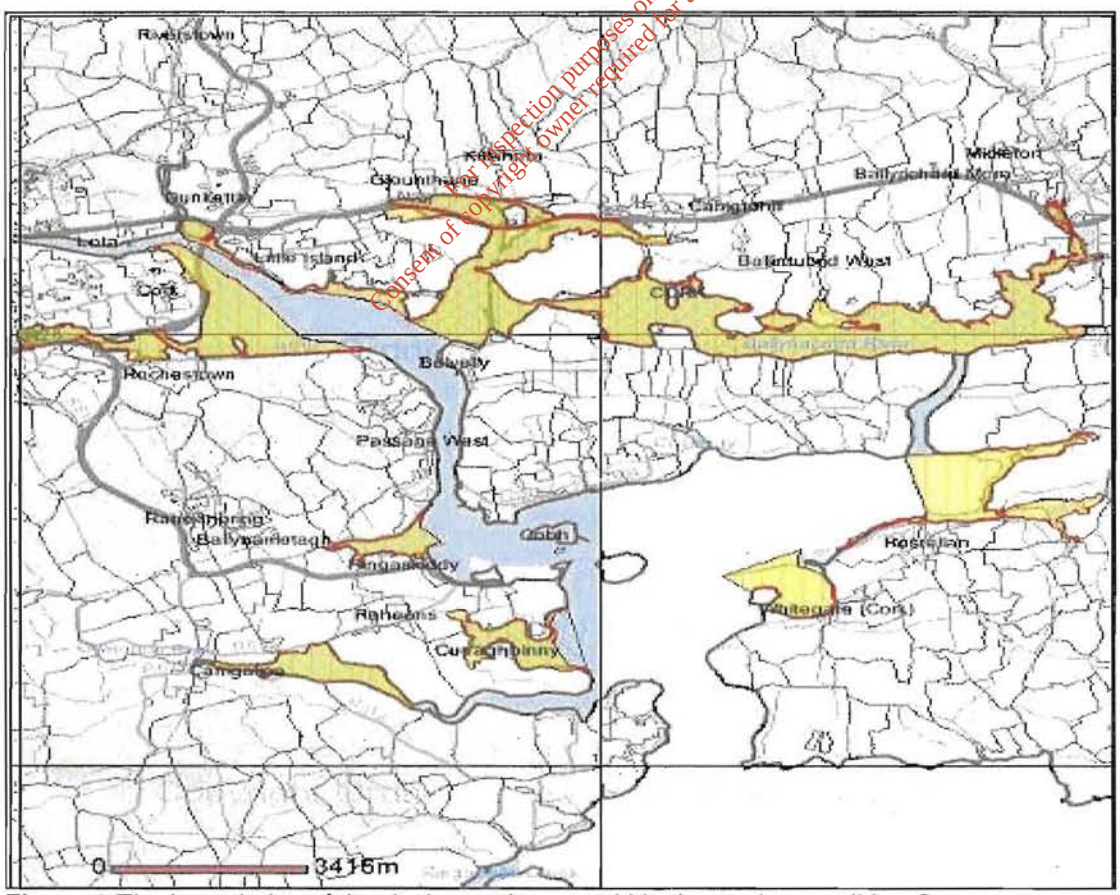


**Figure 2** The boundaries of the designated areas within the study area (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07. See Appendix 2 for more information including NPWS Site Synopses of designated areas.

**Table 7** Summary details of the Great Island channel SAC, Cork Harbour SPA and surrounding NHA's. See Appendix 2 for further details.

| Name | Site Code | Designation | Distance from development areas | Notes |
|---|---|---|---|---|
| Great Island Channel | 001058 | S.A.C/ NHA | 2km north east of passage west | Annex I habitats: mudflats and Atlantic salt meadows |
| Cork Harbour | 004030 | SPA | Mainly away from the proposed development areas. Pipelines run along the boundary near Carrigaline and Monkstown. | Annex I habitats mudflats and salt marshes<br><br>Annex I species of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover, Bar-tailed Godwit, Ruff and Common Tern. |
| Templebreedy National school | 000107 | NHA | 3.5km south of Ringaskiddy | Bat roost. |
| Douglas River | 001046 | NHA | 4km west of Passage west | Estuarine area |
| Lough Beg | 001066 | NHA | 0.5km south of Ringaskiddy | Mud flats/ wet grassland |
| Rockfarm Quarry | 001074 | NHA | 1.4km north of Passage | |
| Rostellan lough, Aghada shore and Poulnabiba inlet | 001076 | NHA | 3.2 km east of Cobh | Waterfowl |
| Dunkettle Shore | 001082 | NHA | 4.2 km north east of Passage | Mud flats and sand flats |
| Whitegate Bay | 001084 | NHA | 2 km east of Crosshaven | Mud flats and sand flats |
| Monkstown creek | 001979 | NHA | Directly affected by foreshore pipelines in the vicinity the above SPA | Mudflats and sandflats |
| Cuskinny Marsh | 001987 | NHA | Located 0.1 km east of development area | Semi natural woodland, waterfowl |
| Owenboy River | 001990 | NHA | Directly affected by foreshore pipelines in the vicinity the above SPA | Waterfowl |



**Table 8** Qualifying Interests of Great Island Channel SAC / Cork Harbour SPA

| Site Code | Site Name | EU Habitat Code | Habitat Description |
|---|---|---|---|
| 001058 | Great Island Channel | 1140 | Mudflats and sandflats not covered by seawater at low tide |
| 001058 | Great Island Channel | 1330 | Atlantic salt meadows (Glauco-Puccinellietalia maritimae) |

## Flora and habitats

Following the Phase 1 habitat survey and marine habitat survey of the affected area, the different habitat types (as classified according to Fossitt, 2000 and O'Connor, 2004) were identified. The following is a description of the various habitats found within the affected areas. The habitat code according to Fossitt is in brackets after the habitat name. The habitats present in both terrestrial and coastal areas recorded in the study during the June 2007 survey are discussed below. The habitats of selected marine areas are indicated in Figure 3. Figure 4 shows the boundaries of local designated areas.

The proposed site for the wastewater treatment plant is located on an area of improved agricultural grassland. This area is intensively used for grazing by dairy cattle. This grassland is species poor and is dominated by rye grass *Lolium perenne*, meadow grasses *Poa* spp. and white clover *Trifolium repens*. Agricultural herbaceous species such as the common sorrel *Rumex acetosa*, broad leaved dock *Rumex obtusifolius*, thistles *Cirsium arvense*, *C. vulgare* and nettles *Urtica dioica* also occur frequently within this habitat. This habitat has a reduced plant biodiversity. The plant community is influenced by nutrient enrichment which results primarily in a grassland monoculture of grass species. Consequently this area is of local value only.

Hedgerows are located through the centre and around the field boundaries of the proposed wastewater treatment plant area. The hedgerow located through the centre of the site appears to be planted and is dominated by hawthorn *Crataegus monogyna*. However at the northern end of this hedgerow gorse *Ulex europeaus*, bramble *Rubus fruticosus* and cleaver *Galium aparine* become more common. The hedgerow located around the boundary of the site is dominated by gorse and hawthorn with abundant bramble and nettles. Also common are honeysuckle *Lonicera periclymenum*, blackthorn *Prunus spinosa*, dog rose *Rosa canina* and elder *Sambucus nigra.* Hedgerows are present along the field road boundaries throughout the development area. These habitats are an important aspect of the Irish landscape, as well as being of value as wildlife corridors. Hedgerow habitats are of high local ecological importance.

The existing pumping station at Church Rd, Carrigaline is located upon artificial surfaces. The four proposed pumping stations are partially situated on artificial surfaces. This is a habitat of low ecological value which supports little or no plant species due to consistent anthropogenic activity. This habitat contains little or no plant species and is therefore of little ecological significance.

Treelines are located nearby the proposed Monkstown pumping station. Tree species present within this habitat include beech, ash horse chestnut *Aesculus hippocastanum*, sycamore and poplar *Populus* spp. Treelines are usually planted for aesthetic or shelter purposes. They may be of some use to birdlife for feeding and nesting. Treelines are of local ecological importance.



Areas of amenity grassland are located nearby the site for the proposed Monkstown pumping station. Amenity grassland is dominated by grass species such as plantains; in particular ribwort plantain *Plantago lanceolata* and meadow grasses Poa spp. Broadleaf herbs are dominated by clovers *Trifolium* spp. dandelion *Taraxacum* spp and daisy *Bellis perennis*. This habitat is commonly used for recreational activities and is generally managed through frequent fertiliser application and mowing. This is a habitat of local ecological value.

Mud shore habitat occurs immediately south of the proposed Raffeen pumping station. These mud shores are formed primarily of very fine sediment and along the most sheltered sections of coastline. They are subject to variable, reduced or low salinity. The mud shores were found to support communities of polychaete worms (e.g. estuary ragworm and *Nephytes spp.).* This habitat is dominated by open areas of mud and is a feeding area for estuarine birds. This habitat is situated within the Monkstown Creek NHA and thus is categorised as being of national importance

Mixed substrata shore occurs near the proposed Carrigaloe pumping station. The shore comprises a mixture of rock and sediment; the sediments included gravel sand and mud. These shores occurred in moderately exposed to sheltered locations. Fucoid cover was incomplete at these habitats. This habitat is not located within a designated area and thus is categorised as an area of high local importance.

Sheltered rocky shore habitat occurs on the southern coast of the Great Island and near the proposed West beach pumping station. These habitats include sheltered to extremely sheltered rocky shores of bedrock, and stable accumulations of boulders, cobbles and pebbles. Dense growths of fucoids occurred. This habitat is of high local ecological importance.

The Owenboy and Monkstown Creeks are estuaries. These habitats are located nearby the existing Church rd and the proposed Raffeen pumping stations. This habitat type corresponds loosely with the EU Annex I Habitats 'Estuaries (1130) and 'Large shallow inlets and bays' (1160) and so is of international importance.

*Terrestrial habitats*

Improved Agricultural Grassland (GA1): The majority of the proposed routes running through fields are located on improved agricultural grassland. These habitats are utilised primarily for dairy and beef farming. This generally involves the intensification of farming practices (manuring, artificial fertilisation) in order to achieve optimum grassland conditions. Most of the areas located along the pipeline route are dominated by grass species such as rye grass, meadow grasses, Yorkshire fog *Holcus lanatus* and the common herbaceous species associated with agriculture i.e. the common sorrel *Rumex acetosa*, broad leaved dock *Rumex obtusifolius*, thistles *Cirsium arvense*, *C. vulgare* and nettles *Urtica dioica*.

Evaluation: These areas have reduced plant biodiversity. The plant community is influenced by nutrient enrichment which results primarily in a grassland monoculture of grass species. Consequently this area is of local value only.

Hedgerows (WL1): Hedgerows are located nearby the pipeline routes that are located on the nearby agricultural land areas. These habitats are dominated by hawthorn and blackthorn with species such as bramble, elder, honeysuckle, dog rose and ivy *Hedera helix* also occurring frequently. Other herbaceous species common within this habitat include navelwort *Umbilicus rupestris*, cleaver, speedwells *Veronica* spp, bush vetch *Vicia sepium* and tufted vetch *Vicia cracca*. Large deciduous trees such as ash *Fraxinus excelsior*, sessile oak *Quercus petraea*, pedunculate oak *Quercus robur*, sycamore *Acer pseudoplatanus* and beech *Fagus sylvatica* also occur occasionally on the hedgerows situated within the proposed pipeline routes.



Evaluation: Hedgerows are present along field and road boundaries throughout most of the development area. These habitats are an important aspect of the Irish landscape, as well as being of value as wildlife corridors. Hedgerow habitats are of high local ecological importance.

Mixed Broad leaved woodland (WD1): An area of mixed broad leaved woodland is present along the southern area of Cobh, a route taken by the proposed pipeline. This area of woodland which appears to be planted is dominated by sycamore *Acer pseudoplatanus*. Ash, sessile oak and beech *Fagus* sp. also occur occasionally. The shrub layer of the woodland contains many garden escapes such as Portugal laurel *Prunus lusitanica*, Fuschia *Fuschia magellanica*, juniper *Juniperus communis* and snowberry *Symphoricarpos albus* in addition to abundant bramble and nettles.

Evaluation: This is a fragmented area of woodland, possibly planted as part of a nearby demesne. It is dominated by the non native sycamore in addition to a shrub layer that contains many non native garden escapes. However this area of woodland may act as a wildlife corridor for mammals and a nesting area for bird species. This habitat is of high local ecological importance.

Treelines (WL2): Treelines are located along many of the proposed pipeline routes, both beside roadways and around field boundaries. Many of these treelines were also planted as shelter belts near dwellings. Tree species present within this habitat include beech, ash and oak while Scots pine *Pinus sylvestris*, horse chestnut *Aesculus hippocastanum*, sycamore and poplar *Populus* spp. are also common.

Evaluation: Treelines are usually planted for aesthetic or shelter purposes. They may be of some use to birdlife for feeding and nesting. Treelines are of local ecological importance.

Arable crops (BC1): Fields of wheat *Triticum* spp are located to the south of the proposed site for the wastewater treatment plant. Other areas located nearby the proposed pipeline routes

contain arable crops such as barley *Hordeum vulgare*, oats *Avena sativa* and potatoes *Solanum tuberosum*.

Evaluation: In general these habitats are highly modified and use of herbicides ensures that plant diversity is kept to a minimum. This habitat is of local ecological value.

Tilled land (BC3): An area of tilled land is located to the south of the proposed site for the wastewater treatment plant. This habitat is of local ecological importance.

Evaluation: This habitat is of local ecological importance.

Stones walls (BL1): Stone walls are located on some road and field boundaries throughout the site and pipeline routes. The stone walls in these are generally composed of shale and sandstone that typifies the geology of this area of Ireland. The common plant species include ivy, navelwort, hedge bindweed *Calystegia sepium*, bryophytes and ferns *Asplenium* spp, *Polypodium* spp.

Evaluation: Stone wall habitats that are not bound with mortar often contain diverse macroinvertebrate communities. These in turn are utilised as a food source by many birds and small mammals. As a result these habitats are an important food source in for terrestrial animals and are of local ecological importance.

Artificial surfaces (BL3): Artificial surfaces are located throughout the proposed development areas. This includes the roadways located along and the buildings located beside the proposed pipeline routes. Most of these roadways are not vegetated. The centre of the roadway leading to the proposed site of the wastewater treatment plant is vegetated by meadow grasses and plantains. Also sections of all five pumping stations are located upon areas of artificial surfaces.



Evaluation: These areas contain little or no plant species and are therefore of little ecological significance.

Grassy verges (GS2): Grassy verges are present beside most of the proposed pipelines located upon roadways. These habitats are dominated by grass species such as ribwort plantain *Plantago lanceolata*, cocksfoot *Dactylis glomerata*, bent grasses *Agrostis* spp, meadow grasses *Poa* spp and hairy brome *Bromopsis ramosa*. Herbaceous species such as vetch *Vicia* spp., cow parsley *Anthriscus sylvestris*, hogweed *Heracleum sphondylium*, nettles, thistles *Cirsium* spp., black knapweed *Centaurea nigra* and foxglove *Digitalis pupurea* are common along the roadside verges of the proposed pipeline routes. Wetter roadside areas contain abundant silverweed *Potentilla anserina.* Some shrubs and tree saplings also grow within this habitat and include ash, sycamore, hawthorn, blackthorn and gorse.

Evaluation: These habitats are generally located beside areas of intense anthropogenic use i.e. roads. However they generally support a moderately diverse assemblage of grasses and herbs due to an absence of fertilisation and repeated mowing. Like hedgerows, grassy verges may act as a corridor for wildlife present in the nearby area. This habitat is of local ecological importance.

Ornamental/ non native shrub (WS3): This habitat is located within garden areas that will be impacted by the proposed development works. The area where these habitats will be affected by the proposed pipeline route is located just east of the Cobh to Cork roadway R624, opposite the dockyard area. These habitats are present in garden areas of private dwellings. Plants include *Griselinia* spp., *Escalonia* spp, *fuscia Fuschia magellanica*, Portugese laurel *Prunus lusitanica* and Lawson's cypress *Chamaecyparis lawsoniana*.

Evaluation: This habitat contains many non native species introduced into garden and park areas for aesthetic purposes. Therefore this habitat is of local ecological value.

Spoil and bare ground (ED2): Areas of spoil are located nearby two of the proposed pipeline routes near the centre of the great Island. Spoil heaps have been created through the excavation of soil to possibly facilitate the laying of a pipeline. These habitats contained little plant diversity as they were recently excavated and colonisation of ruderal species has not yet occurred.

Evaluation: This habitat contains no plant species and is considered to be of little ecological significance.

*Marine/estuarine habitats*

Estuaries (MW4) and Sea inlets and Bays (MW2): Cork harbour and the River Lee channel at Passage West / Monkstown is a continuum between the above habitats. The Owenboy and Monkstown Creeks are estuaries. The salinity of these areas is variable due to riverine inputs and tidal currents.

Evaluation: This habitat type corresponds loosely with the EU Annex I Habitats 'Estuaries (1130) and 'Large shallow inlets and bays' (1160) and so is of international importance.

Infralittoral gravels and sands (SS1): This habitat is present in Cork Harbour at Haulbowline and also along the existing IDA pipeline in a moderately exposed to sheltered environment. The faunal communities here are influenced by high levels of disturbance from wave action or tidal currents and include robust fauna such as bivalve molluscs, anemones and robust polychete worms.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. This habitat has links to the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' (1110).



Infralittoral muds (SS3): This habitat occurs in the river channel at Monkstown / Passage-West and consists of sandy muds and soft muds, with conditions ranging from fully marine to estuarine. The only plant or animal life recovered from this area during grab sampling were ragworms (*Hediste diversicolor*).

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Sea walls, piers and jetties (CC1): Sea walls are situated along the R610, the road leading to Monkstown and Passage West, at Rushbrook and at Cobh. This roadway is on one of the proposed pipeline routes. This habitat generally contains few species. Polypody fern *Polypodium* spp, herb robert *Geranium robertanium* and the salt tolerant grass red fescue *Festuca rubra* were recorded in sections of this habitat.

Evaluation: This is a highly modified habitat but is of local importance.

Shingle and gravel shores (LS1): This habitat is present at East Beach, Cobh. This is a moderately exposed shore with accumulations of mobile rocky material. Sediments here comprise mainly shingle, gravel and shells. Coarse mobile sediments typically support little marine life other than opportunist amphipod and isopod crustaceans and oligochete worms.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Mud shore (LS4): This habitat occurs frequently within the harbour system; at Carrigaline, at Crosshaven, to the east of the town centre on the southern shore, at Passage- West at both sides of the river and at Rushbrook and Whitepoint, both on Great Island. These mud shores

are formed primarily of very fine sediment and along the most sheltered sections of coastline. They are subject to variable, reduced or low salinity. The mud shores were found to support communities of polychaete worms (e.g. estuary ragworm and *Nephytes spp.)*. One Oligochete worm, usually present where there is significant freshwater influence, was found at the uppermost site at Carrigaline.

Evaluation: This habitat is dominated by open areas of mud and is a feeding area for estuarine birds. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Sand Shore (LS2): This habitat occurs at Ringaskiddy, on the east facing beach. This is a sheltered shore of medium and fine grained sand, with a small proportion of mud. Scattered stones or shells occur on the surface. Mobile sand of the upper shore is typically impoverished of animal and plant life with the lower shore characterised by amphipod and isopod crustaceans, with some polychaete worms and bivalve mussels.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Mixed sediment shore (LS5): This habitat occurs at Crosshaven, east of town centre on the southern shore. It is a sheltered shore with poorly sorted mixes of sediments of different grades. It supports some fucoids (*Fucus serratus,* Carragheen *(Chondrus crispus) and* sea lettuce *(Ulva lactula*). The habitat did not hold an abundance of fauna with Gammaridae, shore crabs and flat periwinkles found.

Evaluation: This habitat is dominated by open areas of mixed substrate. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.



Moderately exposed rocky shore (LR2): This habitat occurs at the eastern end of Cobh and at the east facing beach at Ringaskiddy. These consisted of moderately exposed shores of bedrock, boulders and stable cobbles. These shores were dominated by communities of barnacles, molluscs such as periwinkles, with bivalves also present. Common mussel beds occurred at Cobh. Fucoid cover was incomplete at these habitats.

Evaluation: This habitat forms shelter for a variety of marine/estuarine organisms. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Sheltered rocky shore (LR3): This habitat occurs at Passage West, near the bottom of the slipway at the end of a public green and at Whitepoint (at the southern tip of Great Island). These habitats include sheltered to extremely sheltered rocky shores of bedrock, and stable accumulations of boulders, cobbles and pebbles. Dense growths of fucoids occurred. The sheltered rocky shores surveyed were found to contain a diverse range of macro-fauna with barnacles (*Eliminus modestus*) Keel worms (*Pomatoceros lamarcki*) especially abundant.

Evaluation: This habitat is of high local ecological importance. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance.

Mixed substrata shore (LR4): This habitat occurs at Crosshaven, just east of the town centre on the southern shore, at Ringaskiddy, on the north facing beach opposite Whitepoint and at Monkstown/ Passage West on both sides of the river. In these areas the shore comprises a mixture of rock and sediment, the sediments included gravel sand and mud. These shores occurred in moderately exposed to sheltered locations and macro-fauna included the

common mussel, periwinkles (*Littorina spp.*), and barnacles. Fucoid cover was incomplete at these habitats.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

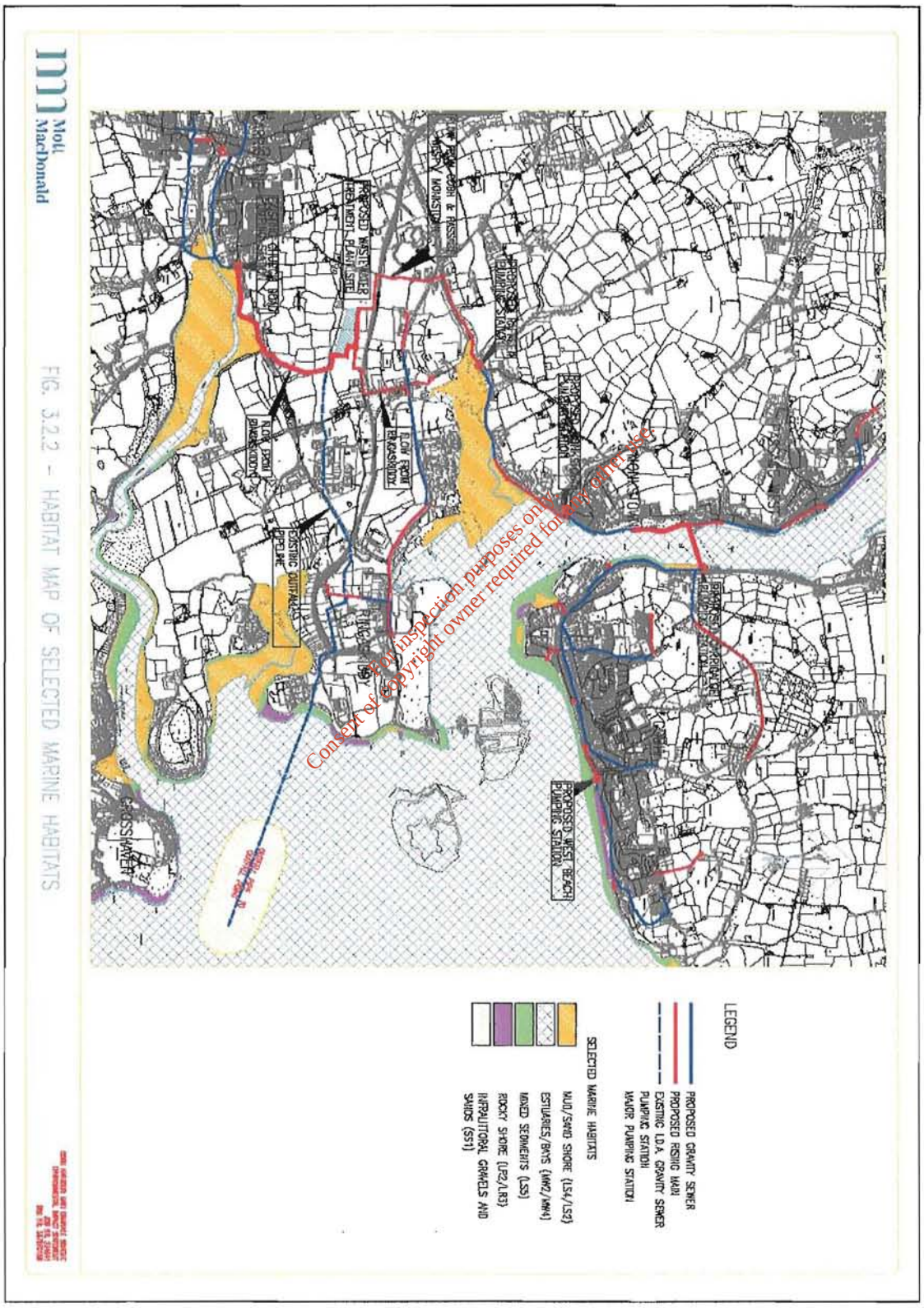




**Figure 3** Selected marine habitats in the vicinity of the proposed development.

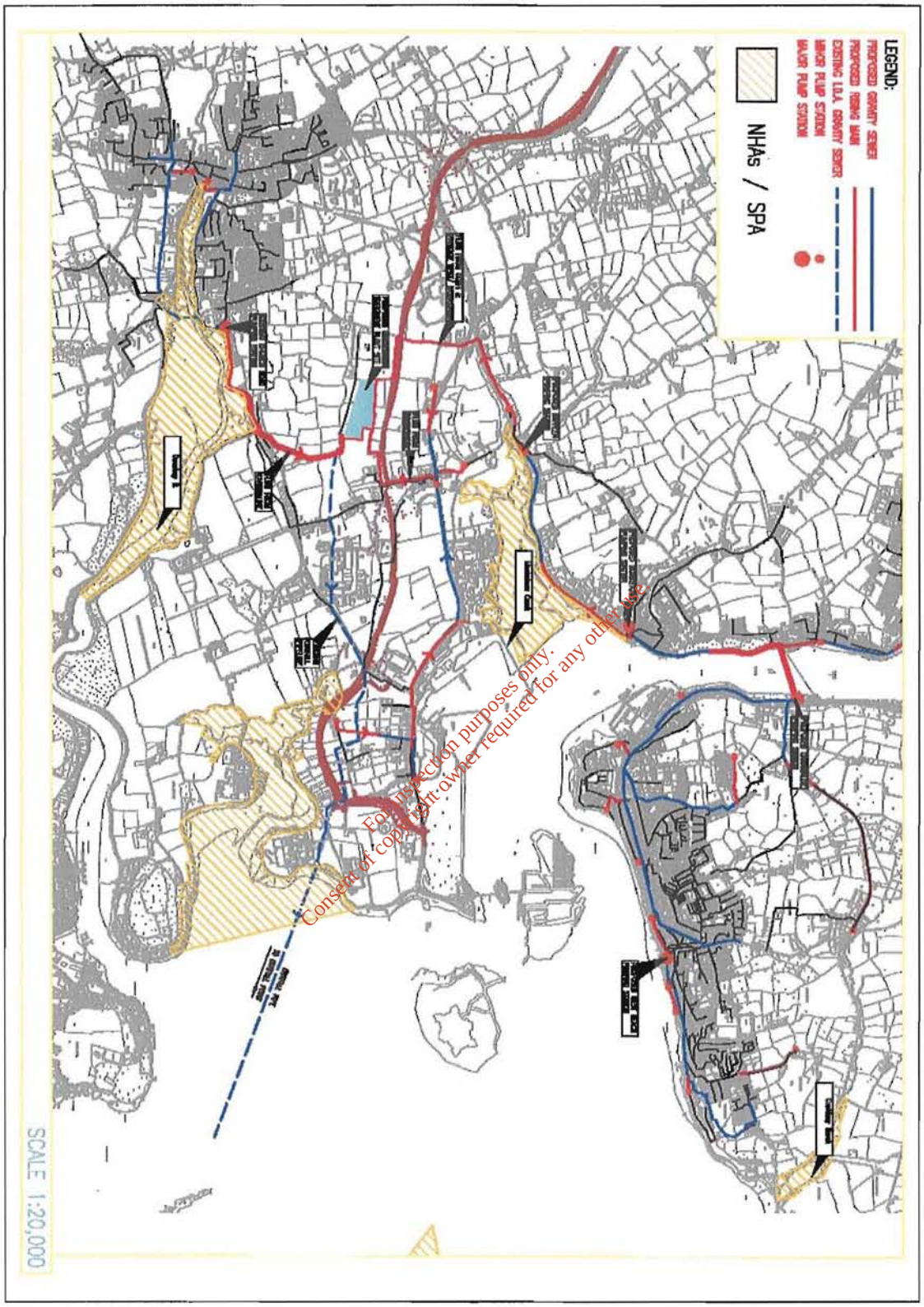




**Figure 4** Boundary of the Owenboy River NHA, Monkstown Creek NHA, Cuskinny Marsh NHA and the Cork Harbour SPA in the vicinity of the proposed development.

*Rare plant species*

Common plant species recorded during the field survey are detailed in the habitat descriptions above. During the field survey, the habitats were also assessed as to their potential suitability for rare plants. The proposed development areas lay within three 10km square Ordnance Survey Grids W 76, W 77 and W 86. A plant species list for these three 10km square was generated from the CD-Rom version of the *New Atlas of British and Irish Flora* (Preston *et. al.,* 2002). This list was then compared to the lists of species protected under the Flora (Protection) Order of 1999; and those included in the Irish Red Data Book (Curtis and McGough, 1988).

Autumn knawel *Scleranthus annuus* is recorded by Preston *et al.* (2002) as being present in each of the three 10km squares W 76, W 77 and W 86 (recorded pre 1970). This species is included in the Irish Red Data Book on the basis of its protected status in the Republic of Ireland. Curtis and McGough (1988) describe this as a data deficient species. It occurs on waste places and roadsides on dry sandy soils. No optimal habitat for this species occurs in the study area and it was not recorded during the current survey.

Meadow barley *Hordeum secalinum*, is recorded by Preston *et al.* (2002) as being present in the 10km square W76 and W77 (recorded pre 1970). This species is included in the Irish Red Data Book on the basis of its protected status in the Republic of Ireland. Curtis and McGough (1988) describe this as a vulnerable species. It occurs mostly on damp heavy soils and has been recorded on meadows bordering estuaries. It is declining due to reclamation and embankment of lands fringing estuaries. However, no suitable habitat occurs in the vicinity of the proposed development due to nearby intensive agriculture.



Penny royal *Mentha pulegium*, was also recorded by Preston *et al.* (2002) as being present in the 10km square W76 (recorded pre 1970). It is a short lived perennial herb of seasonally inundated grassland overlying silt and clay. Penny royal is included in the Irish Red Data Book on the basis of its protected status in the Republic of Ireland. Curtis and McGough (1988) describe this as an endangered species. No suitable habitat for this species occurs in the study area and it was not recorded during the current survey.

Meadow saxifrage *Saxifraga granulata* is a perennial herb with a bulbiliferous rhizome, growing in moist but well-drained, often lightly grazed, base-rich and neutral grassland, in unimproved pastures and hay meadows, and on grassy banks. More rarely, it occurs on shaded river banks and in damp woodland. This plant was recorded by Preston *et al.* (2002) as being present within the 10km squares W67 and W86. Curtis and McGough (1988) describe this as a critically endangered species. This plant not recorded during the current survey and again habitats for this species are unsuitable in the areas surveyed.

Rough poppy *Papaver hybridum* is recorded by Preston *et al* (2002) as being present within the 10km square W77 (recorded pre 1970). It is common on sand and gravel areas. This species was initially thought to be extinct in Ireland until recently where it was found in a neglected barley field in north county Dublin. The decline in this species is attributed to improved methods of seed cleaning and weed control, in addition to a decline in tillage practices. Curtis and McGough (1988) describe *Papaver hybridum* as a critically endangered species. Again no evidence of this plant was recorded in the areas surveyed and it is considered that this plant species is unlikely to occur in the areas affected.

Red hemp nettle *Galeopsis angustifolia*, an annual of arable land, waste places and open ground on calcareous substrates, (including limestone pavements and scree) also found on eskers and on coastal sand and shingle is recorded by Preston *et al* (2002) as being present within the 10km square W77 (recorded pre 1970). Curtis and McGough (1988) describe the red hemp nettle as an endangered species. This plant was not recorded during the current survey and no suitable habitat for this plant was recorded during the current investigations.

Weasel's snout *Misopates orontium* is an annual of light soils, found in arable and other cultivated ground including among horticultural crops, and in gardens and waste places. This species was recorded by Preston *et al* (2002) as being present within the 10km square W67

and W76 (pre 1970) but it was not recorded in the affected areas surveyed. Webb *et al.* (1996) reported weasel's snout to be established in arable fields in Co. Cork. Curtis and McGough (1988) categorise weasel's snout as an endangered species.

None of these species were recorded during the current survey and habitats recorded are generally sub-optimal for the above species. These plant species have all been recorded by BSBI recorders in this general area of Cork previous to 1970.

## Fauna

### *Birds*

Estuarine birds: Cork Harbour is an area of international importance for wintering waterfowl (i.e. wildfowl and waders)[1]. Cork Harbour is recognised as one of the most important wetlands in the country with total counts of just under 30,000 waterfowl annually between 1999 and 2005 (see Appendix 4). Of particular note is that the site supports an internationally important population of Redshank and Black-tailed Godwit. A further 15 species present in the site have populations of national importance (Crowe, 2005).The importance of Cork Harbour for wintering waterfowl (i.e. wildfowl and waders) has been recognised through the designation of sections of Cork Harbour as a Special Protection Area for Birds (SPA site code 4030) under the EU Birds Directive (79/409/EEC). Sections of the harbour are also designated a candidate Special Area of Conservation and proposed Natural Heritage Areas. The SPA site synopsis for Cork Harbour is provided in Appendix 1.



The waterbird populations of Cork Harbour have been monitored periodically since the 1970's (Smiddy *et al*, 1995; Gittings, 1996). Since the winter of 1994/95, annual monitoring of the area has also been carried out as part of the Irish Wetland Bird Survey (I-WeBS). A review of the birds of Cork Harbour has recently been provided in the book 'Ireland's Wetlands and their Waterbirds: Status and Distribution' by Crowe (2005). According to Crowe (2005), the wildfowl and wader population of Cork Harbour is usually taken as a single population as they move readily among subsites depending on tidal state and feeding conditions. However, the Douglas Estuary and Dunkettle in the northwest of the harbour are the most important areas, particularly for Shelduck and several wader species, including Golden Plover, Lapwing, Dunlin, Black-tailed Godwit, Bar-tailed Godwit and Redshank. All regularly occur there in nationally important numbers. The Douglas Estuary is known to be a very important high tide roost. An area of adjacent pasture provides secure roosting area for several wader species, and a feeding area for Wigeon. The Dunkettle mudflats are rich in invertebrates, and attract large numbers of feeding waders. Adjacent waste ground resulting from land reclamation, has also proven attractive as a high tide roost.

Crowe (2005) reports that the southern shore of Little Island (north shore of Lough Mahon) is used as a feeding area by many species, including Black-tailed Godwit. However, not many birds remain there at high tide, although some groups of mixed wader species, including Oystercatcher, Grey Plover and Dunlin, do roost along the shore and on one or two of the disused piers. The north channel subsites, east of Marino Point to Ballynacorra, support nationally important numbers of Cormorant, Shelduck, Pintail, Golden Plover, Lapwing, Dunlin, Black-tailed Godwit and Redshank. All mudflats support feeding birds, and the main roost sites are located at Weir Island and Brown Island and to the north of Fota Island at Killacloyne and Harper's Island. Crowe (2005) also reports that further east Ahanesk also supports a roost, but comments that this is highly sensitive and subject to disturbance.

Harper's Island regularly supports nationally important numbers of Shelduck, Black-tailed Godwit and Redshank, and occasionally Lapwing and Dunlin. Numbers of Black-tailed Godwit occasionally reach international importance. The polder area in the north section is used for

[1] For bird sites, a wetland qualities for international importance if it regularly holds at least 20,000 waterfowl or at least 1% of the population of a species.

feeding and roosting, particularly when fields are wet. Crowe (2005) comments that Brown Island is also important, supporting internationally important numbers of Black-tailed Godwit, and occasionally nationally important numbers of Dunlin.

In the southwest of the harbour, Dunlin, Redshank and Curlew regularly frequent the Owenboy Estuary (Crowe, 2005). Occasionally large wader roosts form in fields near Rabbit Point at high tide. The marsh at Monkstown Creek provides a secure winter refuge to several species of waterbird, with Shelduck, Teal, Redshank and Dunlin the most abundant. At times, nationally important numbers of Cormorant have been recorded using the jetty as a roost. According to Crowe (2005), Lough Beg regularly supports nationally important numbers of Black-tailed Godwit and Dunlin, and the area is valuable as a secure roosting site for flocks of all waterbird species when their feeding areas on the mudflats are covered by the tide.

The section of the harbour south of Great Island is important for Great Crested Grebe and Red-breasted Merganser, both of which regularly occur in numbers of national importance, particularly in offshore waters at Aghada and Whitegate Bay. Rostellan supports nationally important numbers of Little Grebe, while the mudflats westwards as far as Aghada are used by feeding waders. Shoveler regularly occurs in nationally important numbers at Whitegate Bay (Crowe, 2005).

Inland bird populations: The habitats present at the proposed development WWTP site and inland pipeline network are typical of this part of county cork and support bird populations typical of agricultural grassland, hedgerow and suburban habitats. During the walkover study a wide range of relatively common species were noted including skylark, starling, blackbird, dunnock, pied wagtail, jackdaw, rook, wren, robin, chaffinch, blue tit, song thrush, great tit, wood pigeon, collard dove, sparrow, stonechat, swallow, pheasant, kestrel, and song thrush. 'The new atlas of breeding birds in Britain and Ireland: 1988-1991' by Gibbons *et al* (1993) was used to generate a list of inland bird species of conservation concern previously recorded breeding in the study area. A list of these species and the likelihood of them breeding in the areas affected by the proposed development is provided in Table 9.



According to Birdwatch Ireland Peregrine falcons nested at a quarry located approximately 600m northwest of the proposed treatment works site in 2002. This species is listed under Annex 1 of the E.U. Birds Directive and is a species of very high conservation importance. Peregrine Falcons have made a successful comeback in Ireland since the 1960's when they were driven to low levels as a result of persecution and recruitment failure due to bioaccumulation of organochlorine pesticides. These birds have quite large territories and may use parts of the study area for foraging. However, no potential nest sites or important areas for this species would be in any way affected by any aspect of the proposed development.

**Table 9** Inland bird species of conservation concern which have been previously recorded breeding in the 10km squares where the study area is located (adapted from Gibbons *et al*, 1993). The likelihood of these species breeding in the affected areas is indicated.

| Species | Conservation status | Likelihood of breeding in the affected areas |
|---|---|---|
| Barn owl | Red listed | Some suitable habitat may breed. |
| Yellow hammer | Red listed | Some suitable habitat may breed. |
| Coot | Amber listed | No suitable habitat |
| Cormorant | Amber listed | No suitable habitat |
| Cuckoo | Amber listed | No suitable habitat |
| Grasshopper warbler | Amber listed | No suitable habitat |
| Kingfisher | Amber listed | No suitable habitat |
| Sand martin | Amber listed | No suitable habitat |
| Skylark | Amber listed | Some suitable habitat, may breed. |
| Snipe | Amber listed | Little suitable habitat, unlikely to breed |
| Spotted flycatcher | Amber listed | Some suitable habitat, may breed. |
| Stonechat | Amber listed | Some suitable habitat, may breed. |
| Swallow | Amber listed | Likely to breed |
| Water rail | Amber listed | No suitable habitat |

Evaluation: The bird populations of Cork harbour are of International Importance and mach of the harbour is designated as a SPA. The bird populations of the proposed WWTP site and areas affected by pipelines are of local importance.



## *Mammals*

Hayden and Harrington (2000) give the distribution of mammal species in Ireland by 20km squares, each of which is composed of four National Grid 10km squares. The subject lands lie within two 20km squares comprising National Grid 10km squares, W66, W67, W76, W77, W86, W87, W96, and W97. The protected mammal species recorded in this 40km square by Hayden and Harrington (2000) are listed in Appendix 5.

Badger *Meles meles* is common in this part of County Cork. One badger sett was recorded on the west side of the hedgerow located along the eastern boundary of the proposed WWTP site (at IG W75265 63901). This sett was located away from the footprint of the proposed WWTP but is located within 30m of the proposed development. This sett had 3 entrances and was considered to be active at the time of the survey. Badger hair was found on a barbed wire fence nearby. No other setts were recorded during along the pipeline routes; although it must be noted that not all areas could be viewed in detail due to land access restrictions. The badger is protected in Ireland under the Wildlife Acts 1976 and 2000. Despite protection, the illegal killing of badgers is widespread and common.

Otter *Lutra lutra* is listed in Annex II of the EU Habitats Directive and is protected under the Irish Wildlife Acts 1976 and 2000. No otters holts or other important otter features were found in the immediate vicinity of the proposed / existing outfall sites or foreshore pipeline routes. However, otters are present in the area and are known to forage along the affected areas of shoreline. Persistent wet weather during the current foreshore survey may have made signs of otters (i.e. spraints, footprints) difficult to detect.

All Irish Bats are protected by the Bonn Convention 1992 (Agreement on the Conservation of Bats), the Bern Convention 1982, and the Wildlife (Amendment) Act 2000. No potential or known bat roosts would be directly affected by the proposed development. Many of the hedgerows and treelines in the study area are likely to be used by bats for foraging and commuting.

**Plate 1** Badger sett located near the proposed WWTP site.

Bat Conservation Ireland (BCI) recorded 3 species within 10km of Monkstown. Table 10 lists the BCI records of bat roosts in the Carrigaline area. Roosts for common pipistrelle *Pipistrellus pipistrellus*, soprano pipistrelle *Pipistrellus pygmaeus* and Leisler's bat *Nyctalus leisleri* are present, with additional records for unidentified pipistrelle bats. A total of 101 roosts have been recorded and 50 transect records exist since 1987. BCI recommended that a bat survey to determine the roosting, commuting and foraging potential for local bat populations. However, it was concluded that the current proposal has a low likelihood of affecting bat populations. The treatment plant site itself is not considered to be of any importance to bats and the marine areas affected by the proposal are not used by this group of animals. Most of the proposed pipeline route follows existing roads and felling of significant numbers of mature trees / building demolition is not a feature of this project. No trees along the corridor of the pipeline were identified as being of particular importance to bats. Any trees felled during the construction phase of the project would however need to be checked for bats in advance. Once installed, the proposed pipeline would in no way affect bat foraging or commuting, as would say a road scheme.



**Table 10** Bat records from the study area currently available on the BCIreland database.

| Species | W7666 | | |
|---|---|---|---|
| | Roost | Roost | Details |
| Common pipistrelle | NR | 2 | Grid Refs: W78148 67380, W66786 61559 |
| Soprano pipistrelle | NR | 1 | Grid Ref: W73982 62775 |
| Pipistrelle sp. | 1 | 1 | Maternity roost at W6657, Transect Grid Ref: W69742 67868 |
| Leisler's bat | NR | 2 | Grid Refs: W73982 62775, W66786 61559. |

Other protected species, listed under Appendix III of the Berne Convention which are likely to be present in the study area are hedgehog *Erinaceus europaeus*, pygmy shrew *Sorex minutus*, and Irish hare *Lepus timidus hibernicus*. These species were not recorded during the site walkover however they are present throughout the Irish countryside and it is most likely that they occur within the study area

Cork Harbour is known to contain both resident and vagrant populations of common dolphins *Delphinus delphis*. For example, in February 2001 common dolphins were observed on 9 days in groups ranging from 300-1,000 inside Cork harbour (Source: IWDG). The Annex II listed harbour porpoise *Phocoena phocoena* and bottlenose dolphin *Tursiops truncatus* have also been recorded in Cork Harbour as well as common, striped and Risso's dolphin and killer whales (IWDG, pers comm.).

While Hayden & Harrington (2001) show seals as having not been recorded from Cork Harbour, both harbour and grey seals are recorded all around the Irish coast and are

therefore likely to be present in the harbour occasionally. Seals have been observed in Cork Harbour (Ecofact, unpublished) and reference has been made to the presence of both harbour and grey seals occurring here in the scientific literature (e.g. Smiddy, 1998). While it seems likely that at present Cork Harbour is not an important habitat for seals, nevertheless they are likely to receive some benefit from the cleaner waters expected in the harbour as a result of the proposed development as cetaceans such as seals are potentially vulnerable to a wide range of human and livestock pathogens.

### *Reptiles and Amphibians*

Two reptile species occur in Ireland; the viviparous lizard *Lacerta vivipara* and the slow worm *Anguis fragilis*. The viviparous lizard occurs in County Cork and may be present in the general study area. These reptile species were not recorded within the study area during the walkover survey, however, suitable habitat occurs in the study area and lizards are likely to be present. Terrestrial invertebrates in general are an understudied group. However, it is likely that the invertebrate populations present within the proposed development area are typical of Irish farmland and urban areas. It is unlikely that any rare species occur due to the generally highly modified nature of the habitats present.

### *Terrestrial Invertebrates*

Terrestrial invertebrates in general are an understudied group. However, it is likely that the invertebrate populations present within the proposed development area are typical of Irish farmland and urban areas. It is unlikely that any rare species occur due to the generally highly modified nature of the habitats present.



### *Marine Invertebrates and their habitats*

The results of the on-site marine/estuarine macroinvertebrate survey are presented in Appendix 6. The macroinvertebrate species recorded were the typical species that would be expected from a sheltered Irish estuary such as Cork Harbour. All the species were common, euryhaline and pollution tolerant species (with the exception of the Common starfish *Asterina rubens* – mainly a marine species – which was recorded at three sites). Brackish water habitats usually have impoverished fauna due to fluctuations in salinity and water levels (Barnes, 1994). However, the main species present in these areas can often form high densities and, as is the case in Cork Harbour SPA, provide valuable feeding opportunities for wintering birds. The results from the individual stations are outlined in Table 11. A general discussion of the reports is provided below.

Cork Harbour is a large, sheltered bay system, with several river estuaries. It is classed as a bay since it's a semi-enclosed waterbody more than 50% enclosed by land (Fossitt, 2000). However, the harbour is strongly influenced by the Rivers Lee, Douglas, Owenacurra and other freshwater inputs and is similar to an estuary and the mixing of the very different water masses can be expected to give rise to complex sedimentological and biological processes and patterns.

The River Lee west channel up as far as Passage West is 12-16 m deep (O' Kane, 2007). Three general types of shore were identified in this general area. One of these was rocky shores, characterised by the habitats of 'Moderately exposed rocky shores' (LR2) at Ringaskiddy and Cobh, and 'Sheltered rocky shores' (LR3) at Passage West. The corresponding biotopes for these areas were 'Moderately exposed littoral rock' and *'Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock'. Another prevailing shore type was 'Mixed substrata shores' (LR4) on the River Lee west passage, Ringaskiddy and Crosshaven. The other main type of shore was composed of littoral sediment, namely mud shores (LS4). This was the main habitat on the Owenboy Estuary near Carrigaline and Crosshaven, at the south western part of Great Island near Cobh, and the lower shore near the ferry crossing. The biotope for these locations was "*Hediste diversicolor* in littoral mud".
Marine soft sediments, estuaries, and brackish waters are places of extraordinary biological interest, and home to an immense diversity of plants and animals (Little, 2000). Brackish water bodies are those waters found close to the sea and are intermediate in salinity between

freshwater and sea water. The east facing shore at Ringaskiddy could be described as a minor bay of muddy sandy shoreline grading to rocky shore at the northern and southern reaches. With the exception of the sandy beach, this part of the shore, as well as the shoreline east of Cobh could be classed as 'marine rocky shores'. The results of the quadrate survey illustrate this via the distribution of limpets. The rocky shores at Ringaskiddy and Cobh appeared 'clean' except for populations of the encrusting barnacle *Elminius modestus.* In fact, such rocks are covered by a thin layer of diatoms and cyanobacteria that provide food for mobile grazers such as the common limpet *Patella vulgata.* Limpets, a keystone species were generally present other than on the River Lee west passage and the Owenboy River estuary, with highest densities recorded at Ringaskiddy (Q5-6/$m^2$) and Cobh (Q15-36/$m^2$). Keystone species have a disproportionate effect on its environment relative to its abundance, affecting many other organisms in an ecosystem and help in determining the types and numbers of various others species in a community. An ecosystem may experience a dramatic shift if a keystone species is removed, even though that species was a small part of the ecosystem by measures of biomass or productivity.

'Estuarine rocky shores' at the mouths of estuaries, on the other hand, have communities similar to those on nearby open coasts (Little and Kitching, 1996). With distance up the both the Owenboy estuary and River Lee west passage, there was a general decline in species numbers (except Site Q9). Partly, this may have been due to decreasing and increasing salinity variation. The decline is also related to two other effects. In some places the rocks were covered with a layer of deposited silt, and in other places rocks would be exposed to currents with a high suspended sediment load, acting as a scouring agent in abrading the rock surface. A classic example of this phenomenon was observed in the current study where the River Lee west passage showed an increase in diversity 'upstream' at Passage West (Q9), in contradiction to what one would expect in terms of salinity variation and species diversity. This could be attributed to the constricted channel width between Glenbrook at the west side and Ballynoe at the east side of the channel, thus increasing the flow of water. The width of the channel at this location was the obvious reason for the choice of the ferry crossing. Water velocity determines sediment type, but only in combination with factors like supply of sediment, and effects that the organisms themselves have on the sediment. As well as the supply of oxygen, the other major factor which is brought by the water is food. Water supplies the suspension feeders with plankton, and deposit a rain of detritus on the surface that supplies the deposit feeders. Water flows in the harbour vary according to the tide.



Silt layers like those on the River Lee western passage (typical of estuarine rocky shores) may inhibit settlement by larvae of animals and spores of plants so that in some cases, estuarine rocks may stay bare of macro-flora and fauna for years (Little, 2000). This was not the case in this study though there were generally more grazers such as edible and flat periwinkles in the outer parts of Cork Harbour, thereby increasing the value of outer harbour in terms of diversity. Mussels *Mytilus edulis* formed dense continuous growths on the lower and middle shore on the western shore of the River Lee western passage. Attached by long threads (byssus) to rocks, they were growing on top of each other and occupied a lot of space. Densities in the order of 500/$m^2$ were recorded from the River Lee west passage at Site Q10. These mussels would be preyed upon by terrestrial animals such as birds and otters when the tide is out and by a variety of marine organisms including green shore crabs, common starfish, and fish when the tide is in (Suchanek, 1986). Thus, it can be said that mussels are a potentially important source of food for fauna in the region. However, mussels are responsible for considerable movements of sediment with each individual depositing over 600mg wet-weight of pseudofaceal and faecal matter per day (pseudofaeces are the materials taken in by filter feeders but rejected, instead of being consumed). Some mussels have been found to deposit a layer of mud 60cm thick in a two year period (Ehlers, 1988).

The ragworm *Hediste diversicolor* was found in all the core samples taken but was most abundant in the Owenboy Estuary area. Numbers increased from the upper part of the mudflat (7 at C1, 43 at C2 and 57 at C3) to the most seaward site. The highest density recorded in the River Lee west passage was at Glenbrook (N=21). The success of the ragworm in the harbour can be explained by its array of feeding strategies. It will catch and consume other animals smaller than itself, eat pieces of green seaweeds, scavenge, even pulling small dead fish into it's burrow, consume the surface layers of sediment and can

secrete a filter of mucus to trap plankton and other suspended particles (Barnes, 1994). The common ragworm is responsible for considerable loss of saltmarsh and mudflat habitats on the southeast coast of England. They can feed in several ways but predominantly they partially emerge from their burrows in the mudflats and eat pieces of plants, seeds, seedlings and the small algae that inhabit the mud surface and also help reduce mudflat erosion. There is also some evidence that the increased abundance of this worm over recent decades has had negative consequences for other mudflat invertebrates and this may have an effect on the food availability for wading birds. This is thought to be a reason for the decline in some species of wading birds on some estuaries in SE England, identified by the British Ornithological Union surveys (NERC website).

Evidence of lugworms *Arenicola spp.* in the form of holes and casts were recorded at 50% of core sampling sites but only one specimen was recovered in a core sample. The low incidence may have been due to the relatively small area surveyed by core sampling. The mechanical disturbance brought about by ragworms or lugworms is known to increase the emigration rate of *Corophium volutator,* and at these times are at greater risk from casual predation. (Morrisey,1998). The ragworm interacts with *Corophium volutator* by predation, interference and disturbance (Olaffson and Persson, 1986) and this may also explain the general absence of *Corophium volutator* in the current study. Indeed, the only location where *Corophium volutator* were recorded on the River Lee west passage was at core sampling Site C8 with a correspondingly low density of ragworms. This trend was also observed in the Owenboy Estuary Site C1 where the JNCC biotope was "*Hediste diversicolor* and *Copophium volutar* in littoral mud". *Corophium volutator* may have densities as much as 100,000/$m^2$ and can reach into low salinities (Little, 2000). Distributions of brackish water species are dynamic and individual populations may not occupy the same patches of sediment from year to year. What is a dense patch of *Corophium* this year may be occupied by ragworms or lugworms next year (Barnes, 1994).



Another habitat type encountered was 'Mixed sediment shores' (LS5), characterised by a poorly sorted mixture of sediments of different grades, including pebbles, gravel, sand and mud. The western site At Crosshaven (Q1) was a habitat of this type where larger cobbles were present and supported some cover of fucoids, crabs, amphipod crustaceans and flat periwinkles. An area of the biotope 'barren littoral shingle' or 'shingle and gravel shore' (LS1) was identified at Cobh. The latter habitat is known to support little marine life other than opportunist amphipod, isopod crustaceans and oligochaete worms. However, no macrofauna were detected in this habitat during the current survey. Intermediate sizes of sediment such as shingle are usually 'intertidal deserts', in which macrobiota are absent. These circumstances arise because shingle shores on which particles may range from something like 5mm to 250mm diameter are usually only deposited where currents are quite fierce and particles are continuously moved around. When this happens, they grind against each other making life on their surface and between them virtually impossible (Little, 2000).

During the sublittoral survey of the harbour, four sites were investigated. In the region of the IDA outfall pipe, infralittoral mixed sediments were recorded at two locations. Infralittoral muds were recorded at the River Lee west passage. Only one ragworm was recorded from the Site near the existing outfall.

Crustaceans: Arthropods are the most numerous animal group. Arthropods have an external skeleton and paired, jointed limbs. Phylum Arthropoda includes crustaceans, insects and spiders. Crustaceans include crabs, lobsters, shrimp, krill and barnacles (Hayward and Ryland, 2005). From the sampling of 25 sites along the intertidal part of the shore in Cork Harbour, a total of 7 species of crustacean were recorded. Only 2 species were recorded from core sampling; the mud shrimp *Corophium volutator* was found at the upper site on the Owenboy Estuary (C1) at Carrigaline and also at Cobh (C8) while the green shore crab *Carcinus maenas* was found at the lower site on the Owenboy Estuary (C3). The small numbers of crustaceans recorded by core sampling was expected due to the nature of this sampling technique i.e. sampling to depths on mudflats where crustaceans cannot live.

In the quadrate sampling, crustaceans were recorded at all sites with the exception of the barren site (Q13) at Cobh. Where there was suitable habitat such as rocks and boulders,

barnacles were present in their hundreds. *Elminius modestus* was well distributed (found at 9 sites) and was the dominant sedentary crustacean species. *Semibalanus balanoides* was found at two sites on the western channel; Q4 at Ringaskiddy and Q6 at Monkstown. Also recorded at sites adjacent to these was *Balanus crenatus*, as well as at Site Q11 on Great Island south of the ferry crossing. The habitats where barnacles were recorded were 'Moderately exposed rocky shore' (LR2) and 'Mixed substrata shore' (LR4). The ubiquitous green shore crab was generally common throughout the intertidal area and the highest densities were recorded at Sites 7 (38/$m^2$) and 9 (28/$m^2$) on the Monkstown/Passage west side of the channel, and at Sites 14 (24/$m^2$) and 15 (28/$m^2$) at the eastern end of Cobh town on Great Island. The preferred habitat for the crab was 'Mixed substrata shore' (LR4), 'Sheltered rocky shore (LR3)' and 'Moderately exposed rocky shore' (LR2). Through macroalgae, stones and other invertebrates, these habitats offer refuge and feeding opportunities to these scavengers.

The freshwater shrimp *Gammarus deubeni* was recorded at 4 sites and was most common at Site 14 in Cobh. It was sparsely distributed around other parts of the harbour, occurring at Passage west and Ringaskiddy. Fair numbers of mud shrimp were recorded at the eastern side of the channel at Site Q11. Another gammarid, *Chaetogammarus marinus* was present on 'Mixed Sediment shore' at Crosshaven. This species was only found at this site.

Crustacean food supply is probably the most important factor in determining the distribution of fish. Some fish, such as flounder fish feed on benthic infauna. For example, the flounder consumes *Corophium*, snails such as *Hydrobia* and some bivalve species and is generally found where these dominate the benthos. Bass specializes on the shrimp *Crangon* and mysids while whiting feeds on *Crangon*, mysids, amphipods and cumaceans (Henderson *et al*, 1992). In winter, most crustaceans migrate out to deeper water; so generally, numbers are higher in estuaries in summer.



Life on soft shores versus life on rocky shores: Owing to the sheltered conditions in Cork Harbour, the intertidal flats are often muddy in character. Most of the animals that live on soft shores spend their time below the surface of the sediment – these are the infauna. The animals that live on the surface of the sediment are known as the epifauna. These include nearly all crabs and snails, though these may burrow at times. Large numbers of grazing animals and predators invade the mudflats at specific times. At high tide, fish such as mullet and flatfish such as flounder move up the shore. (Little, 2000). Plants, on the other hand, must at least keep part of their structure in the light for photosynthesis.

Perhaps the primary difference between all particulate shores and rocky shores for organisms is one of dimensions. Rocky shores are mostly two dimensional environments, except where heavy growths of algae form vertical canopies, while particulate shores offer three dimensions. Thus for organisms on rocky shores, there is no escape from predators: many rocky shore animals are sessile and their defence can exist only in terms of heavy armament, as for example in barnacle or limpet shells. This was reflected in the number of shelled mollusc species recorded at the more exposed sites at Ringaskiddy (six species at Q3 and Q5) and Cobh (4 species at Q15) while the River Lee west channel generally had only two species of shelled mollusc.

In sand or mud, however, animals can retreat into the depths when predators appear. One of the other beneficial effects of sediments is that the finer ones at least retain a large amount of water at low tide. Death from dessication is not such a problem as it is on rocky shores, except high on the shores in coarse sands. At high tide, the sediment acts as a buffer against changes in salinity, temperature and pH that may occur in the overlying water (Little, 2000). Yet another bonus is that because organic materials usually end up as small particles, they accumulate in sediments – so it is often possible to make a living simply by eating the sediment, especially in the finer muds. Very few rock dwellers can do this, unless the rock is permeated with burrowing algae. There are however some hazards for organisms living in sediments. First, there is nothing to anchor to, unless the organisms happen to be very small, like microalgae or bacteria. In addition, particles are far from stable so that while a particular patch of shore may be here today, it may be gone tomorrow. This calls for flexibility of lifestyles, and particularly flexibility of feeding behaviour.

Filter feeding (by mussels, cockles, etc.) is less prevalent in brackish environments than it is on sandy or rocky marine shores, perhaps because the especially high content of silt in estuaries would tend to clog any filter and render food collection and sorting energetically expensive. However, the oyster has been recorded in waters turbid with silts ceased to sort the potential food particles form the background silt, but simply swallowed the lot (Barnes, 1994). Turbid estuaries are well known for the paucity of suspension feeders such as sea squirts, hydroids, and sponges probably due to the clogging of the feeding apparatus with silt (Little, 2000). None of these animals were found during the current survey.

The distribution of sediments: The movements of sediments on exposed sandy beaches are controlled mainly by the forces of wave action, while in sheltered bays and estuaries waves are less important and tidal forces predominate. The influences of waves and tide are not mutually exclusive. The relative importance of wind-driven waves and of tidal currents to a great extent determines coastal landforms and sediment distribution. In particular, as tidal range is a measure of the strength of tidal currents, it is often a good descriptor of tidal processes. The tidal range at Cobh is greater than 4m (ISA website) and is therefore termed macrotidal. It can be said that tidal forces predominate the movement and sorting of sediments. The overall balance between tidal forces and the forces of wave action greatly influences the sedimentary regime in which soft shore organisms live. Nowhere was this more evident than at the sites around the ferry crossing (near the proposed marine crossing) where there was a reduction in the diversity of organisms.

Particle size, sorting, and consequences for the biota: For plants as well as for animals, conditions within the sediments are crucial because they affect such factors as the supply of water, oxygen, and nutrients, and the stability of the system. Many of these factors are in turn determined by the size of the particles involved in the sediment, and the degree to which the particles are sorted. This is because size and sorting determine how 'open' the sedimentary environment is and therefore how much water flows through it, bringing with it fresh supplies of oxygen (Little, 2000). The muds at Cork Harbour support a range of macro-invertebrates, notably *Macoma balthica, Scrobicularia plana, Hydrobia ulvae, Nepthys hombergi, Nereis diversicolor* and *Corophium volutator*. Green algae species occur on the flats, especially *Ulva lactua* and *Enteromorpha spp*. Cordgrass (*Spartina spp.)* has colonised the intertidal flats in places.



Very often, it is impossible to analyse all the size fractions of sediments completely, but a good idea about its properties can still be obtained by estimating just the proportions of the finer particles. If the proportion of finer particles (fine sands, silt, clay) is high, drainage will be poor and oxygen concentrations will be low. If the proportion of silt-clay fraction is high, the organic fraction is likely to be high, and the sediment will also usually show cohesive properties. These cohesive properties are caused by electrochemically charged sites on clay particles and allow hydrogen bonding and the particles therefore bind together.

Smaller particles fill the gaps between particles and reduce the porosity. The importance of this is the way it determines the permeability or the rate at which water passes through the sediment. In general, if the proportion of fine grains is high, the permeability is low. For organisms living below the surface this means low oxygen content, so they have to adjust or bring in oxygenated water. Porosity is also important in determining the density of a sediment bed. When porosity is low and density high, the sediment is compacted and generally hard. Such sediments behave as solids, are difficult to erode and often have restricted biological activity.

During core sampling all the sites investigated on both the Owenboy Estuary and the River Lee west passage, it was noted that the mud was fairly cohesive but was also soft. On a scale of 1-5 where 1 is firm and 5 is soft, all sites scored 4. Porosity and stability was therefore deemed to be moderate at these locations.

How organisms affect sediments: Organisms themselves can affect the structure and chemistry of the sediment, and thus alter their own micro-environments and those of others. In contrast to plants, most animals in sediments create disturbance rather than stability. Some organisms act to bind sediment together and others loosen sediment structure and are called

'bioturbators', while many have complex effects that may act in both directions. Disturbance by some polychaete worms takes place by forming burrows. Irrigation of these burrows effectively raises the RPD (redox potential discontinuity) for these worms. In the current survey, casts of lugworm *Arenicola spp.* were recorded at 50% of the core sampling sites. These worms create a roughly U-shaped tube, through it draws oxygenated water by pumping movements of the body. Throughout mudflats, the polychaete worm *Nereis diversicolor* can increase porosity dramatically (Hansen and Kristensen, 1997). In general, the effects of disturbance are negative, and it has been suggested on a wider scale that deposit feeders as a whole may increase sediment stability so much that they make life impossible for suspension feeders.

Tube building worms in some cases have positive effects. The tubes of the polychaete *Lanice conchilega* act like steel reinforcing rods in concrete, and increase the rigidity of the sand (Jones and Jago, 1993). In a study on the Exe Estuary (SW England), it was found that resuspension from substrate with 100% mussel cover was about three times lower than the 0% cover (Widdows *et al,* 2002).

Anoxic layer: In coarse sands and much finer substrates conditions change with depth but the changes are slight in the former and dramatic in the latter. Near the surface the redox potential (a measurement which reflects the balance between oxidation and reduction) is positive, showing that oxygen is present and that oxidation is the primary chemical process. Lower down the potential decreases and then becomes negative, showing a reducing environment. The oxidised surface sediments are yellow or brown while the reduced sediments are black. In between is a grey layer in which the redox potential decreases rapidly (RPD layer). The depth of the RPD reflects how rapidly oxygenating water passes through the sediment. In the oxic zone, the animals have 'normal' aerobic metabolic processes like those of surface dwelling species. In the reducing zone, there are high levels of hydrogen sulphide and ammonia, both of which are toxic. Animals in this zone have to employ anaerobic processes, or provide their own oxygen supply. The supply of oxygen to the infauna is without doubt the most important chemical influence on the biology of sediments. In the summertime, the RPD rises due to increased infaunal respiration resulting in quicker consumption of oxygen and a decline in oxygen levels.



The RPD depth in the Owenboy Estuary was generally in excess of 20cm, meaning that the oxic zone was on this mudflat was usually more than 20cm deep. The implications for the infauna are that they can penetrate deeper in to the substrate and therefore more of them can exist in this habitat. The bivalve filter feeder *Spisula elliptica* as well as the ragworm was present at site C2, while the mudflat at Crosshaven (Site C4) was home to ragworm and catworm polychaetes, both sites with the deepest RPD in this estuary. With the exception of the ragworm, only epifauna were recorded at other sites on the Owenboy Estuary – those with shallower RPD. On the River Lee west passage, only the site on the mudflat at Glenbrook (C5) had an RPD greater than 20cm. This site had, by far, the highest density of ragworms in this part of the harbour (N=21). Sites C6, C7 and C8 were all located south of the ferry crossing and had RPD of between 1cm and 20cm and between them, supported ragworm, catworm, lugworm, cockle and *Corophium*. The current survey was carried out in June and so the RPD would have been approaching its highest level. The RPD depth fluctuates seasonally in accordance with temperature (Little, 2000). The RPD is an important factor in the ecology of Cork Harbour and should its mean depth rise, a reduction in diversity would be expected.

Resuspension of sediment and suspended particles: When shear water velocity exceeds a critical value, sediment is eroded and when it falls below a critical value, sediment is deposited. These two crucial values are usually different however, particularly for fine sediments where shear velocity for deposition is very much lower than that for erosion. When sediments are moved back into the water column, the process is called re-suspension. Re-suspension is caused by a combination of tidal currents, wave action, bioturbation, and human activities such as dredging and trawling, when a mixture of inorganic sediment, organic particles, bacteria, diatoms, and so forth move into the boundary layer (layer of water just above the sediment).

In estuaries which show a high tidal range, where there is usually a rich supply of particles, the boundary between deposited and suspended states may be hard to determine. During spring tides (those of high amplitude), fine particles are brought into suspension. Many estuaries have regions where suspended concentration is high - the so called 'turbidity maximum'. During neap tides (those of low amplitude), current velocities fall and the fine sediments are deposited again. The mixture that results is called fluid mud and may travel considerable distances with the tide. As it tends to become anoxic quickly, its passage over the substrate may have far reaching consequences for the infauna.

Conclusions: Phytoplankton is the first level of the food chain (primary producer) in the study area, followed by the zooplankton, which feeds on the phytoplankton. The zooplankton are then eaten by small fish and crustaceans, which all go on to be eaten by bigger fish, seals etc. Any changes in primary production will have implications for the whole ecosystem.

In the marine environment, nutrient enrichment is suspected when surface phytoplankton blooms are seen to occur more frequently and for longer periods. Changes in the relative abundance of phytoplankton species may also occur, with knock-on effects throughout the food web, as many zooplankton grazers have distinct feeding preferences. In 2005, many Irish shellfisheries were closed for a prolonged period as a result of harmful phytoplankton species. In sheltered areas, high nutrient levels appear to favour the growth of green macroalgae ('seaweeds') belonging to such genera as *Enteromorpha* and *Ulva*. These macroalgae are common in Cork Harbour.

In the ABC method (abundance-biomass comparisons), there is high diversity of large species but few individuals in the unpolluted community, whereas the polluted community has low diversity of many small individuals, particularly polychaetes (Warwick, 1986). In the core samples taken during the current survey, a low diversity and large numbers were recorded from mudflats, implying a polluted status. In the contrary, the pollution tolerant polychaete worm *Capitella capitata* was not recorded during the current survey. An average of two species was recorded at core sampling sites. The nature of such quantitative sampling however is such that a small area is sampled, and many of the larger fauna can be missed easily. This is especially true of subsurface bivalves such as the common cockle *Cerastoderma edule*, and lugworms. In combination, these two species occurred at only four core sampling sites.



Estuarine waters enriched by nitrogen from fertilizers and sewage have been responsible for the decline of a number of estuarine invertebrate species, often by causing oxygen depletion of bottom water (Barnes, 1994). Currently, Cork Harbour and the Owenboy Estuary receives untreated sewage from at least 10 locations. In estuaries, elevated rates of microbial respiration deplete oxygen, and periods of anoxia occur more frequently, especially in summer when water temperatures are high and there is slow water circulation.

Changes take place in benthic communities in shallow coastal waters following eutrophication. Where there is a deep RPD depth, the structural diversity afforded by the plants and the availability of oxygen in the sediment promotes a diverse community of animals. The sites examined on the mudflats of Inner Cork Harbour and the Owenboy Estuary did not hold a diverse community, indicative of reduced oxygen levels.

This loss of structural diversity and oxygen from the benthos causes the animal community to be replaced, in part by one of bacterial decomposers. Algal mats, associated with anoxic conditions were recorded on a mudflat to the west of Cobh (Site C7) and also on a rocky shore east of Cobh (Site Q15). Both of these sites were adjacent to outfalls. The cord grass (*Spartina anglica*), which has spread rapidly around the coasts of Britain in the past 100 years is aided by the increased nutrient supply to saltmarshes (Barnes, 1994). The spread of this species in Cork harbour is currently of conservation concern (Source NPWS).

The prevalence of the ragworm in the samples obtained during the current assessment is indicative of pollution. This species contributes to the degradation of mudflats through its feeding habits and has knock on effects for birds and fish. The presence of the common starfish *Asterina rubens* at three sites during the current survey - usually an indicator of good

water quality - cannot be relied upon in the current case as it has been found that those in estuaries have special adaptations, thereby limiting their use as an indicator. Kowalski (1955), for example, found *Asterias rubens* from the Baltic Sea to have a longer righting time, smaller body size, different organic and inorganic composition, later maturation, and lower reproductive capacity than individuals from the North Sea. Indeed, some estuarine populations are sterile and are maintained only by recruitment.

Overall, it can be said that the outer part of the harbour is more diverse, and habitats are of a marine nature as opposed to estuarine. However, in general the situation of reduced diversity within estuaries is observed within the study area but is more profound that would be expected if the area was not affected by organic pollution. It is clear from the data collected during the current study that the existing untreated inputs of sewage in the harbour are having a significant negative of the benthic macro-invertebrate community. Reducing these inputs as is currently proposed would have a significant positive impact on the ecology of Cork harbour.

**Table 11** Summary of macofauna surveys undertaken in the study area during 2007.

| Station | Results |
|---|---|
| Station C1 | This site was located in Carrigaline to the east of the bridge over the Owenboy River on the northern muddy shore. A total of 3 invertebrate species were recorded in the core samples taken at this site. These were the ragworm *Hediste diversicolor*, another polychaete worm (family Naididae) and the crustacean *Corophium volutator*. The latter was the most common species with 16 recorded. In the town of Carrigaline just upstream of this site, grey mullet *Chelon labrosus* were seen foraging upstream of the bridge. Raw sewerage was seen discharging into the river from a pipe on the northern bank in this area. |
| Station C2 | A core sample was carried out at this site which was located on the northern muddy shore of the Owenboy Estuary. This site was approximately 400m east of Site C1 and both sites had similar physical characteristics. Two species of invertebrate were found; the ragworm *Hediste diversicolor* and the bivalve *Spisula elliptica.* |
| Station C3 | This site was located in the mudflats of the Owenboy Estuary. A total of 57 ragworms *Hediste diversicolor*, one green shore crab *Carcinus maenas* and a bivalve *Spisula elliptica* were recorded in the core samples taken. |
| Station C4 | This site was located at Crosshaven to the east of the town centre on the southern shore adjacent to the R612. Two species of ragworm were recorded in the cores takenat this site; *Hediste diversicolor* (12) and a catworm *Neptys sp.* (2). Though numbers were low the size of the individual worms was large. The combined weights of the two worms were 15.2g and 3.63g respectively. |
| Station C5 | At Passage West, core sampling was undertaken on the mud shore adjacent to the R610 at Glenbrook. The only invertebrate recorded at this site was the ragworm *Hediste diversicolor* (n= 21). The accumulated weight of these worms was 17.9g. |
| Station C6 | This core sampling site was located on a muddy shore adjoining the R624 on Great Island to the south of the ferry crossing. Three ragworm and one lugworm were recorded at this site. One sea anemone (family Actinidae) was also recorded. Lugworm *Arenicola marina* casts were recorded on the surface of the mud at this site. |
| Station C7 | This site was located at Rushbrook on Great Island on a muddy shore. One invertebrate species was found here in the core samples - the catworm *Nephtys sp.* A total of 7 of these bristleworms were recorded and weighed 7.54g, averaging at just over a gram each. An outfall pipe was seen to be discharging untreated sewage onto the mid shore near this site. |
| Station C8 | This site was located near the south tip of Cobh at White point. The vicinity of the site was characterised by a muddy shore. Three invertebrate species were recorded at this location; the catworm (4), *Corophium volutator* (1) and the cockle *Cearstoderma edule* (1). |

| Station | Results |
|---|---|
| Station Q1 | This site was located at Crosshaven on a mixed sediment shore adjacent to the R612 road. JNCC quadrate sampling was undertaken at this site. Three species of organism representing 3 groups were recorded at this site. Flat periwinkles *Littorina obtusata,* green shore crabs *Carcinus maenas* and a single shrimp *Chaetogammarus marinus* were recorded |
| Station Q2 | A quadrate sample was carried out also at the foreshore to the northeast of Crosshaven. The shoreline was characterised by *Fucus serratus* on mixed substrata. A total of 11 invertebrate species were recorded in the quadrates. Calcified housing of both the keel worm *Pomatoceros lamarcki* and the barnacle *Elminius modestus* was abundant on hard substrata. The sand mason *Lanice conchilega* (Polychaeta) was also present with one specimen recorded in the quadrates. Two green shore crabs were noted. The most diverse group were the snails (Gastropoda) and 4 species were recorded. These were the edible periwinkle *Littorina littorea* (50), grey topshell *Gibbula cineraria* (5), flat periwinkle *Littorina mariae* (20 and the common limpet *Patella vulgata* (1). The total weight of the edible periwinkles was 229g. Two chitons *Lepidochitona cinereus,* two Snakelocks anemone *Anemonia viridis* and a common mussel *Mytilus edulis* were also recorded at this site. |
| Station Q3 | This site was located to the east of Ringaskiddy between Paddy's point and golden rock. This site was to the south of the proposed WWTP outfall pipe on a shore typified by bouders and stable cobbles and was near a muddy sand beach. Thirteen macrofauna species were found at this location and the most diverse group were the snails. The edible periwinkle was the dominant snail (n=29). Other snails recorded were the grey topshell (7), flat periwinkle *Littorina obtusata* (5), flat topshell *Gibbula umbilicalis* (3), common limpet (2) and the flat periwinkle *Littorina mariae* (1). Two barnacle species were found *Elminius modestus* and *Balanus crenatus*. The former was the more abundant of the two. Small numbers of the sand mason, *Gammarus deubeni*, snakelocks anemone and the edible mussel were recorded at this site. |
| Station Q4 | This site was located to the east of Ringaskiddy between Paddy's point and Golden rock. This site was to the north of the proposed WWTP outfall pipe. Some bedrock as well as boulders and cobbles occurred at his site. There was a sandy beach approximately 30 meters to the south of this site. Six invertebrate species were recorded in the quadrates. The most frequent organisms were the common limpet and the common mussel. Two green shore crabs were recorded. Edible periwinkles (3) and snakelocks anemone (1) were also recorded at this site. |
| Station Q5 | A quay at the eastern end of a sea wall at Ringaskiddy was the location of this site. It was opposite Whitepoint in Cobh across the west channel of the Lee Estuary. The shore had a significant slope and was composed of bedrock, boulders and stable cobbles with some fucoids. Eleven invertebrate species were identified from this site. The periwinkle *Littorina littorea* was numerous with 59 specimens recorded in the one $m^2$ quadrate. Five other species of snails were recorded at this site; common limpet (6), the flat periwinkles *Littorina mariae* (5) and *Littorina obtusata* (4), *Littorina rudis* (5), and the flat topshell (1). Four large common mussels were recorded and weighed 23.8g. A snakelocks anemone, a chiton, green shore crabs (3) and *Gammarus deubeni* (4) were also recorded at this site. |
| Station Q6 | This site was located at Monkstown immediately north of the pier adjacent to the R610 road. The shoreline type was mixed substrata with mussel beds and 9 invertebrate species were found here. Twenty nine common periwinkles were recorded. Over one hundred each of the barnacles *Elminius modestus* and *Semibalanus balanoides* were recorded making these the most common invertebrates at this site. Fifteen green shore crabs weighed 8.67g and 5 common mussels weighed 73.2g. Other organisms recorded were the common starfish *Asterina rubens* (1), Hediste diversicolor (1), common limpet (2) and the chiton *Lepidochitona asellus* (1). |
| Station Q7 | At Monkstown, another quadrate survey was carried out just south of the ferry pier on a mixed substrata shore dominated by the common mussel *Mytilus* |

| Station | Results |
|---|---|
| | *edulis*. The barnacles *Elminius modestus* and *Balanus crenatus* were numerous along with juvenile green shore crabs (38). The crabs had a total weight of 44.88g. The common periwinkle was abundant. A total of 104 of these snails were found and weighed 567g. The only other organism found at this site was the Beadlet anemone starfish *Actinia equina.* |
| Station Q8 | This site was located between Monkstown and Passage West adjacent to the R610 road to the north of the ferry. This was a fairly sheltered location and there was a mixture of rock and sediment at the site. The most common invertebrate was the sand mason *Lanice conchilega*, a polychaete worm. Three other invertebrate species were recorded; common mussel (21), common cockle (1) and green shore crab (1). |
| Station Q9 | Located near the bottom of a slipway in Passage West, this site was a sheltered rocky shore with dense growth of fucoids (mainly *Fucus serratus*). Eleven invertebrate species were recorded at this site with the barnacle *Elminius modestus* being the most common. The predatory green shore crab was numerous with a total of 28 recorded. Most of these were juvenile crabs with an average weight of less than 1g. Common mussels (19) were recorded and most were not yet fully grown. Eight small beadlet anenomes were noted. The most diverse group recorded at this site were the snails and three species of periwinkle were recorded; *Littorina mariae* (5*), L. obtusata* (3) and *L. littorea* (1). Five *Cirratulus cirratus* (polychaete worm) and in excess of 20 keel worms *Pomatoceros lamarcki*. The freshwater shrimp *Gammarus deubeni* and a common starfish were also recorded at this site. The occurrence of freshwater and marine organisms at the same site indicates the estuarine nature of the site. |
| Station Q10 | This site was located on Great Island just north of the river ferry adjacent to the R624 road. The shoreline was mixed substrata and no mounds or casts were noted at this site. Edible mussels were abundant at this site with 476 specimens weighing in excess of 5kg. Another bivalve, the common cockle (4) weighed an average of 20g each. Two sea anenomes were found at this site, the beadlet (10) and snakelocks (8). Other invertebrates recorded were green shore crabs, barnacles, and two species of periwinkle. |
| Station Q11 | This site was on a mixed substrata shore on Great Island south of the ferry crossing. A total of 52 common mussels recorded at this site. Two species of barnacles (*Elminius modestus* and *Balanus crebnatus*) were abundant. The sand hopper *Corophium volutator* was common with 20 specimens recorded. Beadlet anemone, edible periwinkle and green shore crab were also present. Four of each of *Cirratulus cirratus* (Polychaeta), flat periwinkle and common starfish *Asterina rubens* were recorded at this site. |
| Station Q12 | Near the town of Cobh at Whitepoint, a quadrate survey was carried out on a shore typified by boulders and cobbles with *Fucus serratus*. A total of 8 marine invertebrates were recorded at this site. The most diverse group were the Polychaete worms where the keelworm *Pomatocerous lamarckii*, the sand mason *Lanice conchilega* (3) and *Cirratus cirratus* (3) were recorded. Two snails were recorded in abundance but were generally small. These were *Littorina rudis* (681) and the edible periwinkle *Littorina littorea* (328). |
| Station Q13 | On a shingle and gravel moderately exposed shore, a survey was carried out on the East beach tot the east of Lynch's quay. No macroinvertebrates were found at this site. The gravel was loose and being shifted constantly by the by the action of the waves. |
| Station Q14 | This site was located in Cobh to the east of Red chimney stack on a shingle and gravel shore. A total of 9 macroinvertebrate species were found here. The shrimp *Gammarus deubeni* was numerous as was the barnacle *Elminius modestus.* Snails were abundant at this site with *Littorina rudis* (681*), L. littorea* (122) and grey topshell (4) recorded. The periwinkles were generally very small, averaging at less than 1g. Indeed, 691 *Littorina rudis* weighed only 118g. The common mussel was also numerous, 152 were recorded and weighed approximately 1.3kg. Other organisms found were the green shore |

| Station | Results |
|---|---|
| | crab (24), beadlet anemone (16) and the isopod *Lekanespharea rugicauda* (8). |
| Station Q15 | The shore here consisted of bedrock, boulders and stable cobbles and had a sparse cover of fucoids. An algal matt was also recorded at this site. Eight invertebrate species were recorded during the quadrate sampling here. The most diverse group were the snails where 4 species ranged from common (flat topshell) to abundant (common periwinkle and *L. rudis*). Over 1kg of mussels accounted for 220 individuals of small size. The green shore crab was frequent among the coble and boulders and 28 recorded weighed 18.9g. The keelworm *Pomatoceros lamarckii* occurred on the seaweed and on hard substrata. Three beadlet anenomes *Actinia equina* were recorded at this site. |
| Stations G1-G4 | No organisms were recorded in the grabs taken at Sites G1-G3. One *Hediste diversicolor* was recorded at Site G4. |

## *Fish and fisheries*

The majority of fish found in estuaries feed primarily on the benthos (organisms living on or at the bottom of a body of water). Estuarine opportunist species typically enter estuaries from the sea for a period each year, but do not stay there permanently. The majority drift into estuaries as larvae from eggs spawned in coastal waters and as young fish they take advantage of the rich benthic food sources of the harbour. The harbour is therefore deemed important as a nursery ground for juvenile fish before they return to the sea as recruits to their adult population. Adult mullet were seen grazing on algal films from the soft substrata at the Owenboy estuary and also on the River Lee western passage near Cobh during the current survey.



Cork Harbour is an important habitat for fish and is an important location for shore and boat angling. However few fish surveys have been undertaken in the area. A marine fisheries survey of Cork Harbour was undertaken by the Central Fisheries Board during 2001 (King, 2002). A total of 33 sites were examined over a five-day period. A wide range of species was recorded, consistent with the large diversity of habitat niches available in this extensive expanse of water. The fish species encountered included more truly estuarine forms as well as those from surf beaches and areas of steeply sloping bed close to shore. However, no specimens of the Annex II listed juvenile twaite shad *Allosa fallax* or lamprey species were recorded during the assessment. The most commonly encountered groups were juvenile sprat/herring, flounder, gobies, mullet, sand smelt and the 15-spined stickleback. Many species were found in single locations only. The most upstream location was a slipway formerly used for salmon draft netting opposite the ESB power station at Marino. This site yielded four species in the CFB survey, including young scad. This was one of four locations in the harbour where scad were taken. Scad are an important commercial fish species. The highest species diversity was found in the lower Harbour area. A total of 13 species was taken at the north most point of Ringaskiddy, directly south of Haulbowline. As well as the commonly-recorded species, this site yielded two species of pipefish, two wrasse species, blenny, bullhead and butterfish. Species diversity was also higher at the stations at Rushbrook, Cuskinny Beach and the slipway at Crosshaven.

Cork Harbour is an important location for sea angling in Ireland and both shore and inshore angling takes place. Cork Harbour is also an important launching point for deep sea angling. According to the Central Fisheries Board, shore angling is the most important form of sea angling in Ireland. This type of angling is undertaken from land and is divided into three forms; beach, rock and pier fishing. Inshore angling is carried out from small 4-6m boats, usually fitted with outboard engines. It is normally confined to sheltered bays and inlets and is popular in Cork Harbour. A total of eight deep sea angling charter boats registered in the Irish Charter Boat Directory are based within Cork Harbour, and numerous other private boats are also utilised for sea angling in the area. The species most frequently taken by shore and inshore fishing in Cork Harbour are turbot *Psetta maxima*, ray (especially blonde ray *Raja brachyura*), conger *Conger conger*, plaice *Pleuronectes platessa*, dab *Limanda limanda*, codling *Gadus morthua*, and dogfish *Scyliorhinus* spp. (Dunlop & Green, 1992).

Cork Harbour is an important location for angling for marine fish qualifying for Irish Specimen Fish Committee (ISFC) awards. The ISFC was established in 1955 in order to investigate, authenticate and record fish of exceptional size captured on rod and line in Irish waters. The committee consists of both government and angling representatives. A fish qualifies as a specimen (or a record) if it exceeds a specific minimum qualifying weight and is captured according to rules determined by the ISFC. A list of authenticated specimens (and records) is published annually by the ISFC. During the period 1955-1996, a total of 8,863 marine specimens were authenticated by the ISFC (Quigley & O'Connor, 1997). Of these, 46.4% were from the south west region of Ireland. Cork Harbour accounted for 13.11 % of all the specimens recorded in the southwest region, including five Irish records; electric ray *Torpedo nobiliana* (32.9 kg, Crosshaven, August 1933); blonde ray (16.57 kg, Cork Harbour, September 1964); turbot (15.43 kg, Cork Harbour, June 1982); homelyn ray *Raja montagui* (3.76 kg, Cork Harbour, September 1983); and grey mullet *Crenimugil labrosus* (4.13 kg, Cork Harbour, September 1993). Of the 539 specimen fish captured in Cork Harbour during the period 1955-1996, the most important species in terms of specimen numbers was blonde ray (108). Pollack *Pollachius pollachius*, turbot, ling *Molva molva*, and bass *Dicentrarchus labrax* were also important species with 72, 40, 39 and 38 specimens respectively captured during the period 1955-1996. Boat fishing in Cork Harbour usually takes place during the period April to October, while shore angling is from April to January. The main shore angling marks in Cork Harbour are described in Appendix 6. The nearest fishing important fishing location to the proposed development is at Monkstown where cod, conger, dab, dogfish, flounder, thornback ray, rockling and whiting can be caught (SWRFB website)

While it has not yet been quantified, the effects of trawls on the benthos may be severe, causing disturbance and hence decreasing the amount of benthic biomass available as food to a variety of organisms (Little, 2000). This undoubtedly happens in Cork Harbour, where local anglers called for an end to this exploitation. In a web based the Passage west and Monkstown news, the news article 'Fished Out' by Leo McMahon (13th September, 2007, Passage west Monkstown news) described how sea anglers at Glenbrook and Monkstown were being fished out every time a commercial fishing boat and trawled the Lee Channel. A letter from South Western Regional Fisheries Board was welcomed which agreed it was very desirable there should be no trawling for cod or other fish in that section of the inner harbour in order to enhance sea angling resources and recreational angling. Commercial activities may thus have direct effects on the biology of substrata.



Cork harbour is also used by a number of anadromous and catadromous fish species migrating to and from rivers which flow into the harbour. Anadromous fish migrate into freshwater to spawn and their progeny pass down into the sea to grow to maturity. Catadromous fish have an opposite life cycle and migrate to the sea to spawn and their progeny move into freshwater to grow to maturity. Species important in this respect are Atlantic salmon, River lamprey and Sea lamprey (anadromous) and the European eel (catadromous). The main river of fisheries importance flowing into Cork Harbour is the River Lee which is known to contain all of these species (O'Halloran *et al,* 1998). These species are discussed as follows:-

1. Atlantic Salmon: The Atlantic salmon is listed under Annexes II and V of the EU Habitats Directive and Appendix III of the Bern Convention. It an economically important species and salmon recreational fisheries occur on the lower River Lee. Salmon migrate into the River Lee and other rivers flowing into Cork harbour during all months of the year. The largest runs probably occur during the period May to July as in other Irish rivers. Downstream migrations of young salmon (smolt) occur during April and May when water temperatures are in the 12-18 degree C range (O'Halloran *et al,* 1998). The reported salmon catch on the River Lee and Owenboy Rivers in 2005 was 419 and 1, respectively (Wild salmon and sea trout statistics report, CFB, 2005).

2. Lampreys: River lamprey and Sea lamprey are listed in Appendix II, while river lamprey is listed in both Appendices II and IV, of the Habitats Directive (92:43:EEC). All three species are listed in Appendix III of the Bern Convention. Sea Lamprey (*Petromyzon marinus*) and River Lamprey (*Lampetra fluvialitis*) migrate upstream to

the River Lee during the period March to May. Sea Lampreys is larger and more common than the latter. Spawning takes place in freshwater habitats when water temperatures exceed 15 degrees C. After hatching, the larvae (ammocoetes) drift downstream and distribute themselves in suitable silt beds and remain there for 4-5 years. The upper estuary may be used to some degree in this respect. Young lampreys on the River Lee are thought to migrate downstream during April and May as is suspected for other rivers.

3. European Eel: Juvenile European Eel (*Anguilla anguilla*) or elvers migrate upstream into freshwater habitats such as the River Lee during April and May. The upstream migration occurs when water temperatures exceeding 12 degrees C are associated with flood spring tides and normal river discharges. Resident eels also occur in estuarine / marine habitats and are likely to occur in the study area.

Bait collection is an important activity prior to shore and inshore angling expeditions. Anglers dig for lugworm *Arenicoli* spp. at low tide or collect crabs *Carcinus maenas* from under rocks. The main bait collecting areas and fishing hotspots in Cork Harbour are presented in Appendix 7.

**Table 12** Fish species expected in areas affected by the proposed development.

| Location | Fish species expected to be present |
|---|---|
| Crosshaven. | Flounder, mullet, electric ray, eel, common goby, plaice, pollack, mackerel, garfish, wrasse, bull huss, bass, salmon, sea trout, sea lamprey, river lamprey. |
| River Lee West Channel (Ringaskiddy, Monkstown, Cobh) | Pipefish, wrasse species, blenny, bullhead and butterfish, sprat/herring, flounder, common goby, sand goby, mullet, sand smelt, 3-spined stickleback, scad, pipefish, bull huss, coalfish, bass, mackerel, turbot, electric ray blonde ray, homelyn ray, thornback ray, grey mullet, conger, plaice, dab, rockling, whiting codling, dogfish, eel, sea lamprey, river lamprey, salmon, sea trout. |
| Owenboy River Estuary | Mullet, flounder, salmon, sea trout, eel, 3 spined stickleback, sea lamprey, river lamprey |

Adapted from Dunlop and Green (1992), SWRFB website, sea-angling-ireland.org



## Shellfish

Cork Harbour is a shellfish production area (Code CK-CH). This area lies north of a point from Roberts Head (coordinates -8.30375 51.74379) to Roches Point (coordinates -8.25113 51.79285) up to and including the mean high water mark. In Ireland the main bivalve species are mussels, native and pacific oysters, razorfish, scallops, clams and cockles. All the shellfish production areas have been described and given sample codes in the molluscan shellfish production area maps. Shellfish Areas are classified by the microbiological quality of the water. Areas are assigned a classification of A, B or C by the Department of Communications, Marine & Natural Resources based on microbiological monitoring. In order to ensure the quality of shellfish for human consumption controls are placed on the waters used for shellfish cultivation and harvesting. These controls are driven by the EU Directive 'laying down the health conditions for the production and the placing on the market of live bivalve molluscs' (91/492/EEc) and by 1996 regulations (S.i. no. 147 of 1996) implementing the directive. The Department of communications, marine and natural resources (DCMNR) is the competent authority in Ireland for classifying shellfish production areas.

The Status of Shellfish Production Areas: The Department of Communications, Marine and Natural Resources (DCMNR) is contracted by the Food Safety Authority of Ireland (FSAI) to implement the Marine Biotoxin Monitoring Programme in Ireland. The Marine Institute is the National biotoxin reference laboratory and carries out marine biotoxin testing on behalf of the DCMNR. The Marine Institute carries out a range of toxin analysis at its own laboratories and also contracts regionally located laboratories to carry out analysis.

The status of a production area depends on the result of the last sample for each species in that area. Before harvesting from any production area, two samples, taken a minimum of 48 hours apart, must have biotoxins below the regulatory limit. With the first of these two clear samples the area is assigned a "Closed Pending" status and with the second the area is assigned an "Open status". If a result is positive for biotoxins then the area is assigned a Closed status and the area will need two clear results a minimum of 48 hours apart to return to an Open status again. The frequency of testing is laid down for each species and this may have seasonal variation. If the frequency is not adhered to then the area loses its Open status.

The most recent published information on the Cork Harbour shellfishery is from 2005 when three shellfish bed production areas were examined (Table 13). Shellfish species sampled were the king scallop *Pecten maximus* at Cobh (Code CK-CH-CH), flat/native Oyster *Ostrea edulis,* pacific oyster *Crassostrea gigas* and edible mussel *Mytilus edulis* on the north channel (Code CK-CH-NC), and pacific oyster at Rostellan (Code CK-CH-RN). (FSAI website). The current classification (B) means that the oyster may be taken alive from those regions in the bed in column III, and sold for consumption following purification in an approved plant for two days.

**Table 13** Annex ;Designated Bivalve Mollusc Production Areas In Ireland,_October 2005, from the Live Bivalve Molluscs (Production Areas), Second Designation 2005.

| I | II | III | IV | V | VI |
|---|---|---|---|---|---|
| **Production Area** | **Boundaries** | **Bed Name** | **Species** | **Previous Classification** | **Current Classification** |
| Cork Harbour | Between 8°16.4' W and 8° 15.6' W. | North Channel West | Oysters | B | B |
| Cork Harbour | Between 8°14.6'W and 8°13.2'W. | North Channel East | Oysters | B | B |
| Cork Harbour | Ahada Pier to Gold Point | Rostellan | Oysters | B | B |



Marine Biotoxins and Shellfish Species: A very intense bloom was recorded in 2005 around parts of the western coast of Ireland and resulted in discolouration of seawater and foaming in coastal embayments. This coincided with a warm spell of weather. Major mortalities of benthic and pelagic marine organisms were observed and a complete decimation of marine faunal communities was reported and observed in several locations. Deaths of echinoderms, polychaetes and bivalve molluscs were observed in County Donegal and Mayo, while farmed shellfish and hatchery raised juvenile bivalve spat suffered significant mortalities along the Galway and Mayo coasts (Silke *et al,* 2005).

Only the shellfish classed as bivalve molluscs feed by filtering the water that washes over the shellfish bed. The microscopic planktonic algae (phytoplankton) in the marine environment are critical food for filter-feeding bivalve shellfish (e.g. mussels, oysters, scallops and clams). The bivalves feed directly on the phytoplankton, using their gills as sieves to strain them from the water. In some situations, however, phytoplankton can have a negative effect causing serious economic losses to aquaculture, fisheries and tourism operations and having major human health impacts. Because of their feeding mechanism, these shellfish can accumulate chemical and/or bacteriological pollutants and naturally occurring toxins from the surrounding waters even at a considerable distance from pollution sources. A single mussel, for example, may filter up to 300 times its weight in one hour. This represents a substantial amount of water. Thus, the health of molluscan bivalve shellfish and the waters in which they grow are closely related. The vast majority of phytoplankton are beneficial and are the ultimate determinants of the size of fish stocks and can proliferate into enormous concentrations of up to millions of cells per litre when sufficient light and nutrients are available (Raine, 2003).

There are four main toxic algal groups that occur in Irish waters. These are the phytoplankton species that produce the toxins that cause Diarrhetic Shellfish Poisoning (DSP), Paralytic Shellfish Poisoning (PSP), Amnesic Shellfish Poisoning (ASP), and Azaspiracid Poisoning (AZP). In previous years, closures in shellfish growing areas around the Irish coast mainly resulted from DSP events, with localised closures in Cork Harbour due to PSP events.

Paralytic Shellfish Poisoning: Paralytic Shellfish Poisoning (PSP) toxins - saxitoxins - are produced by *Alexandrium* spp. Due to the potential severity of the toxin, the presence of this species in water samples triggers increased testing of shellfish samples for PSP toxins. To date the main production area that has experienced closures due to PSP toxins is North Channel in Cork Harbour. Paralytic Shellfish Poisoning toxicity occurred in mussels in early to mid June 2005 in the north channel, Cork Harbour (Clarke *et al.* 2006), which corresponded a rise in *Alexandrium spp.* levels to 1080 cells/litre.

It is now well established that the *Alexandrium* community is mixed in the Cork harbour area, with the presence of the non-toxic *A. tamarense* and the PSP toxin-producing *A. minutum*. The latter species has been identified as the organism responsible for the PSP events recorded in the region, as the toxin profiles obtained from cultures derived from locally *A. minutum* isolates coincided with those obtained from contaminated shellfish samples taken in 1996. (ISSSW, 2005). In mid-September 2003 shellfish sites in the Cork Harbour area were closed as a result of a small bloom of *Alexandrium spp* following positive bioassays and confirmatory chemical tests (Cusack *et al*, 2004).

In the *Status of Irish Aquaculture* report (MERC Consultants, 2006), all native oyster (*O. edulis)* growing areas were tested twice during the year for the presence of the List II parasites *Bonamia ostrea* and *Marteilia refringens*. A total of 2,099 oysters were tested in the course of this screening programme. In 2005, the entire coastline of Ireland was free of *M. refringens.* Areas infected by *Bonamia ostrea* included Cork Harbour.



Trace metal contamination: In a report for trace metal and chlorinated hydrocarbon concentrations in shellfish from Irish waters in 2001 (Glynn *et al,* 2001), it was found that water and shellfish quality were similar to previous years and conformed to the requirements of the Directive. Copper levels were found to be 11.1mg $kg^{-1}$ wet weight for pacific oyster, well below the Spanish standard of 60mg $kg_{-1}$ set for oysters. Levels for other trace metal and chlorinated hydrocarbon levels continued to be very low. The results of bioassay testing for algal toxins in mussels and in oysters (*Ostrea edulis* and *Crassostrea gigas*) in the current and previous reporting periods show that there was generally a much higher level of positive results for the mussel than there was for the two oyster species; this difference is likely to be accounted for both by the greater volumes of water filtered by mussels per unit body weight as well fact that they are cultured in the upper part of the water column where exposure to phytoplankton is likely to be greater than it is for the bottom growing oysters. The data also shows that the proportion of samples of all species giving positive results was much greater in the years 1999 to 2001 than it was in the earlier and later years of the period covered. In the case of the oysters, all samples gave negative results in 2002 and 2003. In the EIA modelling study carried out by O' Kane and Barry (2007), the spatially varying maps of concentration showed that the proposed scheme may reduce considerably the forcing on primary production in the inner harbour (Lough Mahon) and in the North Channel behind Great Island. There would be also a relative improvement throughout the Outer Harbour.

## Water quality

The Environmental Protection Agency undertakes an annual survey of the water quality of estuaries and near shore coastal waters. In general, the water quality status of these waters is considered to be high. Some estuaries, mainly those in the south and east, however, are over-enriched with nutrients and have been classed as eutrophic. In the latest Water Quality In Ireland 2005 report, which covers the period 2001-2005, a total of 10 estuaries or less than 15% of those waters surveyed were classified as eutrophic (EPA website).

Rapid industrialisation in the Cork Harbour area along with increased population growth has led to increased vulnerability to pollution in the harbour, water quality is variable, with the estuary of the River Lee and parts of the Inner Harbour being somewhat eutrophic. A study by the Environmental Protection Agency from 1999 to 2003 sampled water in the Lee river, Lee estuary, Lough Mahon, Owenacurra river, Owenacurra estuary, the North Channel of Great Island and in Cork Harbour (Toner *et al*, 2005). Nutrient enrichment was measured as Dissolved Inorganic Nitrogen (DIN) and orthophosphate (MPR) while undesirable disturbance was measured as percentage saturation of Dissolved Oxygen (DO). The results of this survey are provided in Table 14.

The Lee Estuary remained in an impacted condition due mainly to the severe levels of deoxygenation consistently observed in the reach between the Port of Cork and Blackrock Castle; the criteria for nitrogen was also breached in this water body in both assessments, though only in the winter period in 1999–2003. Phosphate levels also appear to have fallen since the last assessment, when both winter and summer levels were in breach compared to neither being excessive in the current period. However, since the chlorophyll criterion was not breached in either assessment, the Lee Estuary has not been classified as Eutrophic in either period, though this may at least partly result from physical limitations on algal growth such as low transparency.

Lough Mahon exhibited a partial degree of recovery in respect of dissolved oxygen levels in both periods. It is of note, however, that, while all four of the individual nutrient criteria were breached in Lough Mahon in the 1995–1999 assessment, only one of these, the winter nitrogen criterion, was in breach in the current period. This may to some extent reflect the developments being undertaken under the Cork Main Drainage Project, which was largely completed in 2004 and has achieved the cessation of the discharges of untreated sewage into the Lee Estuary and Lough Mahon. Biological treatment processes are currently in operation at the recently commissioned WWTP at Carrigrennan, Little Island. It is too early to predict whether the addition of nitrogen removal will be required to reverse the eutrophic status of Lough Mahon, recently designated, along with the Lee Estuary, as a Sensitive Area. The most recent information available rates the estuarine and coastal water quality for cork harbour in the period 2001-2005 as being intermediate.



The municipal outfalls to tidal waters and corresponding population equivalents (domestic and industrial) served is shown in Table 15. Under the OSPAR convention, eutrophication is defined as: "*The enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients.*"(OSPAR 2000). Eutrophication may occur in the coastal zone and effects include increased production of phytoplankton and macroalgae, deoxygenation of the water column, and changes in composition of species (including indirect impacts on ecological health as a result of enhanced primary production) (OSPAR 2000b). Eutrophication may have the potential to trigger algal blooms and of particular concern is the potential to increase harmful algal production.

The moderate status of water quality in Cork Harbour (EPA Estuarine and Coastal Water Quality Map) is reflected by growths of *Enteromorpha* and *Ulva*. These arise from high concentrations of nutrients such as nitrates and phosphates (left in solution even after primary and secondary sewage treatment). High nutrient levels have been linked to the occurrence of algal blooms in which dinoflagellates reach very high densities, releasing toxins and contaminating shellfish (Raffaelli *et al*, 1998). Parts of the shoreline have faecal coliform counts in excess of 1500/100ml near outfalls at Ringaskiddy, Cobh, and Passage West and also at the existing IDA outfall in the outer harbour.

Industrial effluents and urban run-off contain an enormous variety of substances in addition to the faecal derived organic matter and nutrients of sewage. Two other categories that are important for estuaries are the halogenated hydrocarbons (such as the pesticide DDT and polychlorinated biphenyls, PCB's) and heavy metals (such as zinc, cadmium, lead and mercury). These substances are not readily broken down in the natural environment and

many tend to be taken up by organisms but are not excreted; the phenomenon of bioaccumulation. Concentrations may build up to higher concentrations at higher levels in the food chain (Clarke, 1997). One reason for the apparent tolerance of fauna to heavy metals is their ability to sequester metals in granular form. Mussels, for example store lead in granules in its digestive gland.

Another compound, tributly tin (TBT) used in anti-fouling paints has extensive sublethal effects. Very small quantities of this compound cause changes to reproductive systems of molluscs and can reduce populations of shellfish. In the oyster *C. gigas* TBT also causes reduced growth of tissues, but excessive growth of the shell, so the oysters never grow large enough for sale. In a monitoring of tributyl tin contamination undertaken by Minchin (2003), there were indications of shell thickening in oysters in the North Channel. The lowest value, 0.2, was found in the East Passage. Gel was found in the lamellae of some shells.

Currently, there are two sewerage schemes in Ringaskiddy; sewers constructed by the IDA that serve industry and the others serving the village. In the second half of the 1970s, the IDA purchased large land banks in the harbour area, notably at Little Island and Ringaskiddy. It invested in the required drainage infrastructure, including a major marine outfall for discharge of effluent in Ringaskiddy. The sewer which serves the village is a combined sewer, and discharges directly to Cork Harbour. There is no treatment at present but there is a proposal to connect Ringaskiddy to the proposed Cork Harbour Sewerage Scheme. Although most existing industries have their own on-site treatment prior to discharging to the IDA outfall sewer, there is no secondary treatment plant and the macerated effluent is discharged to the harbour. (Cork County Council, 2006). The EIA conducted by O' Kane and Barry (2007) modelled the existing faecal coliform concentrations in the untreated discharge from the study areas. Currently (2010) the untreated discharge from the Cork Lower Harbour area are contributing a concentration of 1500fc/ml to parts of the Passage West, Cobh, and Ringaskiddy shores. These areas of high concentration extend during neap tides (O' Kane and Barry, 2007). Currently, there are active raw sewage outfalls at Carrigaline/Crosshaven, Passage West, Glenbrook, Monkstown and Ringaskiddy village. At Cobh, there are operating outfalls at King's Quay, west beach, White Point, Pilot's Pier and Corbett outfall.

**Table 14** Municipal outfalls to tidal waters and corresponding population equivalents, smaller outfalls (< 2000 p.e.) are not included. Table adapted from Boelens *et al.* 1999, data modified from O'Leary *et al.* 1997.

| Location | Carrigaline | Monkstown Creek | Passsage West | Cobh |
|---|---|---|---|---|
| Population Equivalent | 2000-10,000 | 15,000-150,000 | 2000-10,000 | 2000-10,000 |

**Table 15** Assessment of the trophic status of the main water bodies of Cork Harbour 1999 – 2003. C: Compliant, B: Breach; U: Unpolluted, I: Intermediate, E: Eutrophic (adapted from Toner *et al*, 2005).

| Water Body | Salinity | | | | DIN (mg/l $N^2$) | | | | MRP (µg/L P) | | | | Chl a (µg/L)(Summer) | | | | DO (%) (Summer) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | n | Summer | n | Winter | | Summer | | Winter | | Summer | | Median | | 90%ile | | 5%ile | | 95%ile | | |
| Lee River | 0.1 | 44 | 0.1 | 79 | 2.4 | C | 1.8 | C | 30 | C | 18 | C | 6.7 | C | 10.4 | C | 84 | C | 114 | C | **U** |
| Lee Estuary | 0 | 7 | 8.2 | 165 | 3.1 | B | 1.9 | C | 15 | C | 45 | C | 4.6 | C | 15.4 | C | 31 | B | 109 | C | **I** |
| Lough Mahon | 23.6 | 9 | 30.7 | 135 | 1.4 | B | 0.4 | C | 14 | C | 28 | C | 5.6 | C | 23.8 | B | 62 | B | 114 | C | **E** |
| Owenacurra River | 0.1 | 24 | 0 | 20 | 6.6 | B | 6.2 | B | 32 | C | 59 | B | 6.7 | C | 10.4 | C | 84 | C | 114 | C | **I** |
| Owenacurra Estuary | 11.6 | 2 | 17.6 | 51 | 3.2 | B | 1.3 | C | 14 | C | 18 | C | 8.4 | C | 35.9 | B | 80 | C | 134 | B | **E** |
| North Channel Great Island | | 0 | 31.6 | 45 | | | 0.2 | C | | | 11 | C | 7.3 | C | 29.3 | B | 89 | C | 123 | B | **I** |
| Cork Harbour | 21.6 | 2 | 34.1 | 71 | 2.5 | B | 0 | C | 7 | C | 5 | C | 4.5 | C | 12.9 | C | 89 | C | 112 | C | **I** |

## 3.2.4 CHARACTERISTICS OF THE PROPOSAL

### *3.2.4.1 Introduction*

The proposed development includes for the construction of a secondary wastewater treatment plant, which will form an integral part of the Cork Harbour Main Drainage Scheme. The objective of the scheme is to upgrade the existing drainage network to modern standards and to expand the network in order to cater for the future needs of the area.

Currently, the wastewater from the population centres within the Cork Lower Harbour Area (namely Carrigaline, Ringaskiddy/ Shanbally, Cobh, Monkstown/Passage West and Crosshaven) is not treated and is discharged directly to the Lower Harbour. The proposed site is a greenfield site located approximately 11km south of Cork City and 2.24km west south west of Ringaskiddy in the Shanbally area as shown in Figure 2.

The proposed site consists of portions of two large agricultural fields located on sloping ground and currently used for pasture. The land has been zoned for Utilities and Infrastructure (adopted amendment to the Carrigaline Electoral Area *Local Area Plan 2005).* The site has an area of approximately 7.36 hectares and is located between two overhead high voltage power lines to the north and south of the site.

With the exception of a small Bord Gais substation, which adjoins the south-west corner of the site, the site is bordered on all sides by adjoining agricultural fields. The boundaries of the two fields consist primarily of managed, immature to semi-mature hedgerow. A large ESB substation is situated circa 160 metres west of the site and a sports field is located circa 80 metres to the northeast of the site.



According to the adopted amendment to the Carrigaline Electoral Area *Local Area Plan 2005*, the site has been zoned for Utilities and Infrastructure. It is also noted that there are proposals to construct a branch of the National Primary Route N28 to by-pass the villages of Shanbally and Ringaskiddy on lands immediately north of the site. This new route for the upgraded will provide a buffer between the site and industrial lands to the north.

There is an area zoned for residential development approximately 134m east of the proposed WWTP site boundary for which planning applications have been granted. There are no existing site services.

### *3.2.4.2 Proposal*

The proposed development consists principally of the construction of a large sized urban wastewater treatment plant to serve the population centres of Cork Lower Harbour and its' environs. The proposed wastewater treatment plant is an essential element of the Cork Harbour Main Drainage Scheme. Associated works, which will be carried out as part of the proposed development, include:

- The widening of sections of the minor road to the west of the site
- The upgrading of the site access road
- Marine crossing
- New wastewater pumping stations
- The laying of rising mains, surface water sewers and gravity wastewater sewers to direct the wastewater to the new treatment works
- New wastewater treatment works-

The treated wastewater will be discharged to Cork Lower Harbour through the existing IDA outfall.

The overall area of the two fields on which this proposed wastewater treatment plant will be constructed is approximately 17.5 hectares. However, the fields are traversed by overhead high voltage electrical cables. By providing sufficient clearance from these power lines a

suitable area of approx. 7.36 ha is available between the power lines. This area is considered adequate for the construction of the proposed wastewater treatment plant, including facilities for organic-material removal, nutrient removal (if required), basic sludge treatment and appropriate landscaping measures.

The discharge standards, which shall apply to the proposed Wastewater Treatment Plant, are:

| | |
|---|---|
| Biochemical Oxygen Demand | - 25 mg/litre |
| Total Suspended Solids | - 35 mg/litre |
| COD - | - 125 mg/l |

The principal elements of a treatment plant of the type and scale proposed include preliminary, primary and secondary treatment of the wastewater stream with further provision for treatment of surplus sludge arising from the primary and biological stages of the treatment process.

The layout of the proposed development is shown in Figure 1.

## 3.2.5 ENVIRONMENTAL IMPACTS

Ecological impacts can occur by several different means. As construction works will take place near and within the boundary of the Cork Harbour SPA / Owenboy River NHA / Monkstown Creek NHA, there is potential for direct negative impacts on these internationally and nationally important sites to occur during the construction and operation of the proposed scheme. Other designated areas would not be affected due to their distance from the proposed scheme. Construction impacts could occur as a result of impacts on bird feeding areas due to foreshore construction works or the release of suspended solids contaminated runoff / deleterious substances into nearby areas. Indirect impacts as a result of noise, disturbance etc. could also occur during the construction phase. Contamination incidents (i.e. accidental) from the operation of the WWTP could also occur. However, mitigation measures have been provided to ensure that significant impacts on the designated areas and Cork Harbour in general do not occur during either the construction or operation of the proposed scheme. The provision of a modern WWTP in this region is expected to result in moderate significant benefits for water quality in Cork Harbour compared with the "do nothing scenario". A summary of impacts, mitigation measures and predicted impacts is provided in Table 17.

The results of the baseline survey were evaluated to determine the significance of the features located in the study area on an importance scale ranging from:

- International
- National
- County
- High local
- Local importance
- Local value
- Insignificant

Potential impacts during the construction and operation phase of the proposed scheme are discussed below.



### *3.2.5.1 Types of Impacts*

Direct ecological impacts are those that result in physical loss or degradation of a habitat. Indirect or secondary impacts are those, which contribute to the long-term decline in the quality of the habitat. The means of assessing impact significance is based on the Institute of Ecological and Environmental Management draft guidelines on Ecological Assessment (IEEM, 2002). A full explanation of the methods and terminology used is presented in Appendix 1.

#### Direct Impacts

The proposed development occurs on artificial man made, semi-natural and natural habitats as described above. The footprint of the development will cause a direct impact though the loss of habitat. In the case of the proposed WWTP this will be a permanent impact but will only affect habitats of low conservation importance. In the case of the foreshore and off-road pipeline this would be a temporary impact provided suitable reinstatement measures are employed.

#### Secondary Impacts

Secondary or indirect impacts are defined as effects that are "*caused by and result from the activity although they are later in time or further removed in distance, but still reasonably foreseeable*". The proposed development could cause secondary ecological impacts. If these impacts significantly altered the type and/or quality of the habitat, then such changes would be effectively additional habitat losses. In the case of the proposed development, potential secondary/indirect impacts would include habitat fragmentation, disturbance and pollution. In

the present assessment these possible impacts have been taken into consideration. Secondary or indirect impact could include noisy construction phase activities disturbing wildlife utilising habitats close to the works areas. In particular, avifauna of conservation interest feeding along the shoreline could be displaced. Increased human activity associated with construction works could also disturb wildlife in adjacent habitats. Soil exposed during trenching works could be washed into nearby aquatic areas, leading to elevated suspended sediment levels. Spills of construction materials, fuels and lubricants could also be washed from the works area to nearby marine areas. An increase in suspended sediments and other pollutants could impact aquatic communities close to the proposed works area. Uncontrolled dumping or stockpiling of materials could disturb habitats adjacent to the proposed works area. Pollution emanating from an accidental release of untreated/partially treatment effluent during the operational phase could also cause an indirect direct impact on the receiving habitats. However the improvement in water quality due to the operation of the proposed WWTP would be an overall positive and permanent indirect impact.

## Cumulative impacts

Cumulative impacts are incremental changes in the environment that result from numerous manmade small-scale alterations. Cumulative impacts can result from individually minor but collectively significant effects taking place over a period of time. Potential cumulative impacts resulting from the current development are related to disturbance, habitat loss and pollution. Such potential effects have been considered in the current assessment. The main cumulative impact of the proposed development is however expected to be positive. Combined with the previous phases of the Cork Main Drainage Scheme, and other pollution control measures being implemented in the Cork Harbour region, the current development would have a cumulative effect of improving water quality within Cork Harbour and its associated internationally and nationally important designated areas.



An interesting possible indirect cumulative impact of the proposal would be that by controlling the man-made organic input (i.e. untreated and poorly treated sewage) into the harbour, the nutrients available for macrofaunal production would decline, possibly reducing the biomass of organisms present. This could result in a depressed food supply for wintering birds compared with the existing situation. However, a similar response to cleaner conditions would be an increase in the numbers of macrofaunal species present and this would be an important positive impact for biodiversity. A reason for this increase in diversity is that algal mats would be less frequent and associated anoxic conditions would be deeper than is currently the case. This would influence the macroinvertebrate population by allowing animals to penetrate deeper into sediments – increasing the available habitats three dimensionally. This would also allow for greater biomass and diversity and would be expected to offset any loss of biomass as a result of reduced nutrient inputs. It is also expected that the littoral areas of Cork Harbour would retain a high level of productivity, as is typical in estuarine waters.

### *3.2.5.1 Construction phase impacts*

## Designated areas

Potential impacts on Cork Harbour SPA / Owenboy River NHA / Monkstown Creek NHA designated areas would occur as a result of construction activities when the pipes are laid near the designated shoreline areas. Overall, the potential impacts on designated areas during the construction phase are assessed as being Moderate Negative. There will be moderate positive impacts on these areas due to cleaner water during the operational phase.

A foreshore pipeline is proposed to run along a section of the Owenboy River (within the Owenboy River NHA and Cork Harbour SPA). Installation works associated with this pipe could result in significant habitat loss along the pipeline route and increase the risk for suspended solids laden runoff. It is predicted that there will be a short term increase in the turbidity of the water column during the construction and laying of pipes, as increased suspended solids enter the water column. However, this pipeline would be placed along the upper shore, thereby reducing the level of suspended solids (due to decreased flushing from

high tides). An increase in turbidity could result in increased siltation, smothering of organisms and a reduction of light for phytoplankton over the construction period. High levels of suspended solids settling on the estuary bed could potentially alter habitats resulting in a potential loss of feeding and spawning grounds. Mobile species may move away from unfavourable conditions, however sessile, benthic fauna may be smothered and lost. However, estuarine habitats have very high natural levels of suspended solids so this impact is likely to be negligible with suitable mitigation. Moreover, the benthic faunal community in affected areas such as the Owenboy River is considered to be a very tolerant one.

The effects of elevated suspended sediment in marine environments depend primarily on two factors: the size range of the sediment particles, and the food content of the suspended sediment. If the changes to sediment involve particles above the maximum size used by most suspension feeders (about 2mm diameter) then effects will probably be minimal. If the food content in sediment increases, animals may be able to get more nutrition for time spent feeding. If the food content decreases, animals will have to work harder for their food. The more energy they have to spend to gain the same amount/quality of food, the less energy they have for growth and reproduction. As the energy used on feeding increases, the animal loses condition and, finally, dies. A recent study (NIWA Science, 2007) has found adverse effects of increased suspended sediment concentrations on filter feeders. For example, consistently negative effects were found on the growth and condition of mussels and the growth of cockles. Feeding rates of all species initially increased, but as suspended sediment continued to increase, feeding rates decreased. Some of the research also suggested that the response to increases will depend on the reproductive state of the animal and whether they live in areas with frequent high suspended-sediment concentrations.

Other types of animals may also be affected by increased suspended-sediment concentrations. An increased flux of sediment settling on the bed is likely to affect animals that feed on deposited sediment. Lower water clarity may affect the quantity, type and depth to which bottom-living microscopic algae and seaweeds can grow, thus affecting feeding and distributions of grazers such as limpets. Lower water clarity may also affect feeding abilities of visual fish feeders such as mullet. However, it must be noted that no macroinvertebrate grazers were recorded in the Owenboy Estuary in the current survey and the community identified would be very tolerant to increased suspended solids levels. Mullet were recorded in the Owenboy River at Carrigaline and propably occur throughout the estuary, but their ability to relocate with ease would decrease the chances of a decline in their status. Any suspended solids releases during the construction phase of the current project would also be short-term in nature and this would also reduce the potential for significant effects.



Impacts on the shoreline could also reduce the foraging areas for wintering birds and have an impact on the local macrofauna community in these areas. Construction works near the shore area could deter birds from using the affected areas due to physical intrusion and indirect effects such as noise. However these impacts can generally be avoided with careful site management and appropriate timing of the proposed works. The pipeline will also run along the upper shoreline near the existing road. This area is already disturbed and would not be used extensively by birds. With the mitigation measures proposed the lower shore would not be directly or permanently affected. One of the pipelines associated with the scheme will also run along the road bordering the Monkstown Creek NHA (included in Cork Harbour SPA). Noise, disturbance and runoff from these areas could also have significant impacts in the absence of mitigation. However again, the road corridor is already disturbed and all the significant potential impacts can be mitigated.

Chemical contamination could also occur during the construction phase. Such contamination could result from accidental spillages, such as oil and other chemicals through poor operational management, the non-removal of spillages, poor storage, handling and transfer of oil and chemicals. However, if suitable precautions are taken and best practice for the storage, handling and disposal of such material are followed, impacts will be minimal. To prevent chemical pollution, all fuels or chemicals kept on the construction site will be stored in bunded containers. All refuelling and maintenance will be carried out in ramped containment areas away from sensitive environments (i.e. up-gradient of protected habitats or adjacent watercourses). Prior to any construction taking place, local fishing interests should be notified

and in the event of any spillage or accident occurring below the high water mark of ordinary or medium tides, or above the high water mark which may impact on the foreshore during the carrying out of the works, or during operations following the completion of these works, the Irish Coast Guard will be notified immediately by telephone.

## Flora and habitats

The route of the proposed sewer network is mainly restricted to the existing road infrastructure. The impacts associated with the laying of the sewer network in these locations will be negligible. This habitat type is of no ecological interest and is isolated from any semi-natural habitats. Therefore, the general potential impact on flora is rated as imperceptible negative as changes brought about by the proposed development would be limited to the immediate areas for which work is proposed.

Improved agricultural grassland habitats will be lost at the site of the proposed WWTP. This habitat is of low conservation importance and its loss would not be of ecological significance. The access road to the site, which is currently the access road to the Bord Gais substation, will be upgraded in order to cater effectively with traffic associated with the proposed development. Stonewall and Hedgerow habitats will be temporarily disturbed during the construction phase of the development at locations where the pipeline passes and/or runs along field boundaries. Stone walls and hedgerows will be re-instated following the installation of the sewer network. Impacts on these habitats would be minor in significance.

The disturbance of improved agricultural grassland, arable and horticultural land, artificial surfaces and drainage ditches (except where these discharge into a designated area) along the pipeline network is of imperceptible negative impact, as these are all modified habitat types. Discharge into a designated area via drainage ditches could potentially occur on the pipeline route located in agricultural land to the south of the Owenboy Estuary NHA.



Disturbance of hedgerows, particularly with mature trees, in the same areas would be of slight to moderate negative significance, where such disturbance results in either direct habitat loss through hedgerow removal, or indirect effects such as dieback through severance or restriction of tree roots. Habitat loss could also occur through dumping of spoil on hedgerow banks.

The laying of the sewers along shoreline habitats would cause disturbance to a number of estuarine habitats. This would be of minor to moderate significance. However, there is considerable scope to mitigate the impacts on these habitats through careful site management and habitat restoration.

Many of the potential impacts on aquatic habitats have already been discussed in relation to designated habitats in Section 3.1.3 above. Potential impacts on the aquatic areas of Cork Harbour would occur as a result of construction activities when the pipes are laid near or within the shoreline areas. Installation works associated with the foreshore pipeline along the Owenboy River could result in significant habitat loss along the pipeline route and increase the risk for suspended solids laden runoff and accidental releases of other deleterious substances (i.e. oils, fuels etc.).

The road network where the proposed pipelines will be installed is mainly older road, which does not have the pollution control of the modern highway systems currently being built in Ireland under the strict NRA environmental guidelines (NRA, 2005) eg. interception of run-off prior to entering the sewer system. Water and other substances which find their way onto these roads would run untreated into the nearest drain/stream or river. Machinery working on the road during the excavation, laying, backfilling and installation of the pipeline has the potential to produce pollutants both directly (i.e. leaking fuels, oils etc.) and indirectly as a result of the construction work (i.e. suspended solids, leached pollutants etc.). During the construction phase, pollutants and chemicals used could contaminate the area. Potential contamination of sediments and marine flora/fauna from the accidental release of organic polymers or heavy metals associated with cementing and/or grouting materials from the foundations may occur. These materials are toxic to marine organisms in sufficient quantities

and in the event of an accidental release; it could potentially contaminate the estuarine sediments adjacent to the development, inhibiting recolonisation of the area after construction. However, with the mitigation measures proposed where restrictions on refuelling and careful management of trench digging and waste management would be implemented, the impacts would be reduced to imperceptible. No sensitive marine flora communities were identified in the study area during the current assessment.

## Fauna

Aquatic fauna: Installation of pipelines in off-road, foreshore and in-channel areas could result in significant impacts on birds, mammals and invertebrates and increase the risk for suspended solids laden runoff and accidental releases of other deleterious substances (i.e. oils, fuels etc.). In particular the internationally important bird communities using the site in winter could be affected. These issues have been dealt with above. Careful timing of the works would ensure that impacts on wintering birds are avoided. Impacts of construction on fauna are deemed to be moderate negative, since work along the foreshores could result in noticeable ecological consequences outside the development boundary. The Owenboy Estuary, in particular could potentially be affected as a foreshore pipeline is proposed for a section of the northern shore. Other foreshore areas could also be affected to the same extent by excavations along roads but with less probability.

Excavation of the foreshore areas would result in the disruption of macrofaunal communities in these areas. As detailed above, pollutants and chemicals used could contaminate the area during the construction phase, potentially contaminating the sediments and associated fauna. However the extent of such areas is relatively limited and the extent of areas disturbed will be reduced as far as possible. Reinstatement of habitats along the pipeline footprint would ensure that such impacts were short-term in nature only.



The machinery and noise associated with construction could have a short-term negative impact upon mammals such as otters and perhaps seals using the shoreline. According to David (2006), underwater construction noise can adversely impact on marine mammals such as dolphins and in some circumstances (i.e. underwater pile driving) the noise can be detectable many kilometres from the source through the medium of water. Construction activity will be responsible for an increase in the noise levels in the water near all areas under construction.The single largest marine construction is the installation of the pipeline across the River Lee west passage. However, this will not involve particularly invasive underwater construction works such as blasting so significant impacts on dolphins, porpoises and other marine mammals are not expected. Moreover, this area is already disturbed as a result of the existing ferry at this location.

Sediment plumes may present a small level of habitat disturbance to seals foraging in the River Lee west channel while installing the marine pipeline but is not considered to be significant in the context of areas nearby which will remain unaffected. It is most likely that any effects of the proposed excavation work at the River Lee west channel, on seals will be minimal. As such, these communities would be acclimated to episodic increases in turbidity levels associated with living in estuarine conditions.

Limpets, a keystone species are not present at the proposed crossing and populations to the south are not expected to be affected. It is envisaged that the pipelines in the west channel will be tunnelled or laid by open cut techniques. The open cut technique is considered to have more potential environmental impacts associated with it. With the open cut technique, the pipelines will be laid below the river bed and backfilled to the original river bed profile. It is likely that the pipes will be encased in concrete for protection in shallower sections. The activities associated with the open cut technique would result in the disruption and removal of parts of the mussel beds in the vicinity. However, the impacts on mussels and other fauna would be more than compensated for by the cleaner conditions brought about by the proposed development.

Benthic excavation activity can result in damage to the biological environment but a relatively small area of the River Lee west channel would be disturbed. Temporary anchors may be

installed in the river bed in order to place the pipeline correctly. The disturbed area would be protected so as to reduce potential bed erosion by tidal movements during construction. Since the substrate will not undergo any major changes, no change in the RPD depth, and therefore no consequences for the infauna outside the construction area are envisaged. In addition, the dominant infauna of the mudflats (ragworms) are versatile creatures and could cope with minor environmental changes. With the placement of anchoring devices, flows could be impeded and oxygen availability to fauna nearby reduced but considering the relative size of the proposed devices and flow rates in the channel this is not expected to be a significant impact.

The overall balance between tidal forces and the forces of wave action greatly influences the sedimentary regime in which soft shore organisms live. Should this balance change, or should there be a change in sediment supply, a shore may erode, accrete, or change in sediment composition. For example, silt and mud particles clump together and do not behave as individual particles like sand particles. The result is that they are hard to erode, and high shore mudflats in particular are relatively stable (Little, 2000). Therefore, increased eddies due to obstacles in the west passage during construction are not deemed to be a threat to the adjacent mudflats/shores. In an estuary, particles are far from stable so that while a particular patch of shore may be here today, it may be gone tomorrow (Little, 2000). Where mussels and substrate stabilising seaweeds are absent for the west channel, slight habitat changes probably already occur periodically. However, it can be concluded that due to the adaptability of the organisms present and the flow regimes in the channel, at most minor negative impacts are envisaged from this part of the scheme.

Should the tunnelling option be used, the impacts on the marine ecology will be significantly reduced as there will be no interface between the tunnelling environment and the marine environment other than minimal vibrations. These would not be considered to have a significant impact on the marine ecology.



Terrestrial fauna: Installation of pipelines along the existing road network could also have impacts on the habitats that fauna use due to contaminated runoff and potential damage to the roots of hedgerows and tree lines. Birds nesting in hedgerows could be disturbed and their young left abandoned. However, with the mitigation measures proposed (i.e. timing of hedgerow removal or destruction outside of the bird nesting season) this would not occur.

The machinery and noise associated with construction could have a short-term negative impact upon terrestrial mammals such as badgers Disturbance to the sett (located within 30m of the WWTP site) during construction would be a short-term significant negative impact for the badger social group involved. However, with appropriate mitigation measures this sett could be fully protected during the construction phase of the proposed development.

Site development and boundary treatments could result in the loss of hedgerows within and on the margins of the affected areas. Some of these hedgerows provide corridors for mammals to move through the grassland. Loss of all of these hedgerows would be of imperceptible negative impact in a local context. No known bat roosts would be affected by the proposed development. However, some trees along the pipeline route may be used to some degree by bats. However, with the mitigation measures proposed (i.e. checking any trees to be felled for bats) no direct negative impact on bats would occur, however there will be a negative impact on bats due to loss of habitat.

## Water Quality

Installation of pipelines particularly in off-road, foreshore and in-channel areas could result in significant water quality impacts and increase the risk for suspended solids laden runoff and accidental releases of other deleterious substances (i.e. oils, fuels etc.). The potential impact on water quality is rated as moderate negative.

Excavation of the foreshore areas could result in localised pollution, particularly elevation of suspended solids. However the extent of such areas would be relatively limited and the extent

of areas disturbed will be reduced as far as possible. Reinstatement of habitats along the pipeline footprint would ensure that such water quality impacts were short-term in nature only.

The following sources of pollution are included on the Scottish Environmental Protection Agency (SEPA, 1996) list of the main sources of pollution from construction sites:

- The discharge or entry into waters of contaminated site run-off or pumped contaminated surface/ground waters;
- Loss of oil from machinery or storage areas;
- Cement and cement wash from batching plants, storage areas and other areas where cement grout or concrete is being applied;
- Silty water arising from exposed ground, stockpiles of soil, plant and wheel washing, and site roads.

In the absence of suitable mitigation, all the above impacts could occur during the construction of the proposed scheme.

### *3.2.5.2 Operational phase impacts*

#### Designated areas

Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. However, the risk of such an event occurring is extremely low in a modern well managed plant as is proposed. The large size of Cork Harbour along with tidal currents would mean that the receiving waters would have a high resilience to such unlikely events. The risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. The normal operating quality of the proposed discharge into Cork Harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for Cork Harbour and its associated designated areas.

The scheme has been designed to ensure that minimum maintenance of the collection system will be required. Any such maintenance works would be preceded by further consultation with NPWS where impacts on habitats or species subject to legal protection are predicted to occur.



#### Flora and habitats

Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. This may result in a significant eutrophication of the water with the occurrence of harmful algal blooms. These harmful algal blooms can cause fish kills, contaminate seafood with toxins, pose a direct risk to human health, or otherwise alter ecosystems in ways that are perceived as harmful. These harmful algal blooms have the potential to contaminate shellfish with biotoxins, which may be released via the foodchain into the surrounding marine habitat.

The potential impact on the receiving waters from emergency overflows from the Carrigaloe, Monkstown and Raffeen pump stations is likely to be more negative than the current situation. Overflow discharges at these pumping stations will include the wastewater from Cobh, and from Passage West in the case of the pumping stations at Monkstown and Raffeen.

However, the risk of such a large scale eutrophication event occurring is extremely low in a modern well managed plant as is proposed. The large size of Cork Harbour along with tidal currents would mean that the receiving waters would have a high resilience to such unlikely events. Nonetheless, the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. The normal operating quality of the proposed discharge into Cork Harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for Cork Harbour and its associated flora communities. The reduction in nutrient inputs into the harbour during the operational phase of

the scheme would lead to a decrease in algal mats and *Enteromorpha*, plants which thrive on high nutrient loading. This would be a moderate positive impact.

## Fauna

Aquatic fauna: The normal operating quality of the proposed discharge into Cork harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for fish and other aquatic fauna in Cork Harbour. Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. This could also affect fish and other aquatic life in the area surrounding the outfall. The magnitude of the effect would depend on a variety of factors; the components of such a discharge, the dispersion of these components (related to currents) and the length of time between the operation of the proposed development and a pollution episode (diversity of the aquatic community would be expected to increase with time following operation of the proposed development). However, the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case and with the proposed effluent discharge standards. The ecosystem around the outfall would continue to change until a sustainable balance would be eventually reached where organisms suited to the new environmental conditions would thrive. The maintenance of this balance would be dependent on a generally unchanging environment such as the one that the proposed discharge would provide. The diversity of organisms would be expected to increase with distance from the proposed outfall.

Current nutrient inputs by foul water outfalls into the affected aquatic areas would be significantly reduced during the operation of the proposed scheme. Such inputs result in increased in primary production and turbidity, indirectly suppressing filter feeder activity. Phytoplankton blooms are expected to be less frequent with the expected reduction in nutrient loading due to the proposed development and restrictions on the edibility of shellfish would ease considerably due to the reduction in associated biotoxins. Water quality around the shorelines within the harbour and along the Owenboy Estuary is expected to improve, encouraging an increase in diversity of infauna (polychaete worms, bivalves, etc.) and epifauna (crabs, crustaceans, snails, etc.). A reason for this increase in diversity is that algal mats would be less frequent and associated anoxic conditions would be deeper than is currently the case. This would influence the macroinvertebrate population by allowing animals to penetrate deeper into sediments - increasing the available habitats three dimensionally. This would also allow for greater biomass and diversity and would be expected to offset any loss of diversity as a result of reduced nutrient inputs. For example, a reduction in ragworm densities would not be a negative impact for feeding birds on mudflats because ragworms would be replaced by other species such as lugworms and catworms.



Improvements in water quality would also be expected to have positive benefits for fisheries. The value of Cork Harbour as nursery for young fish would increase with improved water quality and the consequences of this would extend beyond the mouth of the harbour, with increased recruitment to the open sea. Adult mullet would not be as concentrated around previously present outfalls. However, this is considered to be a neutral impact. The reduction of nutrients into the affected aquatic areas would improve water quality, habitats and diversity, and consequently add to the conservation status of Cork Harbour.

Should untreated sewage be discharged to Cork Harbour or the Owenboy Estuary via pump stations during the operational phase, water quality and associated fauna could be adversely affected by the resulting pollution. Depending on environmental conditions, the organic loading could cause depletion in oxygen levels through increased BOD and deprive macroinvertebrates and fish of oxygen. Fish could migrate to a location where oxygen levels are sufficient for survival. Depending on flushing rates, an accidental release of untreated sewage would also encourage growth of macroalgae such as *Ulva* and *Enteromorpha* and change the RPD depth (anoxic layer depth) of the substrate, with implications for the infauna such as cockles and *Corophium*. However, with the proposed modern development this is unlikely to occur.

The water velocity, and therefore the supply of oxygen to marine fauna is not expected to change as a result of the proposed crossing since the proposed pipeline crossing is to be finished to the same level as the existing bed.

Terrestrial fauna: There is a possibility that the long-term operation of the WWTP could cause further disturbance to local mammal communities such as badgers due to an increase in human activity. However, disturbance is anticipated to be minimal and mammal species using the areas around the WWTP can be expected to continue to do so during the operational phase. Any significant maintenance works on the scheme (including pipeline network) will be preceded by further consultation with NPWS, where impacts on habitats or species subject to legal protection are predicted to occur.

## Water quality

Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. This could affect water quality and consequently fish and other aquatic life. However, the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. The consequences of an accidental release are discussed in the previous section.

The normal operating quality of the proposed discharge into Cork harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for water quality in Cork Harbour. A study, commissioned by Mott MacDonald Pettit, was undertaken in 2007 by J. O' Kane and K. Barry of University College Cork (O' Kane & Barry, 2007). The study aimed to provide a detailed Environmental Impact Assessment of the likely change in water quality in Cork Harbour as a result of the proposed Cork Harbour Main Drainage Scheme. A computer model was devised; covering an area from the Old Head of Kinsale to the Waterworks weir in Cork City. This model was developed to assess the likely relative change in water quality as a result of this proposed scheme. This model simulated the release, transport and decay of various micro-organisms in Cork Harbour and the surrounding area due to discharges of waste. In order to determine the relative improvement in water quality the model was firstly configured to simulate the release of untreated waste from the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline. It was then used to simulate the release of treated waste from the proposed WWTP at Carrigaline. This study was based upon the projected human population in the harbour area for 2010.



At present the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline all discharge untreated sewage into Cork Harbour, each associated with concentrations higher than those proposed at the proposed treated effluent outfall (current IDA outfall). The proposed scheme will collect this waste and treat it to a secondary standard at the new WWTP near Carrigaline. The treated effluent will be discharged through the existing Carrigaline/Crosshaven IDA outfall near the mouth of the harbour at Fort Camden. The discharge standards, which shall apply to the proposed wastewater treatment plant are 25 mg/l for Biochemical Oxygen Demand (BOD), 35 mg/l for total suspended solids and 125 mg/l for chemical oxygen demand (COD). With anticipated populations in the future, the projected inputs of the proposed treatment plant would be 10,371$m^3$ treated per day while currently an estimated 7,515 $m^3$ raw sewage enters the harbour. These estimates are based on flow rates from the various outfalls (O' Kane and Barry, 2007).

In the O' Kane report, three separate water quality issues which are likely to be affected by the proposed scheme were considered; faecal coliform bacteria, *Norovirus* and simple nitrogen cascade.

- *Faecal coliforms:* Faecal coliforms are bacteria found in the intestinal tracts of humans and most other mammals and are used as an indicator of faecal pollution in water. Elevated levels of faecal coliforms in water can indicate a higher risk of pathogens being present in the water. The number of faecal coliforms per 100ml of

water is a recognised standard in water quality. The mandatory and guide values for faecal coliforms in the Bathing Water Directive are 2000 and 100 counts per 100ml of water respectively. The guideline values for the Shellfish Hygiene Directive are, for faecal coliforms, less than 300 counts per 100ml in the shellfish flesh and inter-valvular liquid. During the operational phase it is estimated that the concentration of faecal coliforms in the Lower Harbour Area (contributed by the WWTP) will be significantly less than the current scenario (untreated dishcarges). The model predicts an 80-95% reduction in the contribution of faecal coliform concentrations to the Lower Harbour Area.

- *Norovirus:* The *Norovirus* or "Winter Vomiting bug" is the primary pathogen in outbreaks of gastroenteritis following consumption of raw oysters. The *Norovirus* was included as part of the study in order to determine the impact of the proposed treatment plant on the oyster farms and water-contact recreational areas in Cork Harbour.

- *Nitrogen Cascade:* The study examined the impact of the proposed scheme on the ecological and biological status of Cork Harbour by using a model containing three species of nitrogen; organic nitrogen, ammonia and nitrate. Changes in the distribution of nitrogen can have an impact on the ecological and biological status of a harbour by the increase or decrease of primary production by phytoplankton and macrophytes. O 'Kane & Barry (2007) quantifies the relative effect of the scheme on the concentration of these three species throughout the harbour and adjacent coast and the relative effect is measured against an unaltered background concentration of each species of nitrogen.



In spite of an increasing human population in the Cork Harbour area, the O'Kane & Barry (2007) study predicted a marked relative improvement in water quality due to the reduction in pollutant load as a result of the proposed treatment plant, and the increased dilution available when the treated effluent is discharged just inside the mouth of the harbour.

The study found that a 95% relative reduction in the maximum number of faecal coliforms may be expected for Lough Mahon, the Inner Harbour, the East and West Passages and the area around the Ringaskiddy ferry terminal, and predicted an 80% relative reduction in the maximum number of faecal coliforms for the outer harbour when the treatment plant is operational. O'Kane & Barry (2007) also showed that the contribution of faecal coliforms from the proposed treatment plant into Cork Harbour would be several orders of magnitude less than the requirements for faecal coliforms under the Shellfish Hygiene and Bathing Water Directives.

The O' Kane & Barry (2007) study also found that the proposed treatment would significantly reduce the number of *Norovirus* in the harbour and the waters outside Roche's Point leading to a relative improvement in water quality. The model showed a 90 – 95% relative reduction in the maximum number of *Norovirus* at the oyster farm in the North Channel after the construction of the proposed treatment plant and a 90% relative reduction for Lough Mahon, the Inner Harbour, the East and West Passages as well as the area around Ringaskiddy while for the rest of the harbour and the area outside Roche's Point an 80% relative reduction may be expected. It is important to state that these percentages are relative to the improvement to be expected from the proposed treatment plant with respect to an unaltered background In the O' Kane report discharges of treated effluent from Carrigrennan, Midleton or Cloyne or the untreated discharges from the outfalls serving the towns on the eastern side of the harbour were not considered Neither was the impact of stormwater overflows considered. The results are therefore not representative of absolute water quality. They simply show the relative improvements in water quality.

Additionally, the study showed that the proposed scheme may reduce considerably the forcing on primary production in Lough Mahon and in the North Channel behind Great Island as a result of decreased levels of organic nitrogen, nitrate and ammonia. The study also predicted a relative decrease in primary production in the outer harbour, with the possible

exception of the immediate vicinity of the diffuser, to be located inside the mouth of the harbour.

### *3.2.5.3 Do nothing impact*

The 'do nothing' impact would result in continued discharging of untreated effluent into Cork Lower Harbour. The provision of a modern WWTP in this region is expected to result in moderate significant benefits for water quality in Cork Harbour compared with the "do nothing scenario".

### *3.2.5.4 Worst Case Scenario Impact*

In the worst-case scenario (i.e. a failure of the mitigation measures proposed) habitat loss, pollution and disturbance of avifauna in NHA/SPA areas could occur. However, such worst-case scenario impacts are considered unlikely and would at worst only a small area of these sites would be affected. During the operational phase a worst case impact would be an accidental release of untreated effluent from the WWTP. This would affect water quality in the receiving water to which the outfall is discharging. However, the risk of such an event occurring is extremely low in a modern well managed plant as is proposed. The large size of Cork Harbour along with tidal currents would mean that the receiving waters would have a high resilience to such unlikely events. It should be noted that the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. Indeed, at present untreated raw sewage is being released into the harbour.

## 3.2.6 MITIGATION MEASURES

### *3.2.6.1 Construction Phase Mitigation*

#### Designated Areas

The appointed sub-contractor will prepare detailed method statements prior to initiating construction works. These method statements will outline how the impacts of the proposed works in and near designated areas will be minimised. The method statement will be developed in consultation with NPWS.

The main conservation interest of the affected designated areas (Cork Harbour SPA, Monkstown Creek NHA and Owenboy River NHA) is wintering birds and the habitats which they use. The mitigation response required will include the following:

1. Excavation works and associated machinery on and near the foreshore will take place during August and September only, unless otherwise agreed with the NPWS, DCENR and SWRFB.
2. Minimise habitat disturbance in foreshore areas where possible.
3. Avoid the release of pollutants and sediment into adjoining areas.

The main mitigation measure required to protect the designated areas will therefore be the careful timing of works, the minimising of habitat disturbance and the protection of water quality. These measures are in accordance with the recommendations of the SWRFB (South Western Regional Fisheries Board). Excavation works on and near the foreshore should take place during August and September only. Approval from NPWS, DCENR and SWRFB would be required for work outside this period. Indeed, Birdwatch Ireland recommends that efforts be made to ensure that there is no deterioration in waterbird habitat quality which might be caused by pollution and dredging of the mudflats, and that little disturbance is caused to wintering waterbirds during any construction. Timing of works to this window would ensure that both breeding and wintering birds would be protected thus maintaining the conservation objectives of the designated areas. If works are limited to the line of the pipelines only and the top layer of sediment / substrate is used in the reinstatement works, the foreshore macro fauna community in the disturbed areas would be expected to recover quickly.



To minimise marine habitat, species loss and disturbance, efforts will be made to keep the area of shore disturbed by the pipeline trenches to a minimum. In order to minimise the amount of suspended solids released into the water column during construction, the area of shore disturbed will be minimised. Contractors installing pipelines will use chemicals that have been approved for use in the marine environment and employ methods that reduce the release of polluting materials into the water column. More detailed mitigation measures for suspended solids are given in the fauna section below.

In the event that particularly invasive techniques will be used during construction of the marine crossing the methods and programme of construction activities will be developed in consultation with appropriately qualified and experienced marine ecologists, the NPWS, DCENR and SWRFB. The purpose of this consultation will be to determine specific constraints for specific activities in relation to water quality and marine ecology.

#### Flora and habitats

As for the designated areas, the area of estuarine habitats disturbed by excavation will be kept as small as possible and employ methods conducive to maintaining good water quality. Prior to construction, the amount of hedgerow that will be required to be removed will be determined so that only the amount of hedgerows which is absolutely necessary to be removed will be impacted upon. Under the Wildlife (Amendment) Act 2000 restrictions are placed on the removal of scrub (on previously uncultivated land), hedges and ditch clearance, with such works prohibited between 1st March and 31st August. The construction schedule will

pay due cognisance to such restrictions, unless authorisation is received from the NPWS for works within this period.

Proposed landscaping works will use native species of local provenance which are commercially available. The details of species to be used in landscaping works will be developed in consultation with an appropriately qualified ecologist.

## Fauna

The remedial and reductive measures outlined for designated areas and habitats and flora respectively will also protect fauna in the receiving environment.

The main mitigation measure required to protect fauna will be the careful timing of works, the minimising of habitat disturbance and the protection of water quality. Ideally excavation works on and near the foreshore should take place during August and September only. Approval from NPWS, DCENR and SWRFB would be required for work outside this period. Timing of works to this window would ensure that both breeding and wintering birds would be protected. Works involving the removal of scrub (on previously uncultivated land), hedges and ditch clearance are prohibited between 1st March and 31st August for the protection of nesting birds, unless authorisation is received from the NPWS for works within this period.

The badger sett located near the proposed WWTP will be fenced off and monitored during the construction phase of the project. An appropriately qualified ecologist will be engaged at the pre-construction phase of the project to advice on how to protect this sett. NPWS will be consulted regarding the existence of this sett and mitigation measures proposed. Monitoring of the sett will be in accordance with criteria developed in consultation with the NPWS.



If works are limited to the line of the pipelines only and the top layer of sediment / substrate is used in the reinstatement works, the foreshore macro fauna community in the disturbed areas would be expected to recover quickly.

Should open cut techniques be used for the River Lee west passage marine crossing a construction environmental management plan and monitoring programme will be developed in consultation with an appropriately qualified ecologist, the NPWS, DCENR and SWRFB to monitor water quality.

All stockpiles of soil or fill will be kept 30m from the waters edge and protected by fencing comprised of material known as terram (also known as silt fencing). This fencing will trap any sediment/silt mobilised during periods of high rainfall.

To reduce the impact of pollution and waste from maintenance and boat traffic it is necessary to minimise the likelihood of any spillage or contamination. Potential contaminants will be stored in suitable storage facilities, such as bunded containers. Waste and litter generated during construction will be collected for authorised disposal at suitable facilities. Care and vigilance will be followed to prevent accidental contamination of the site and surrounding environment during construction.

## Water quality

The mitigation measures provided above for designated areas, flora and fauna will be employed to mitigate for water quality.

### *3.2.6.2 Operational Phase Mitigation*

Any newly planted hedgerows, lawns and treelines will be monitored and maintained by a horticulturalist or other suitably qualified contractor. This will include plants around the WWTP and those planted in various other areas around adjacent to pipelines. No fertilisers will be used in any habitat pertaining to the proposed development. Litter, grass cuttings and other wastes will be removed from the WWTP site by a suitable contractor.

Monitoring of the badger sett to the east of the WWTP will be in accordance with monitoring guidelines stipulated by the NPWS.

Provision of continuous monitoring and sampling of wastewater flow entering and leaving the site will be provided. This will also include monitoring and measuring of the storm water content. This wastewater monitoring is critical not only in terms of controlling plant operation but also in terms of complying with the Urban Waste Water Regulations 2001 & 2004 amendments.

To comply with the Waste Water Discharge (Authorisation) Regulations of 2007, a Waste Water Discharge licence will be required from the Environmental Protection Agency EPA for the Cork Harbour WWTP. The purpose of the licence is to make provision for the protection of human, animal and plant life from harm and nuisance caused by the discharge of Dangerous Substances to the aquatic environment as well as to ensure compliance with National law.

In order to minimise the risk of untreated effluent discharging from pump stations an automated control operating system should be put in place to ensure that if a downstream pumping station fails to operate, the upstream pumping station will cease pumping.

It is not anticipated that the WWTP will be staffed 24 hrs/day, automatic control of the plant will be undertaken by a computerised control system, with key information and alarms relayed to the relevant Cork County Council office. When the site is unmanned, any critical alarms of the plant will activate an automatic call-out system. It is recommended that the WWTP have a standby generator to ensure operation of the WWTP during any electrical power failure. In such a modern facility, and adhering to the discharge standards proposed, no further mitigation is required.

## 3.2.7 RESIDUAL IMPACTS

Residual impacts following the implementation of mitigation measures will include the permanent loss of habitat at the WWTP site which is not considered a significant impact. Improvements in water quality will result in long-term moderate positive impacts for marine flora, estuarine birds, marine invertebrates, mammals and fish species. With moderate benefits for biodiversity following the improvement in water quality, the value of the designated areas would be expected to increase in Cork Lower Harbour.

**Table 17** Summary of Impacts and mitigation measures for the Cork Harbour Main Drainage Scheme.

| | Potential impacts | Mitigation Measures | Predicted impacts |
|---|---|---|---|
| Designated areas | Moderate Negative (C). Moderate Positive (O). | Careful timing of the works (considering birds, fish, rainfall), avoiding releases of pollutants, minimal interference with designated areas and vigilant site management(C)<br><br>With the modern WWTP and discharge standards proposed, no mitigation further mitigation (O). | Minor Negative (C). Moderate Positive (O). |
| Flora and habitats | Moderate Negative (C). Moderate Positive (O) | Minimise disturbance, removal of hedgerows restricted to pipeline path and certain times of the year. New plants to be grown will be from a list provided by an ecologist (C).<br><br>Monitoring of reinstated areas and Owenboy estuarine shore, no use of fertilisers (O). | Minor Negative (C). Imperceptible Negative (O). |
| Fauna | Moderate Negative (C). Moderate Positive (O). | Careful timing of the works, avoiding releases of pollutants, careful site management, consultation (C).<br><br>Monitor the badger sett near the proposed WWTP (O). | Minor Negative (C). Moderate Positive (O). |
| Water quality | Moderate Negative (C). Moderate Positive (O). | Careful timing of the works, avoiding releases of pollutants, careful site management, consultation (C).<br><br>Provide 2 holding tanks for stormwater, regular servicing of pump stations (O). | Imperceptible Negative (C). Moderate Positive Impact (O). |

(c) Construction Phase, (O) Operational Phase.

## REFERENCES

MERC Consultants (2006) A compilation report of information on Irish aquaculture (with a view to key programs during the years 2000 to 2006) Marine Institute, Bord Iascaigh Mhara and Taighde Teo.

Barnes R.S.K. (1994) The brackish-water fauna of North-western Europe. Cambridge University Press.

Local news-Passge West Monkstown, 13th September, 2007
www.passagewestmonkstown.ie/news

Boland, H., and Crowe, O. (2006) Irish Wetland Bird Survey: Results of waterbird monitoring in Ireland in 2003/04 and 2004/05. *Irish Birds*, (8):1.

Boelens, R.G.V., Maloney, D.M., Parsons, A.P., Walsh, A.R., 1999. Ireland's Marine and Coastal Areas and Adjacent Seas: An Environmental Assessment. Marine Institute, Dublin, Ireland.

BCIreland (Bat Conservation Ireland) (2007) Deerpark House, Tierwurcher, Kells, Co. Meath.

Birdwatch Ireland (2007), P.O. Box 12, Greystones, Co. Wicklow.

Blaber, S. J .M., (1997) Fish and fisheries of tropical estuaries. Chapman and Hall, London.

Clark, R. B. (1997) Marine Pollution. 4th edn. Clarendon Press, Oxford.

Crowe, O.(2005) Ireland's Wetlands and their Waterbirds: Status and Distribution. BirdWatch Ireland, Newcastle, Co. Wicklow.

Cusack, C., Chamberlain, T., Lyons, J., Salas, R., Clarke, D., Devilly, L., McMahon, T., O Cinneide, M.and Silke, J. (2004). Review of Phytoplankton and Environmental Monitoring 2003. Proceedings of the 4th Irish Marine Science Biotoxin Workshop, Renvyle, County Galway, 7th November 2003, 3-7. Organised by the Marine Institute and Bord Iascaigh Mhara in association with the Irish Shellfish Association and Food Safety Authority of Ireland.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., (2001), Marine Monitoring Handbook, 405 pp, ISBN 1 85716 550 0

David J., A. (2006) Likely sensitivity of bottlenose dolphins to pile-driving noise. *Water and Environment Journal* 20 (1), 48–54.

Dunlop, N. & Green, P. (1992) Sea Angling. *Central Fisheries Board Irish Angling Guides. Gill and MacMillan.*

EPA (Environmental Protection Agency) website accessed on 19-11-07. Estuarine and Coastal Water Quality Map. http://www.epa.ie/downloads

Ehlers, J. (1998) The Morphodynamics of the Wadden Sea. Balkema Rotterdam

Fossitt, J. (2000) A guide to habitats in Ireland. *The Heritage Council, Kilkenny.*

FSAI (Food Safety Authority of Ireland) website accessed on 13-11-07 Molluscan Shellfish Production Areas, Sample Points and Co-ordinates for Biotoxin and Phytoplankton Samples, 2005.

FSAI (Food Safety Authority of Ireland) website accessed on 13-11-07 Live Bivalve Molluscs (Production Areas) (No 2) Designation, 2005

Gibbons, D.W., Reid, J.B. & Chapman, R.A. (1993) The new atlas of breeding birds in Britain and Ireland: 1988-1991. T. & A.D. Poyser

Glynn, D., Tyrrell, L., Mchugh, B., Rowe, A., Monaghan, E., Costello, J., and. Mcgovern, E. (2003) trace metal and chlorinated hydrocarbon concentrations in shellfish from Irish waters, 2001. Marine Institute, Marine Environment and Food Safety Services Abbotstown, Dublin 15.

Hansen, K. and Kristensen, E. (1997). Impact of macrofaunal recolonisation on benthic metabolism and nutrient fluxes in shallow marine sediment previously overgrown with macroalgal mats. *Estuarine and Coastal Shelf Science*, **45**, 613-628.

Hayward, P.J., and Ryland J. S. (2005) Handbook of the Marine Fauna of North-West Europe. Oxford University Press.

IEA (Institute of Environmental Assessment) (1995). Guidelines for Baseline Ecological Assessment. E & FN Spon, London, UK.

IEEM (2002). Guidelines for Ecological Evaluation and Assessment. Institute of Ecological and Environmental Management, Draft Report.

ISSSW (2005) 6th Irish Shellfish Safety Scientific Workshop. Galway, Organised by the Marine Institute, Food Safety Authority of Ireland and Bord Iascaigh Mhara.

ISA (Irish Sailing Association) website accessed on 14-11-2007 for Cobh. http://www.sailing.ie

IWDG (Irish Whale and Dolphin Group) (2007) Merchant's Quay, Kilrush, Co. Clare.

JNCC (Joint Nature Conservation Committee) (1993). Handbook for Phase 1 Habitat Survey. Joint Nature Conservation Committee, Peterborough, UK.

JNCC (Joint Nature Conservation Committee) (1995). Guidelines for Selection of Biological SSSIs. Joint Nature Conservation Committee, Peterborough, UK.

Jones, S.E.a and Jago, C.F. (1993) In situ assessment of modification of sediment properties by burrowing invertebrates. *Marine Biology*, **115**, 133-439.

King, J. (2002) Investigations of Conservation Fish species in 2001. Summary Report and Recommendations. Central Fisheries Board. February, 2002.

Kowalski, R. (1955). (English Summary) Untersuchungen zur Biologie des Seesternes Asterias mbens L, in Brackwasser. *Kieler Meeresforsch.* 11: 201-213

Little, C. (2000) The Biology of Soft Shores and Estuaries. Oxford University Press Inc, New York.

Minchin, D. (2003) Monitoring of Tributyl Tin contaminations in six marine inlets using biological indicators. Marine Institute, Marine Environmeny and food safety services, Parkmore industrial estate, Galway.

Morrisey, D.J. (1998) Differences in effects of grazing by deposit feeders *Hydrobia ulvae* (Pennant) and *Corophium arenarium* (Crawford) on sediment microalgal populations. 1. Qualitative differences. *Journal of Experimental Marine Biology & Ecology*, **118**, 33-42.

O'Leary, G., Meaney, B. and Carty, G., 1997. Urban Wastewater Discharges in Ireland with a Population Equivalent Greater Than or Equal to 2000: A Report for the Years 1994 and 1995. Report by the Environmental Protection Agency, Ardcavan, 33pp.

NIWA Science (2007) Effect of increased suspended sediment on suspension-feeding shellfish. Water and Atmosphere online publication, Vol. 10 No. 4.http://www.niwascience.co.nz/pubs

NERC (Natural Environment Research Council) website, accessed on 19-11-07. The ecology, behaviour and ecosystem effects of the estuarine infaunal ragworm *Nereis diversicolor.* NERC Reference: NER/S/A/2006/14028

O'Connor, D.W., Allen J.H., Golding, Howell, Kieberneicht, L.H., Nothern, K.H., & Recker, J.B (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough.

O' Kane, J.P.J., Barry, K. (2007). Cork Harbour Main Drainage Scheme – EIA Modelling Study. A report to Mott MacDonald Pettit (DRAFT), Department of Civil and Environmental Engineering, University College Cork – National University of Ireland, Cork.

OSPAR. 2000. Quality Status Report 2000 Region III- Celtic Seas. OSPAR Commission, London, UK.

OSPAR. 2000b. Quality Status Report 2000. OSPAR Commission, London, UK.

Olaffson, E.B. (1986) Density dependence in suspension-feeding and deposit-feeding populations of the bivalve on infaunal recruitement *Macoma balthica. Marine Ecology Press Series,* 55, 171-179.

Quigley, D.T.G., and O' Connor, W. (1997) Specimen marine fish from the Southwest Region of Ireland (1955-1996). *A report to the Marine Natural Resources Division, Regional Technical College, Tralee. August 1997.*

Raine, R. (2003) Harmful Algal Blooms. The Irish Scientist yearbook, 2003. The Martin Ryan Institute, NUI Galway. http://www.irishscientist.ie

Richardson, J.W., C.R. Greene Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, California.

Sea angling website http://www.sea-angling-ireland.org/shore

Smiddy, P., O'Hallloran, J., Coveny, J.A., Leonard, P.G., and Shorten, M. (1995) Wintering waterfowl populations of Cork harbour: an update. *Irish Birds* (5): 285-294.

Stace, C. (1997) *New flora of the British Isles.* Cambridge University Press, London.

Suchanek, T.H. (1986). Mussels and their role in structuring rocky shore communities. In P.G. Moore and R Seeds (eds), *The ecology of rocky coasts*, 70-96. New York. Columbia University Press.

Toner, P., Bowman, K., Clabby, K., Lucey, J., McGarrigle, M, Concannon, C., Clenaghan, C., Cunningham, P., Delaney, J., O'Boyle, S., MaCarthaigh, M., Craig, M., and Quinn, R. 2005. *Water Quality in Ireland 2001-2003.* Environmental Protection Agency, Wexford.

Warwick, R. M. (1986) A new method for detecting pollution effects on marine macro-benthic communities. *Marine Biology*, **92**, 557-562.

Widdows, J., Lucas, J.S., Brinsley, M.D., Staff, F.J. (2002) Investigation of the effects of current velocity on mussel feeding and mussel bed stability using an annular flume. Springer Berlin / Heidelberg 1438-387X (Print) 1438-3888 (Online) Vol 56, No. **1**, 3-12.

Webb, D. A., Parnell, J. & Doogue, D. (1996) *An Irish Flora.* Dundalgan Press, Dundalk

Wentworth, C. K., 1922. A scale of grade and class terms for clastic sediments; *Journal of Geology*, 30: 377-392.

## Plates A – Terrestrial Areas

**Plate A1** Improved agricultural grassland located on the site of the proposed wastewater treatment plant.



**Plate A2** Hedgerow habitats located on the north-eastern boundary of the proposed wastewater treatment plant.

**Plate A3** Artificial surfaces - the roadway leading into the proposed wastewater treatment plant site.

**Plate A4** The R610 regional road linking Monkstown to Passage West. This is an area that would be affected by the proposed on-road pipeline network.



**Plate A5** Woodland and shore habitats to the east of Cobh. The proposed pipeline runs along the foreshore in this area.

**Plate A6** An area of farmland with arable crops located to the east of the Carrigaline. This area would be affected by a section of off-road pipeline.

## Plates B – Littoral and inshore areas

**Plate B1** Grab sampling from a boat near the existing IDA outfall pipeline.

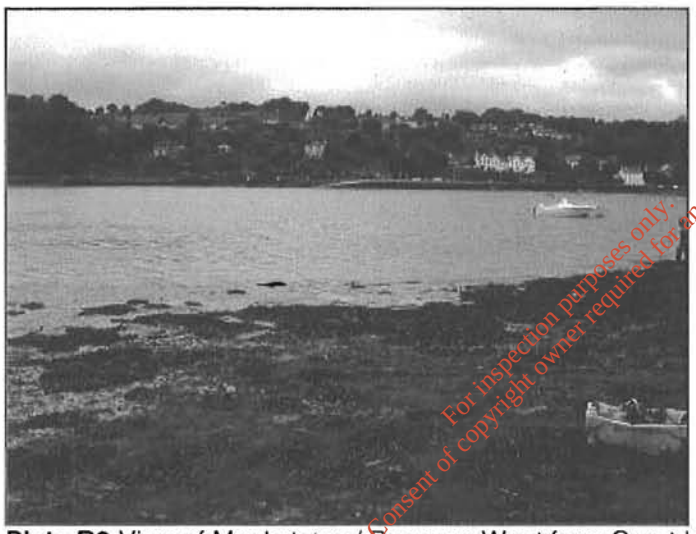



**Plate B2** View of Monkstown / Passage-West from Great Island. 'Mixed substrata shore LR4' was the dominant littoral habitat in this area.

**Plate B3** Owenboy estuary with the biotope '*Hediste diversicolor* in littoral mud'.

**Plate B4** Whitepoint, Cobh. *Fucus serratus* on full salinity lower eulittoral mixed substrata.

**Plate B5** View of Cobh and Cork Harbour. The habitat type 'Shingle and gravel shores LS1' was present here.



**Plate B6** Shoreline near the existing IDA outfall. This habitat comprises mainly of the habitat type 'Muddy sand shores LS3'.

# Appendix 1 Assessment of Impacts and Impact Significance

Criteria for assessing impact type and magnitude are presented in Tables A2.1 and A1.2, respectively.

In assessing the magnitude and significance of impacts it is important to consider the value of the affected feature, this is taken into account in Table A1.2.

**Table A1.1.** Criteria for assessing impact type

| Impact type | Criteria |
|---|---|
| Positive impact: | A change is likely to improve the ecological feature in terms of its ecological value. |
| Neutral | No effect. |
| Negative impact: | The change is likely to adversely affect the ecological value of the feature. |

**Table A1.2** Criteria for assessing impact magnitude

| Impact magnitude | Definition |
|---|---|
| No change: | No discernible change in the ecology of the affected feature. |
| Imperceptible Impact: | A change in the ecology of the affected site, the consequences of which are strictly limited to within the development boundaries. |
| Minor Impact: | A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary, but these consequences are not considered to significantly affect the distribution or abundance of species or habitats of conservation importance. |
| Moderate Impact: | A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary. These consequences are considered to significantly affect the distribution and/or abundance of species or habitats of conservation importance. |
| Substantial Impact: | A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary. These consequences are considered to significantly affect species or habitats of high conservation importance and to potentially affect the overall viability of those species or habitats in the wider area. |
| Major Impact: | A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary. These consequences are considered to be such that the overall viability of species or habitats of high conservation importance in the wider area[2] is under a very high degree of threat (negative impact) or is likely to increase markedly (positive impact). |

## Appendix 2 NPWS Site Synopses.

**SITE NAME: Great Island Channel**
**SITE CODE: 001058**

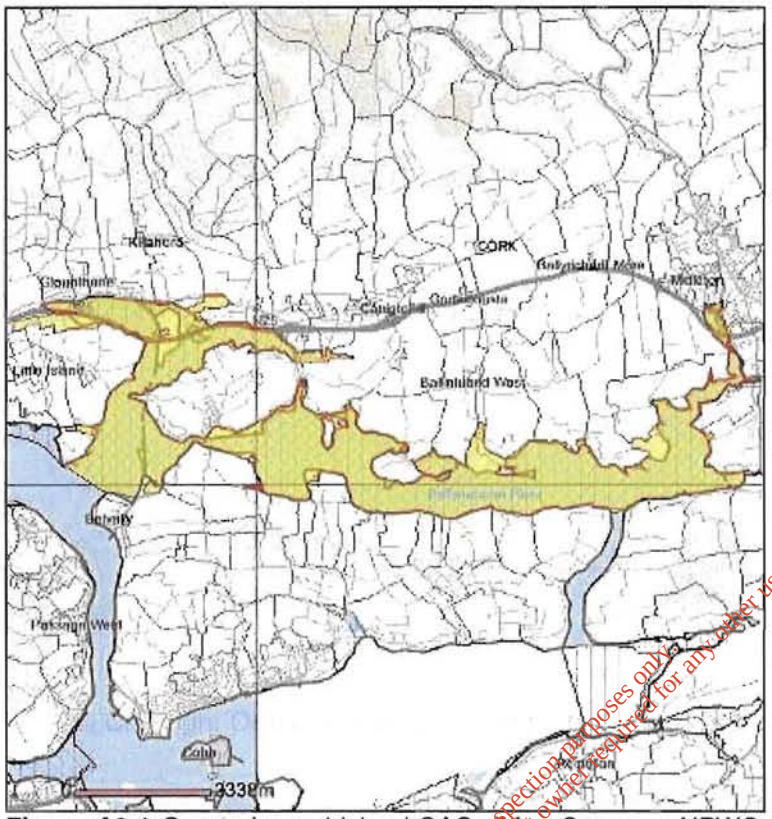


**Figure A2.1** Great channel island SAC. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).



The Great Island Channel stretches from Little Island to Midleton, with its southern boundary being formed by Great Island. It is an integral part of Cork Harbour which contains several other sites of conservation interest. Geologically, Cork Harbour consists of two large areas of open water in a limestone basin, separated from each other and the open sea by ridges of Old Red Sandstone. Within this system, Great Island Channel forms the eastern stretch of the river basin and, compared to the rest of Cork Harbour, is relatively undisturbed. Within the site is the estuary of the Owennacurra and Dungourney Rivers. These rivers, which flow through Midleton, provide the main source of freshwater to the North Channel. The main habitats of conservation interest are the sheltered tidal sand and mudflats and Atlantic salt meadows, both habitats listed on Annex I of the EU Habitats Directive. Owing to the sheltered conditions, the intertidal flats are composed mainly of soft muds. These muds support a range of macro-invertebrates, notably *Macoma balthica*, *Scrobicularia plana*, *Hydrobia ulvae*, *Nepthys hombergi, Nereis diversicolor* and *Corophium volutator*. Green algal species occur on the flats, especially *Ulva lactua* and *Enteromorpha* spp. Cordgrass (*Spartina* spp.) has colonised the intertidal flats in places, especially at Rossleague and Belvelly. The salt marshes are scattered through the site and are all of the estuarine type on mud substrate. Species present include Sea Purslane (*Halimione portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Plantain (*Plantago maritima*), Greater Sea-spurry (*Spergularia media*), Sea Lavender (*Limonium humile*), Sea Arrowgrass (*Triglochin maritimum*), Mayweed (*Matricaria maritima*) and Red Fescue (*Festuca rubra*).

The site is extremely important for wintering waterfowl and is considered to contain three of the top five areas within Cork Harbour, namely North Channel, Harper's Island and Belvelly-Marino Point. Shelduck are the most frequent duck species with 800-1000 birds centred on

the Fota/Marino Point area. There are also large flocks of Teal and Wigeon, especially at the eastern end. Waders occur in the greatest density north of Rosslare, with Dunlin, Godwit, Curlew and Golden Plover the commonest species. A population of about 80 Grey Plover is a notable feature of the area. All the mudflats support feeding birds; the main roost sites are at Weir Island and Brown Island and to the north of Fota at Killacloyne and Harper's Island. Ahanesk supports a roost also but is subject to disturbance. The numbers of Grey Plover and Shelduck, as given above, are of national importance. The site is an integral part of Cork Harbour which is a wetland of international importance for the birds it supports.

Overall, Cork Harbour regularly holds over 20,000 waterfowl and contains internationally important numbers of Black-tailed Godwit (1,181) and Redshank (1,896) along with nationally important numbers of nineteen other species. Furthermore, it contains the large Dunlin (12,019) and Lapwing (12,528) flocks. All counts are average peaks, 1994/95 – 1996/97. Much of the site forms part of Cork Harbour Special Protection Area, an important bird area designated under the EU Birds Directive. While the main land use within the site is aquaculture (Oyster farming), the greatest threats to its conservation significance come from road works, infilling, sewage outflows and possible marina developments. The site is of major importance for the two habitats listed on the EU Habitats Directive that it contains, as well as for its important numbers of wintering waders and wildfowl. It also supports a good invertebrate fauna.

**SITE NAME: Cork Harbour SPA**
**SITE CODE: 004030**

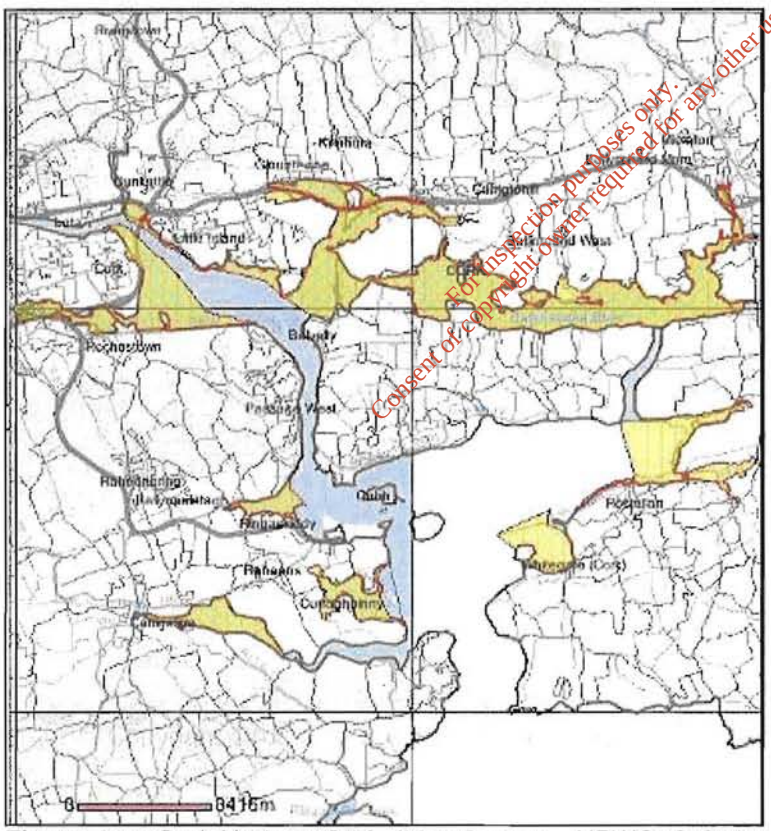




**Figure A2.2** Cork Harbour SPA. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

Cork Harbour is a large, sheltered bay system, with several river estuaries – principally those of the Rivers Lee, Douglas and Owenacurra. The SPA site comprises most of the main intertidal areas of Cork Harbour, including all of the North Channel, the Douglas Estuary, inner Lough Mahon, Lough Beg, Whitegate Bay and the Rostellan inlet. Owing to the sheltered conditions, the intertidal flats are often muddy in character. These muds support a range of macro-invertebrates, notably *Macoma balthica*, *Scrobicularia plana*, *Hydrobia ulvae*, *Nepthys hombergi*, *Nereis diversicolor* and *Corophium volutator*. Green algae species occur

on the flats, especially *Ulva lactua* and *Enteromorpha* spp. Cordgrass (*Spartina* spp.) has colonised the intertidal flats in places, especially where good shelter exists, such as at Rossleague and Belvelly in the North Channel. Salt marshes are scattered through the site and these provide high tide roosts for the birds. Salt marsh species present include Sea Purslane (*Halimione portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Plantain (*Plantago maritima*), Laxflowered Sea-lavender (*Limonium humile*) and Sea Arrowgrass (*Triglochin maritima*). Some shallow bay water is included in the site. Cork Harbour is adjacent to a major urban centre and a major industrial centre. Rostellan lake is a small brackish lake that is used by swans throughout the winter. The site also includes some marginal wet grassland areas used by feeding and roosting birds. Cork Harbour is an internationally important wetland site, regularly supporting in excess of 20,000 wintering waterfowl, for which it is amongst the top five sites in the country. The five-year average annual core count for the entire harbour complex was 34,661 for the period 1996/97-2000/01. Of particular note is that the site supports an internationally important population of Redshank (1,614) – all figures given are average winter means for the 5 winters 1995/96-1999/00. A further 15 species have populations of national importance, as follows: Great Crested Grebe (218), Cormorant (620), Shelduck (1,426), Wigeon (1,750), Gadwall (15), Teal (807), Pintail (84), Shoveler (135), Red-breasted Merganser (90), Oystercatcher (791), Lapwing (3,614), Dunlin (4,936), Black-tailed Godwit (412), Curlew (1,345) and Greenshank (36). The Shelduck population is the largest in the country (9.6% of national total), while those of Shoveler (4.5% of total) and Pintail (4.2% of total) are also very substantial.

The site has regionally or locally important populations of a range of other species, including Whooper Swan (10), Pochard (145), Golden Plover (805), Grey Plover (66) and Turnstone (99). Other species using the site include Bat-tailed Godwit (45), Mallard (456), Tufted Duck (97), Goldeneye (15), Coot (77), Mute Swan (39), Ringed Plover (51), Knot (31), Little Grebe (68) and Grey Heron (47). Cork Harbour is an important site for gulls in winter and autumn, especially Common Gull (2,630) and Lesser Black-backed Gull (261); Black-headed Gull (948) also occurs. A range of passage waders occur regularly in autumn, including Ruff (5-10), Spotted Redshank (1-5) and Green Sandpiper (1-5). Numbers vary between years and usually a few of each of these species over-winter. The wintering birds in Cork Harbour have been monitored since the 1970s and are counted annually as part of the I-WeBS scheme.



Cork Harbour has a nationally important breeding colony of Common Tern (3-year mean of 69 pairs for the period 1998-2000, with a maximum of 102 pairs in 1995). The birds have nested in Cork Harbour since about 1970, and since 1983 on various artificial structures, notably derelict steel barges and the roof of a Martello Tower. The birds are monitored annually and the chicks are ringed. Extensive areas of estuarine habitat have been reclaimed since about the 1950s for industrial, port-related and road projects, and further reclamation remains a threat.

As Cork Harbour is adjacent to a major urban centre and a major industrial centre, water quality is variable, with the estuary of the River Lee and parts of the Inner Harbour being somewhat eutrophic. However, the polluted conditions may not be having significant impacts on the bird populations. Oil pollution from shipping in Cork Harbour is a general threat. Recreational activities are high in some areas of the harbour, including jet skiing which causes disturbance to roosting birds.

Cork Harbour is of major ornithological significance, being of international importance both for the total numbers of wintering birds (i.e. > 20,000) and also for its population of Redshank. In addition, there are at least 15 wintering species that have populations of national importance, as well as a nationally important breeding colony of Common Tern. Several of the species which occur regularly are listed on Annex I of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover, Bar-tailed Godwit, Ruff and Common Tern. The site provides both feeding and roosting sites for the various bird species that use it.

**SITE NAME: Monkstown creek NHA**
**SITE CODE: 001979**

**Figure A2.3** Monkstown creek NHA. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).



Monkstown Creek is situated between Monkstown and the major seaport of Ringaskiddy on the western shores of Cork Harbour. Geologically, Cork Harbour consists of two large areas of open water in a limestone basin, separated from each other and the sea by ridges of old red sandstone. Within this system, Monkstown Creek is a tidal inlet composed of mudflats, with limestone along the southern shore. A brackish lake also occurs, separated from the sea by a sluice gate.

The mudflats and tidal creeks are fringed by a small amount of saltmarsh vegetation while, above the limestone on the southern shore, two areas of semi-natural woodland occur. The latter contain Spindle (*Euonymus europaeus*) and a thick carpet of Bluebell (*Hyacintnoides non-scripta*) and Ramsons (*Allium ursinum*).

The marsh interest of the site is ornithological, with the mudflats acting as winter refuge to at least locally important numbers of waterfowl, including Shelduck, Teal, Redshank and Dunlin. However, Cormorant may reach nationally important numbers with the jetty supporting a Cormorant roost of over 100 birds, in addition to a second roost in the woods (NHA survey, 1994).

The predominant land use is as a safe mooring for small craft; however major industry and a golf course adjoin the site. The main potential threat is water pollution.

The area is of value beacuse its mudflats provide an important feeding area for waterfowl and it is a natural part of Cork Harbour which, as a complete unit, is of international importance for waterfowl.

**SITE NAME: Owenboy River NHA**
**SITE CODE: 001990**

Cork Harbour consists of a central basin with a number of narrow estuaries running E-W in line with the ridge structure of this part of Ireland. The Owenboy River is the most southerly of these bays on the western side and runs from Carrigaline to Crosshaven. It consists of two expanded sections with extensive mudflats at low tide, separated by a much narrower channel. Only the upper part is included in the NHA because it is here that the great majority of birds congregate in winter.

The wildfowl and waders of the whole harbour are usually taken as a single population as they move from site to site depending on tidal and feeding conditions. Many species occur in numbers of international importance within the overall total of 42,000 waterfowl. Some species frequent the Owenboy more than others and Dunlin, Redshank and Curlew are the most numerous birds. A roost of up to 2,000 of these waders uses fields near Rabbit Point at high tide.

There are few other habitats of interest around the estuary. The southern shore is taken up by the Crosshaven road, backed by planted woodland while on the opposite side there are fields of pasture and sections of artificial shore created by dumping. A small section of saltmarsh however occurs east of Morgan's Quay and contains a series of brackish and freshwater communities in microcosm.

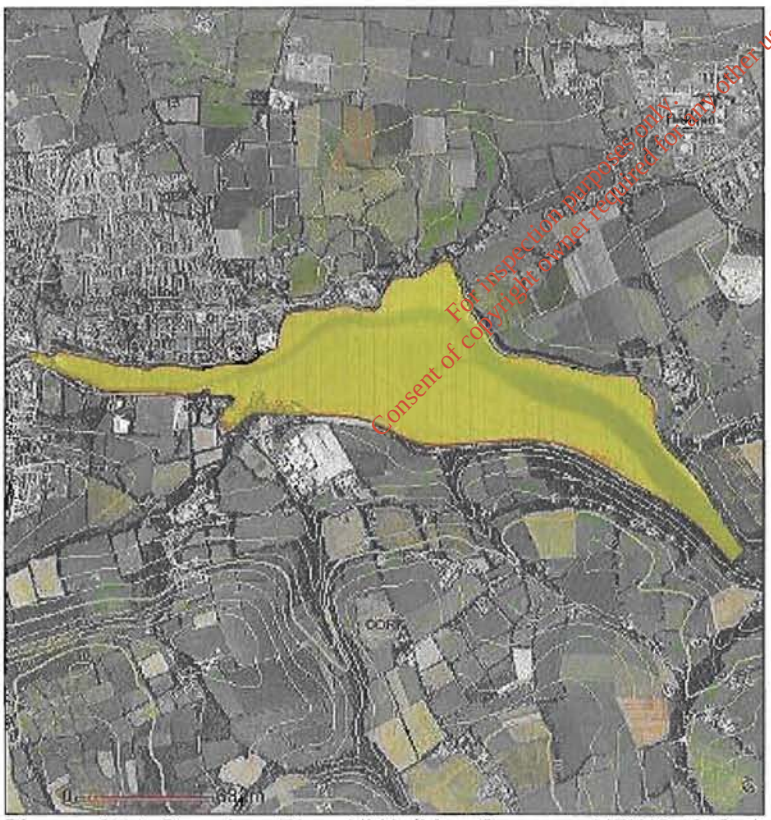



**Figure A2.4** Owenboy River NHA (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

## Appendix 3 Plant species list of different habitats.

| Common name | Scientific Name | GA1 | WD1 | WL1 | BL3 | GS2 | CC1 | LS1 | BL1 | BC1 | WL2 | GS4) | WS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alder | *Alnus glutinosa* | | ✓ | ✓ | | | | | | | ✓ | | |
| Annual meadow-grass | *Poa annua* | ✓ | | ✓ | | ✓ | | | | | | ✓ | |
| Ash | *Fraxinus excelsior* | | ✓ | ✓ | | | | | | | ✓ | | |
| Ash seedlings | *Fraxinus excelsior* | | ✓ | | | ✓ | | | | | | | |
| Barley | *Hordeum vulgare* | | | | | | | | | ✓ | | | |
| Bent | Agrostis spp | ✓ | ✓ | ✓ | | | | | | | | | |
| Bird's foot trefoil | *Lotus corniculatus* | | | ✓ | | ✓ | | | | | | | |
| Black knapweed | *Centaurea nigra* | | | ✓ | | ✓ | | | | | | | |
| Blackthorn | *Prunus spinosa* | | ✓ | ✓ | | | | | | | | | |
| Bladder wrack | *Fucus vesiculosus* | | | | | | | ✓ | | | | | |
| Bluebell | *Hyacinthoides non-scripta* | | ✓ | | | | | | | | | | |
| Bramble | *Rubus fruiticosus agg.* | ✓ | ✓ | ✓ | | ✓ | | | | | | | |
| Broad-leaved dock | *Rumex obtusifolius* | ✓ | | | | | | | | | | | |
| Broad-leaved willowherb | *Epilobium montanum* | | | | | | | | | | | | |
| Brookweed | *Samolus valerandi* | | | | | | | | | | | ✓ | |
| Bugle | *Ajuga reptans* | | ✓ | | | | | | | | | | |
| Bulrush | *Typha latifolia* | | | | | | | | | | | | |
| Bush vetch | *Viccia cracca* | ✓ | ✓ | ✓ | | | | | | | | | |
| Butterfly bush | *Buddleja davidii* | | | ✓ | | | | | | | | | ✓ |
| Celandine | *Ranunculus ficaria* | | ✓ | | | ✓ | | | | | | | |
| Chickweed | *Stellaria media* | | | | | | | | | ✓ | | | |
| Cleavers | *Galium aparine* | ✓ | ✓ | ✓ | | ✓ | | | | | | | |
| Cock's-foot | *Dactylis glomerata* | ✓ | | ✓ | | ✓ | | | | | | ✓ | |
| Coltsfoot | *Tussilago farfara* | | | | | | | | | | | | |
| Common field Speedwell | *Veronica persica* | ✓ | ✓ | ✓ | | ✓ | | | | | | | |
| Common mouse-ear | *Cerastium fontanum* | ✓ | | | | ✓ | | | | | | ✓ | |
| Common Ragwort | *Senecio jacobaea* | ✓ | | ✓ | ✓ | ✓ | | | | | | | |
| Common reed | *Phragmites australis* | | | | | | | | | | | | |
| Creeping Bent | Agrostis stolonifera | ✓ | | ✓ | | ✓ | | | | | | ✓ | |
| Creeping Buttercup | *Ranunculus repens* | ✓ | | ✓ | | ✓ | | | | | | | |
| Creeping thistle | *Cirsium arvense* | ✓ | | ✓ | | ✓ | | | | | | ✓ | |
| Curled dock | *Rumex crispus* | ✓ | | | | ✓ | | | | | | ✓ | |
| Daisy | *Bellis perennis* | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| Dandelion | *Taraxacum officinale* | ✓ | | ✓ | ✓ | ✓ | | | | | | | |
| Distant sedge | *Carex distans* | | | | | | | | | | | | |
| Dock | *Rumex* spp. | ✓ | ✓ | | | ✓ | | | | | | | |
| Downy birch | *Betula pubescens* | | ✓ | ✓ | | | | | | | | | |

| Common name | Scientific Name | GA1 | WD1 | WL1 | BL3 | GS2 | CC1 | LS1 | BL1 | BC1 | WL2 | GS4) | WS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eared willow | *Salix aurita* | | | ✓ | | | | | | | | | |
| Enchanter's nightshade | *Circaea lutetiana* | | ✓ | | | | | | | | | | |
| Escalonia | *Escalonia spp* | | | | | | | | | | | | ✓ |
| False fox sedge | *Carex otrubae* | | | | | | | | | | | ✓ | |
| False oat-grass | *Arrhenatherum elatius* | ✓ | | | | | | | | | | | |
| Ferns | *Asplenium spp* | | ✓ | ✓ | | ✓ | | | | | | | |
| Field horsetail | *Equisetum arvense* | | | | | ✓ | | | | | | | |
| Foxglove | *Digitalis purpurea* | | | | | ✓ | | | | | | | |
| Fuschia | *Fuschia magellanica* | | | ✓ | | | | | | | | | ✓ |
| Glaucous sedge | *Carex flacca* | | | | | | | | | | | ✓ | |
| Goat willow | *Salix caprea* | | | ✓ | | | | | | | | | |
| Gorse | *Ulex europaeus* | | | ✓ | | | | | | | | | |
| Great willowherb | *Epilobium hirsutum* | | | ✓ | | ✓ | | | ✓ | | | | |
| Great wood-rush | *Luzula sylvatica* | | ✓ | | | | | | | | | | |
| Greater plantain | *Plantago major* | ✓ | | | | ✓ | | | | | | | |
| Grey willow | *Salix cinerea* | | | ✓ | | | | | | | | | |
| Griselinia | *Griselinia* spp | | | | | | | | | | | | ✓ |
| Ground ivy | *Glechoma hederacea* | | ✓ | | | | | | | | | | |
| Hairy bittercress | *Cardamine hirsuta* | ✓ | ✓ | | | | | | | | | | |
| Hairy brome | *Bromopsis ramosa* | | | ✓ | | ✓ | | | | | | | |
| Hard rush | *Juncus inflexus* | | ✓ | | | | | | | | | | |
| Hawkweed | *Hieracium* agg. | | | | | ✓ | | | | | | | |
| Hawthorn | *Cratageous monogyna* | | | | | ✓ | | | | | | | |
| Hazel | *Corylus avellanna* | | ✓ | ✓ | | | | | | | ✓ | | |
| Hedge bindweed | *Calystegia sepium* | | ✓ | ✓ | | | | | ✓ | | | | |
| Hedge woundwort | *Stachys sylvatica* | | | ✓ | | ✓ | | | | | | | |
| Herb robert Geranium robertanium | *Geranium robertanium* | ✓ | ✓ | ✓ | | ✓ | | | ✓ | | | | |
| Hogweed | *Heracleum sphondylium* | ✓ | | ✓ | | | | | | | | | |
| Holly | *Ilex aquifolium* | | ✓ | ✓ | | | | | | | | | |
| Honeysuckle | *Lonicera periclymenum* | | ✓ | ✓ | | | | | | | | | |
| Horse chestnut | *Aesculus hippocastanum* | | ✓ | | | | | | | | ✓ | | |
| Ivy | *Hedera helix* | | ✓ | ✓ | | ✓ | | | | | | | |
| Juniper | *Juniperus communis* | | | | | | | | | | | | ✓ |
| Knotgrass | *Polygonum aviculare* | | | ✓ | | | | | | | | | |
| Knotted wrack | *Ascophyllum nodosum* | | | | | | | ✓ | | | | | |
| Lawson's cypress | *Chamaecyparis lawsoniana.* | | | | | | | | | | | | ✓ |
| Lesser spearwort | *Ranunculus flammula* | | | | | | | | | | | ✓ | |
| Meadowsweet | *Filipendula ulmaria* | | | | | | | | | | | ✓ | |
| Navelwort | *Umbilicus rupestris* | | | | | | | | ✓ | | | | |

| Common name | Scientific Name | GA1 | WD1 | WL1 | BL3 | GS2 | CC1 | LS1 | BL1 | BC1 | WL2 | GS4) | WS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nettle | *Urtica dioica* | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | |
| Oats | *Avena Sativa* | | | | | | | | | ✓ | | | |
| Parsley water dropwort | *Oenanthe lachenalii* | | | | | | | | | | | | |
| Perennial Rye-grass | *Lolium perenne* | ✓ | | | | ✓ | | | | | | | |
| Perennial sow-thistle | *Sonchus arvensis* | | | | | | | | | | | | |
| Plicate sweet-grass | *Glyceria notata* | | | | | | | | | | | | |
| Polypody fern | *Polypodium* sp. | | | | | | ✓ | | ✓ | | | | |
| Poplar | *Populus spp* | | | | | | | | | | ✓ | | |
| Portugal laurel | *Prunus lusitanica* | | | | | | | | | | | | ✓ |
| Potatoe | *Solanum tuberosum* | | | | | | | | | ✓ | | | |
| Prickly sow-thistle | *Sonchus asper* | | | | | | | | | | | | |
| Primrose | *Primula vulgaris* | | ✓ | | | ✓ | | | | | | | |
| Purple loosestrife | *Lythrum salicaria* | | | ✓ | | | | | | | | | |
| Red clover | *Trifloium pratense* | ✓ | | | ✓ | ✓ | | | | | | | |
| Red fescue | *Festuca rubra* | ✓ | | | | ✓ | | | ✓ | | | ✓ | |
| Redshank | *Persicaria maculosa* | | | | | | | | | | | | |
| Red valerian | *Centranthus ruber* | | | | | | | | ✓ | | | | |
| Remote sedge | *Carex remota* | | | | | | | | | | | ✓ | |
| Rhubarb | *Rheum rhabarbarum* | | | | | | | | | | | | |
| Ribwort Plantain | *Plantago lanceolata* | ✓ | ✓ | | | ✓ | | | | | | | |
| Scarlet pimpernel | *Anagallis arvensis* | | | | | | | | | | | | |
| Scots pine | *Pinus sylvestris* | | ✓ | | | | | | | | ✓ | | |
| Self-heal | *Prunella vulgaris* | | ✓ | ✓ | | ✓ | | | | | | | |
| Sessile oak | *Quercus petraea* | | ✓ | | | | | | | | | | |
| Sharp-flowered rush | *Juncus acutiflorus* | | | | | | | | | | | | |
| Sheep's fescue | *Festuca ovina* | ✓ | | | | | | | | | | | |
| Silverweed | *Potentilla anserina* | ✓ | | ✓ | | ✓ | | | | | | ✓ | |
| Sitka spruce | *Picea sitchensis* | | ✓ | | | | | | | | | | |
| Snowberry | *Symphoricarpos albus* | | | | | | | | | | | | ✓ |
| Soft rush | *Juncus effussus* | | | | | | | | | | | ✓ | |
| Soft shield-fern | *Polystichum setiferum* | | ✓ | | | | | | | | | | |
| Spear thistle | *Cirsium vulgare* | ✓ | | | | ✓ | | | | | | | |
| Square-stalkedSt. John's wort | *Hypericum tetrapterum* | | | | | | | | | | | | |
| Sycamore | *Acer pseudoplatanus* | | ✓ | ✓ | | | | | | | ✓ | | |
| Tufted vetch | *Vicia cracca* | ✓ | ✓ | | | ✓ | | | | | | | |
| Velvet bent | *Agrostis canina* | ✓ | | | | ✓ | | | | | | | |
| Water mint | *Mentha aquatica* | | | | | | | | | | | ✓ | |
| Wheat | *Triticum sativum* | | | | | | | | | ✓ | | | |
| White clover | *Trifolium repens* | | | | | ✓ | | | | | | ✓ | |
| Wild strawberry | *Fragaria vesca* | | ✓ | | | | | | | | | | |
| Wood dock | *Rumex sanguineus* | | ✓ | | | | | | | | | | |

| Common name | Scientific Name | GA1 | WD1 | WL1 | BL3 | GS2 | CC1 | LS1 | BL1 | BC1 | WL2 | GS4) | WS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wood sedge | *Carex sylvatica* | | ✓ | | | | | | | | | | |
| Wood sorrel | *Oxalis acetosella* | | ✓ | | | | | | | | | | |
| Yellow pimpernel | *Lysimachia nemorum* | | | ✓ | | ✓ | | | | | | | |
| Yorkshire fog | *Holchus lanatus* | ✓ | | | | ✓ | | | | | | | |

Improved Agricultural Grassland GA1
Mixed broadleaved Woodland WD1
Hedgerows WL1
Buildings and artificial surfaces BL3
Grassy verges GS2
Sea walls, piers and jetties CC1
Shingle and gravel shores LS1
Stones walls BL1
Arable crops BC1
Treelines WL2
Wet grassland GS4
Ornamental/ non native shrub WS3

# **Appendix 4** Bird counts from Cork Harbour

**Table A4.1** Total numbers of waterfowl recorded at Cork Habour during the IWeBS surveys of 1999-2000, 2000-2001, 2001-2002, 2002-2003, 2003-2004 and 2004-2005 (Boland & Crowe, 2006).

| Year | Numbers |
|---|---|
| 1999 to 2000 | 30,339 |
| 2000 to 2001 | 28,686 |
| 2001 to 2002 | 26,476 |
| 2002 to 2003 | 29,551 |
| 2003 to 2004 | 30,368 |
| 2004 to 2005 | 31,198 |
| **Mean** | **29,398** |

**Table A4.2** Five year mean counts (1998-99 to 2002-03, extracted from Gittings, 2006) and maximum counts for species which are recorded in Cork Harbour. Internationally important species are shown in bold. Nationally important species are shown in italics.

| Species | Mean | Max |
|---|---|---|
| *Dunlin* | *6160* | *8847* |
| *Lapwing* | *4615* | *7267* |
| *Golden Plover* | *4318* | *6888* |
| **Black-tailed Godwit** | **2232** | **3162** |
| *Curlew* | *1919* | *2927* |
| **Redshank** | **1765** | **2269** |
| *Wigeon* | *1561* | *1931* |
| *Shelduck* | *1496* | *1903* |
| *Oystercatcher* | *1467* | *1698* |
| *Teal* | *1184* | *1492* |
| *Mallard* | *505* | *671* |
| *Cormorant* | *360* | *556* |
| *Bar-tailed Godwit* | *263* | *477* |
| *Great Crested Grebe* | *216* | *287* |
| *Turnstone* | *123* | *166* |
| Knot | 100 | 306 |
| *Shoveler* | *95* | *148* |
| *Red-breasted Merganser* | *95* | *128* |
| Grey Heron | 80 | 114 |
| *Little Grebe* | *57* | *60* |
| Ringed plover | 57 | 78 |
| *Pintail* | *51* | *74* |
| *Grey Plover* | *47* | *108* |
| *Greenshank* | *45* | *61* |
| Coot | 39 | 96 |
| Mute swan | 34 | 46 |
| *Little Egret* | *33* | *61* |
| Tufted duck | 33 | 46 |
| Pochard | 23 | 38 |
| Moorhen | 23 | 28 |
| Goldeneye | 18 | 28 |
| Great Northern Diver | 3 | 8 |

## **Appendix 5** Protected mammal species

**Table A.5.1** Protected mammal species recorded from the 40km square within which the proposed development site is located, comprising OS W66, W67, W76, W77, W86, W87, W96, W97. Based on Hayden and Harrington (2000).

| Species | Indication of population | Level of Protection |
|---|---|---|
| Badger | Found throughout Ireland | Wildlife Act, though exceptions are written into the Act for road building. Appendix III Bern Convention |
| Daubenton's bat | Distributed widely through Ireland | Irish Red Data Book 'Internationally important', Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention. |
| Common pipistrelle | Found throughout Ireland | Irish Red Data Book 'Internationally important', Annex IV of the EU Habitats Directive and Appendix II if the Bern Convention. |
| Soprano pipistrelle | Found throughout Ireland | Irish Red Data Book 'Internationally important', Annex IV of the EU Habitats Directive and Appendix II if the Bern Convention. |
| Whiskered Bat | Distributed widely through Ireland | Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention. |
| Natterer's Bat | Distributed widely through Ireland | Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention. |
| Leisler's Bat | Distributed widely through Ireland | Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention. |
| Brown Long Eared Bat | Distributed widely through Ireland | Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention. |
| Hedgehog | Found throughout Ireland | Appendix III of the Bern Convention. |
| Irish stoat | Found throughout Ireland | Appendix III of the Bern Convention. |
| Pygmy shrew | Found throughout Ireland | Appendix III of the Bern Convention. |
| Otter | Found throughout Ireland | Annexe II and IV of Habitats Directive Appendix III of the Bern Convention. |
| Irish (mountain) hare | Found throughout Ireland | Irish Red Data Book 'Internationally important'. Annex V of the Habitats Directive. Appendix III Bern Convention. |
| Red squirrel | Distributed widely through Ireland | Protected under the Wildlife Act; classified as near threatened in a global context in the 2000 IUCN Red List of Threatened Species. |
| Fallow deer | Distributed widely through Ireland | Wildlife Act, 1976. |
| Common dolphin | Distributed widely around Ireland, particularly around the south and west coasts. | Annex IV of the EU Habitats Directive. Whale Fisheries Act, 1937. |

| Species | Indication of population | Level of Protection |
|---|---|---|
| Common porpoise | Widespread in Irish sea. Typically inshore animals. Populations of major significance found off the W. Coast. | Annex II of the EU Habitats Directive. Whale Fisheries Act, 1937. |
| Long finned pilot whale | Main concentrations seen off west coast. Occasionally seen in Irish sea. | Annex IV of the EU Habitats Directive. Whale Fisheries Act, 1937. |

# **Appendix 6** Marine habitat and macrofauna assessment

**Table A6.1** Habitats and biotopes recorded at the quadrate stations surveyed.

| Code | Location | Fossitt Habitat Type | Biotope |
|---|---|---|---|
| Q1 | Crosshaven. North of town centre on the southern shore. | Mixed sediment shore (LS5). Sheltered shore, poorly sorted mix of sediments. Supports some fucoids. | *Littoral mixed sediments.* |
| Q2 | Crosshaven. Just east of the town centre on the southern shore. | Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. | "*Fucus serratus* on full salinity lower eulittoral mixed substrata". |
| Q3 | Ringaskiddy. East-facing beach. | Moderately exposed rocky shore (LR2). Shore of boulders and stable cobbles. Incomplete cover of fucoids(Sampled). The shore also contains a large area of sand shore (LS2). | *Moderately exposed littoral rock.* |
| Q4 | Ringaskiddy. East-facing beach. | Moderately exposed rocky shore (LR2). Shore of bedrock, boulders and stable cobbles. Incomplete cover of fucoids. | "*Mytilus edulis* and *Fucus vesiculosis* on moderately exposed mid-eulittoral rock". |
| Q5 | Ringaskiddy. North-facing shore. Opposite Whitepoint, Cobh. | Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. | "*Fucus vesiculosis* on mid-eulittoral mixed substrata". |
| Q6 | Monkstown. Northern end of town on the western shore. North of pier. | Mixed substrata shore (LR4). Close to sea wall and pier (CC1). Sheltered location. | "*Mytilus edulis* beds on littoral mixed substrata". |
| Q7 | Monkstown. Just south of River Ferry. | Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. | "*Mytilus edulis* beds on littoral mixed substrata". |
| Q8 | Monkstown / Passage West. North of River Ferry. | Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. | "*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock". |
| Q9 | Passage West. Near slipway at bottom of public green. | Sheltered rocky shore (LR3). Boulders and cobbles with dense growth of fucoids. | "*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock". |
| Q10 | Great Island. Just north of River Ferry on east of R. Lee. | Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. | "Mytilus edulis beds on littoral mixed substrata". |
| Q11 | Great Island. South of River Ferry on east of R. Lee. | Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. | "*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock". |
| Q12 | Whitepoint, Cobh. | Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. Dense growth of fucoids. | - |
| Q13 | East Beach, Cobh. Bottom of the steps to the east of Lynch's Quay. | Shingle and gravel shore (LS1). Moderately exposed shore with accumulations of mobile rocky material. Near sea walls (CC1). | "Barren littoral shingle". |
| Q14 | Cobh. East of red chimney stack. | Moderately exposed rocky shore (LR2). Shore of boulders and stable cobbles. No fucoids present. | "*Mytilus edulis* beds on littoral mixed substrata". |
| Q15 | Cobh. Just east of fishing quay. | Moderately exposed rocky shore (LR2). Shore of bedrock, boulders and stable cobbles. | *Moderately exposed littoral rock.* |

**Table A6.2** Habitats and biotopes recorded at the core stations surveyed.

| Code | Location | Fossitt Habitat Type | JNCC Biotope Type |
|---|---|---|---|
| C1 | Carrigaline. Downstream of bridge. On the north side of the channel. | Mud shore (LS4). Sheltered area of variable salinity. | "*Hediste diversicolor* and *Copophium volutar* in littoral mud". |
| C2 | Carrigaline. Downstream of bridge. On the north side of the channel. | Mud shore (LS4). Sheltered area of variable salinity. | "*Hediste diversicolor* in littoral mud". |
| C3 | Carrigaline. Further Downstream of bridge. On the north of the channel. | Mud shore (LS4). Sheltered area of variable salinity. | "*Hediste diversicolor* in littoral mud". |
| C4 | Crosshaven. East of town centre on the southern shore. | Mud shore (LS4). Sheltered area of variable salinity. | "*Hediste diversicolor* in littoral mud". |
| C5 | Glenbrook, Passage West. | Mud shore (LS4). Sheltered area of variable salinity. | "*Hediste diversicolor* in littoral mud". |
| C6 | Great Island. South of River Ferry on east of R. Lee. | Mud shore (LS4). Sheltered area of variable salinity. | "*Hediste diversicolor* in littoral mud". |
| C7 | Rushbrook, Great Island. | Mud shore (LS4). Sheltered area of variable salinity. | "Polychete dominated mid-estuarine mud shores". |
| C8 | Cobh. South facing mudflat at Whitepoint. | Mud shore (LS4). Sheltered area of variable salinity. | "Polychete dominated mid-estuarine mud shores". |

**Table A6.3** Habitats and biotopes recorded at the grab stations surveyed.

| Code | Location | Fossitt Habitat Type | JNCC Biotope Type |
|---|---|---|---|
| G1 | IDA outfall pipe, to the west of Carlisle fort. | Infralittoral mixed sediments (SS4). Sea inlets and Bays (MW2) | Sublittoral mixed sediment in variable salinity. |
| G2 | IDA outfall pipe, to the west of Carlisle fort. | Infralittoral muddy sands (SS2). Sea inlets and Bays (MW2) | Sublittoral mixed sediment in variable salinity. |
| G3 | Proposed pipeline crossing at West Passage. North side. | Infralittoral muds (SS3). Estuary (MW4). | Sublittoral mixed sediment in variable salinity. |
| G4 | Proposed pipeline crossing at West Passage. South side. | Infralittoral muds (SS3). Estuary (MW4). | Sublittoral mixed sediment in variable salinity. |

**Table A6.4** Selected characteristics of the 8 sites assessed using core sampling during June 2007.

| Site No. | Mounds / casts | Burrows / holes | Tubes | Algal mat | Waves / dunes (>10cm high) | Ripples (<10cm high) | Drainage channels / creeks | Standing water | Subsurf. clay / mud | Subsurf. silt / flocculent | Firmness (Firm - Soft) | Stabilty (Stable - Mobile) | Sorting (Well - Poor) | Anoxic layer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | | | | | | | Present | Present | | Present | 4 | 4 | 1 | 3 |
| C2 | | | | | Present | | | Present | | Present | 4 | 4 | 2 | 1 |
| C3 | | | | | | Present | Present | | Present | Present | 4 | 4 | 2 | 3 |
| C4 | | | | | | | | Present | Present | | 4 | 4 | 2 | 1 |
| C5 | Present | Present | | | | | | Present | Present | | 4 | 4 | 2 | 2 |
| C6 | | Present | Present | | | Present | | Present | | | 4 | 4 | 2 | 4 |
| C7 | | Present | | Present | | Present | | Present | Present | | 4 | 4 | 1 | 3 |
| C8 | Present | | | | Present | | | Present | Present | | 4 | 4 | 2 | 4 |

For the anoxic layer depth: 1=not visible, 2= >20cm, 3= 5-20cm, 4= 1-5cm, 5=<1cm.

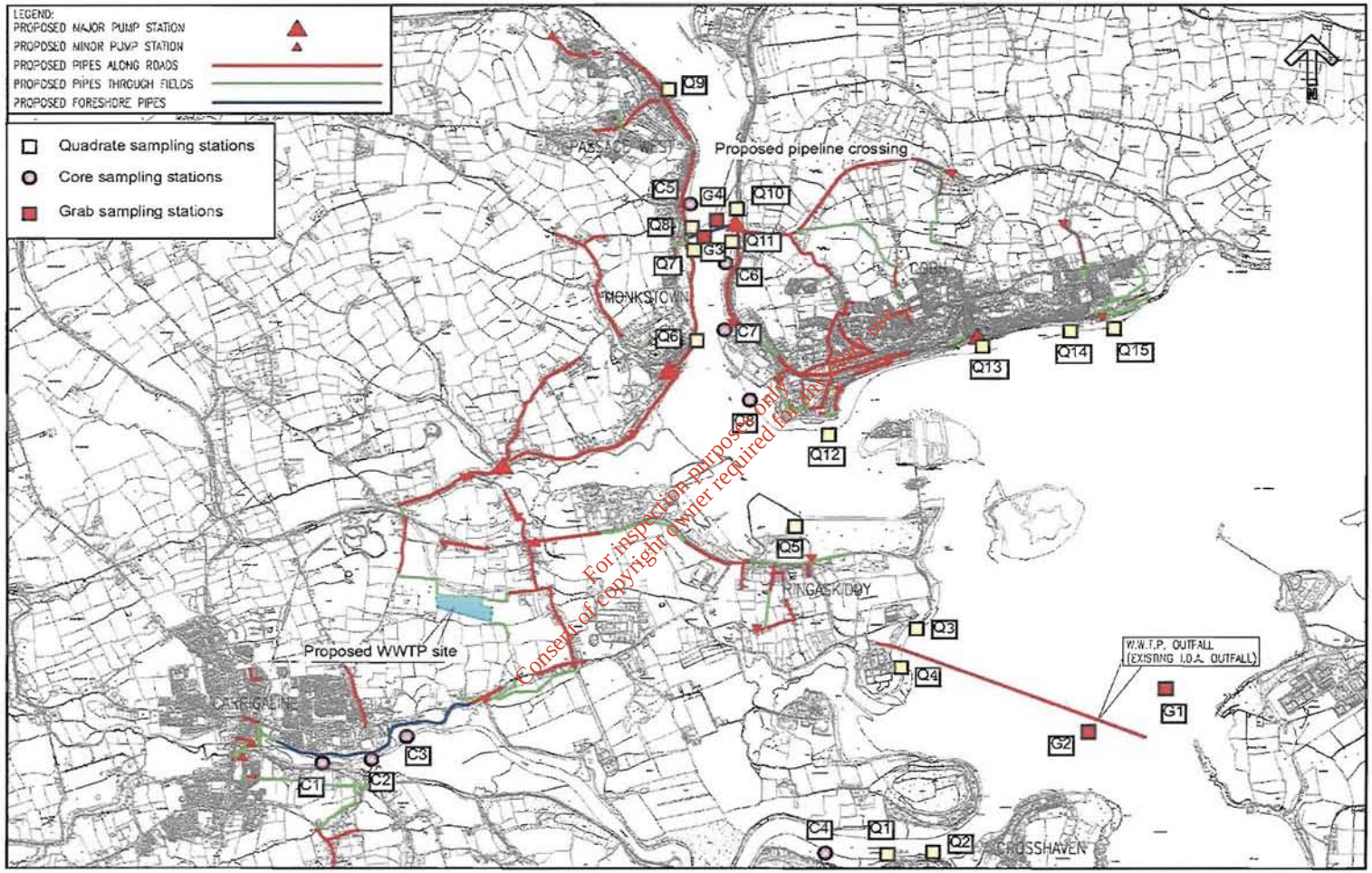




**Figure A6.1** Location of marine / estuarine sampling sites.

**Table A6.5** Numbers of macrofauna recorded at the 8 sites investigated using core sampling during June 2007.

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|
| **SEGMENTED WORMS** (Annelida, Polychaeta) | | | | | | | | |
| Family Naididae | 1 | | | | | | | |
| Ragworm (Family Nereidae) | | | | | | | | |
| *Hediste diversicolor* | 7 | 43 | 57 | 12 | 21 | 3 | | |
| Catworm (Family Nephytidae) | | | | | | | 7 | |
| *Nephtys sp.* | | | | 2 | | | | 4 |
| Family Arenicolidae | | | | | | | | |
| Lugworm *Arenicola marina* | | | | | | 1 | | |
| **CRUSTACEANS** (Amphipoda) | | | | | | | | |
| Family Corophidae | | | | | | | | |
| *Corophium volutator* | 16 | | | | | | | 1 |
| **CRABS** (Crustacea, Decapoda) | | | | | | | | |
| Family Portunidae | | | | | | | | |
| *Carcinus maenas* | | | 1 | | | | | |
| **BIVALVES** (Mollusca, Bivalva) | | | | | | | | |
| *Cerastoderma edule* | | | | | | | | 1 |
| Family Mactridae | | | | | | | | |
| *Spisula elliptica* | | 1 | 1 | | | | | |
| **SEA ANENOMES** (Cnidaria, Actinaria) | | | | | | | | |
| Family Actiniidae | | | | | | 1 | | |
| **Number of species** | **3** | **2** | **3** | **2** | **1** | **3** | **1** | **3** |
| **Total (n)** | **24** | **44** | **59** | **14** | **21** | **5** | **7** | **6** |

**Table A6.6** Weights of macrofauna recorded at the 8 sites investigated using core sampling during June 2007.

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|
| **SEGMENTED WORMS** (Annelida, Polychaeta) | | | | | | | | |
| Family Naididae | 0.09 | | | | | | | |
| Ragworm (Family Nereidae) | | | | | | | | |
| *Hediste diversicolor* | 1.33 | 21.7 | 27.2 | 15.2 | 17.9 | 0.11 | | |
| Catworm (Family Nephytidae) | | | | | | | | |
| *Nephtys sp.* | | | | 3.63 | | | 7.54 | 0.28 |
| Family Arenicolidae | | | | | | | | |
| Lugworm *Arenicola marina* | | | | | | 6.04 | | |
| **CRUSTACEANS** (Amphipoda) | | | | | | | | |
| Family Corophidae | | | | | | | | |
| *Corophium volutator* | 0.39 | | | | | | | 0.08 |
| **CRABS** (Crustacea, Decapoda) | | | | | | | | |
| Family Portunidae | | | | | | | | |
| *Carcinus maenas* | | | 23.7 | | | | | |
| **BIVALVES** (Mollusca, Bivalva) | | | | | | | | |
| *Cerastoderma edule* | | | | | | | | 0.8 |
| Family Mactridae | | | | | | | | |
| *Spisula elliptica* | | 0.58 | 0.97 | | | | | |
| **SEA ANENOMES** (Cnidaria, Actinaria) | | | | | | | | |
| Family Actiniidae | | | | | | 1 | | |
| **Number of species** | **3** | **2** | **3** | **2** | **1** | **3** | **1** | **3** |
| **Total (g)** | **1.81** | **22.3** | **51.9** | **18.8** | **17.9** | **7.15** | **7.54** | **1.16** |



**Table A6.7** Numbers of macrofauna recorded at the 4 sites investigated using grab sampling during June 2007.

| | C1 | C2 | C3 | C4 |
|---|---|---|---|---|
| **SEGMENTED WORMS** (Annelida, Polychaeta) | | | | |
| Ragworm (Family Nereidae) | | | | |
| *Hediste diversicolor* | 0 | 0 | 0 | 1 |
| | | | | |
| **Total (n)** | **0** | **0** | **0** | **1** |

**Table A6.8** Numbers of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

| Species/group | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Q15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CRUSTACEANS** (Amphipoda) | | | | | | | | | | | | | | | |
| Family Gammaridae | | | | | | | | | | | | | | | |
| *Chaetogammarus marinus* | 1 | | | | | | | | | | | | | | |
| *Gammarus deubeni* | | | 1 | | 4 | | | | 14 | | | | | 100 | |
| Family Corophiidae | | | | | | | | | | | | | | | |
| Mud shrimp *Corophium volutator* | | | | | | | | | | | 20 | | | | |
| **BARNACLES** (Crustacea, Family Balanidae) | | | | | | | | | | | | | | | |
| *Elminius modestus* | | 100+ | 100+ | | | 100+ | 100+ | | 100+ | 100+ | 100+ | 100+ | | 100+ | 100+ |
| *Semibalanus balanoides* | | | | 5+ | | 100+ | | | | | | | | | |
| *Balanus crenatus* | | | 20+ | | | | 100+ | | | | 100+ | | | | |
| **CRABS** (Crustacea, Decapoda) | | | | | | | | | | | | | | | |
| Family Portunidae | | | | | | | | | | | | | | | |
| Green shore crab *Carcinus maenas* | 2 | 2 | 7 | 2 | 3 | 15 | 38 | 1 | 28 | 16 | 8 | 2 | | 24 | 28 |
| **SNAILS** (Mollusca, Gastropoda) | | | | | | | | | | | | | | | |
| Topshells (Family Trochidae) | | | | | | | | | | | | | | | |
| Purple/Flat topshell *Gibbula umbilicalis* | | | 3 | | 1 | | | | | | | | | | 12 |
| Grey topshell *Gibbula cineraria* | | 5 | 7 | | | | | | | | | 2 | | 4 | |
| Family Patellidae | | | | | | | | | | | | | | | |
| Common limpet *Patella vulgata* | | 1 | 2 | 4 | 6 | 2 | | | | | | 1 | | | 36 |
| Winkles (Family Littorinidae) | | | | | | | | | | | | | | | |
| Edible periwinkle *Littorina littorea* | | 50 | 29 | 3 | 59 | 29 | 104 | | 1 | 36 | 8 | | | 122 | 328 |
| Flat periwinkle *Littorina obtusata* | 3 | | 5 | | 4 | | | | 3 | | 4 | | | | |
| Flat periwinkle *Littorina mariae* | | 2 | 1 | | 5 | | | | 5 | | | | | | |
| *Littorina rudis* | | | | | 5 | | | | | 8 | | | | 681 | 228 |
| **CHITONS** (Mollusca, Family Ischnochitonidae) | | | | | | | | | | | | | | | |
| *Lepidochitona cinereus* | | 2 | | | 1 | | | | | | | | | | |
| *Lepidochitona asellus* | | | | | | 1 | | | | | | | | | |
| **ISOPODS** (Crustacea, Ostracoda) | | | | | | | | | | | | | | | |
| Family Sphaeromatidae | | | | | | | | | | | | | | | |
| *Lekanespharea rugicauda* | | | | | | | | | | | | | | 8 | |
| **BIVALVES** (Mollusca, Bivalva) | | | | | | | | | | | | | | | |

**Table A6.8 (Continued)** Numbers of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

| **Species/group** | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** | **Q6** | **Q7** | **Q8** | **Q9** | **Q10** | **Q11** | **Q12** | **Q13** | **Q14** | **Q15** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family Mytilidae | | | | | | | | | | | | | | | |
| Common mussel *Mytilus edulis* | | 1 | 2 | 4 | 4 | 5 | 360 | 21 | 19 | 476 | 52 | | | 152 | 220 |
| Family Cardiidae | | | | | | | | | | | | | | | |
| *Common cockle Cerastoderma edule* | | | | | | | | 1 | | 4 | | 1 | | | |
| **STARFISH** (Echinodermata, Asteroidea) | | | | | | | | | | | | | | | |
| Family Asteridae | | | | | | | | | | | | | | | |
| Common starfish *Asterina rubens* | | | | | | 1 | | | 1 | | 4 | | | | |
| **SEA ANENOMES** (Cnidaria, Actinaria) | | | | | | | | | | | | | | | |
| Snakelocks anemone *Anemonia viridis* | | 2 | 1 | 1 | 1 | | | | | 8 | | | | | |
| Family Actiniidae | | | | | | | | | | | | | | | |
| Beadlet anemone *Actinia equina* | | | | | | | 2 | | 8 | 12 | 8 | | | 16 | 3 |
| **SEGMENTED WORMS** (Annelida, Polychaeta) | | | | | | | | | | | | | | | |
| Family Serpulidae | | | | | | | | | | | | | | | |
| Keel worm *Pomatoceros lamarcki* | | 100+ | | | | | | | 20+ | | | 20+ | | | 32 |
| Ragworm (Family Nereidae) | | | | | | | | | | | | | | | |
| *Hediste diversicolor* | | | | | | 1 | | | | | | | | | |
| Family Cirratulidae | | | | | | | | | | | | | | | |
| *Cirratulus cirratus* | | | | | | | | | 5 | | 4 | 3 | | | |
| Family Terebellidae | | | | | | | | | | | | | | | |
| Sand mason *Lanice conchilega* | | 1 | 1 | | | | | 27 | | | | 3 | | | |
| **No of species** | **3** | **11** | **13** | **6** | **11** | **9** | **6** | **4** | **11** | **8** | **11** | **8** | **0** | **9** | **9** |

**Table A6.9** Weights (g) of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

| Species/group | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Q15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CRUSTACEANS** (Amphipoda) | | | | | | | | | | | | | | | |
| Family Gammaridae | | | | | | | | | | | | | | | |
| *Chaetogammarus marinus* | 0.09 | | | | | | | | | | | | | | |
| *Gammarus deubeni* | | | 0.08 | | 0.45 | | | | 0.6 | | | | | 100 | |
| Family Corophiidae | | | | | | | | | | | | | | | |
| Mud shrimp *Corophium volutator* | | | | | | | | | | | 0.52 | | | | |
| **BARNACLES** (Crustacea, Family Balanidae) | | | | | | | | | | | | | | | |
| *Elminius modestus* | | - | - | | | - | n/a | | n/a | n/a | n/a | n/a | | n/a | n/a |
| *Semibalanus balanoides* | | | | - | | - | | | | | | | | | |
| *Balanus crenatus* | | | - | | | | n/a | | | | 100+ | | | | |
| **CRABS** (Crustacea, Decapoda) | | | | | | | | | | | | | | | |
| Family Portunidae | | | | | | | | | | | | | | | |
| Green shore crab *Carcinus maenas* | 1.72 | 1.19 | 13.5 | 22.9 | 22.7 | 8.67 | 44.9 | 82.4 | 22.3 | 112 | 10.4 | 48.4 | | 29.5 | 18.9 |
| **SNAILS** (Mollusca, Gastropoda) | | | | | | | | | | | | | | | |
| Topshells (Family Trochidae) | | | | | | | | | | | | | | | |
| Purple/Flat topshell *Gibbula umbilicalis* | | | 6.91 | | 0.44 | | | | | | | | | | 1.96 |
| Grey topshell *Gibbula cineraria* | | 8.66 | 41.4 | | | | | | | | | 4.94 | | 4.02 | |
| Family Patellidae | | | | | | | | | | | | | | | |
| Common limpet *Patella vulgata* | | 0.1 | 21.3 | 69.5 | 92.1 | 40.4 | | | | | | 8.21 | | | 80.4 |
| Winkles (Family Littorinidae) | | | | | | | | | | | | | | | |
| Edible periwinkle *Littorina littorea* | | 229 | 104 | 10.4 | 140 | 63.2 | 567 | | 6.74 | 217 | 37.5 | | | 113 | 387 |
| Flat periwinkle *Littorina obtusata* | 4.85 | | 9.9 | | 5.43 | | | | 2.4 | | 4 | | | | |
| Flat periwinkle *Littorina mariae* | | 0.39 | 0.72 | | 4.63 | | | | 0.8 | | | | | | |
| *Littorina rudis* | | | | | 2.54 | | | | | 6.42 | | | | 118 | 45.2 |
| **CHITONS** (Mollusca, Family Ischnochitonidae) | | | | | | | | | | | | | | | |
| *Lepidochitona cinereus* | | 0.49 | | | 0.41 | | | | | | | | | | |
| *Lepidochitona asellus* | | | | | | 0.39 | | | | | | | | | |
| **ISOPODS** (Crustacea, Ostracoda) | | | | | | | | | | | | | | | |
| Family Sphaeromatidae | | | | | | | | | | | | | | | |
| *Lekanespharea rugicauda* | | | | | | | | | | | | | | 1.2 | |

**Table A6.9 (Continued)** Weights (g) of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

| Species/group | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Q15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BIVALVES** (Mollusca, Bivalva) | | | | | | | | | | | | | | | |
| Family Mytilidae | | | | | | | | | | | | | | | |
| Common mussel *Mytilus edulis* | | 0.73 | 0.1 | 24.9 | 23.8 | 73.2 | 5000 | 642 | 107 | 5520 | 1679 | | | 1300 | 1210 |
| Family Cardiidae | | | | | | | | | | | | | | | |
| *Common cockle Cerastoderma edule* | | | | | | | | 21.8 | | 80.4 | | 25 | | | |
| **STARFISH** (Echinodermata, Asteroidea) | | | | | | | | | | | | | | | |
| Family Asteridae | | | | | | | | | | | | | | | |
| Common starfish *Asterina rubens* | | | | | | 65 | | | 0.98 | | 6.16 | | | | |
| **SEA ANENOMES** (Cnidaria, Actinaria) | | | | | | | | | | | | | | | |
| Snakelocks anemone *Anemonia viridis* | | | 2.61 | 1.11 | 0.51 | | | | | 3.64 | | | | | |
| Family Actiniidae | | | | | | | | | | | | | | | |
| Beadlet anemone *Actinia equina* | | | | | | | 1.22 | | 1.52 | 6.4 | 6.84 | | | 10.8 | 1.44 |
| **SEGMENTED WORMS** (Annelida, Polychaeta) | | | | | | | | | | | | | | | |
| Family Serpulidae | | | | | | | | | | | | | | | |
| Keel worm *Pomatoceros lamarcki* | | - | | | | | | | n/a | | | n/a | | | n/a |
| Ragworm (Family Nereidae) | | | | | | | | | | | | | | | |
| *Hediste diversicolor* | | | | | | 0.46 | | | | | | | | | |
| Family Cirratulidae | | | | | | | | | | | | | | | |
| *Cirratulus cirratus* | | | | | | | | | 1.28 | | 1.02 | 0.39 | | | |
| Family Terebellidae | | | | | | | | | | | | | | | |
| Sand mason *Lanice conchilega* | | 0.92 | 0.88 | | | | | 43.3 | | | | 1.29 | | | |
| **No of species** | **3** | **11** | **13** | **6** | **11** | **9** | **6** | **4** | **11** | **8** | **11** | **8** | **0** | **9** | **9** |

# **Appendix 7** Angling and bait collection marks in Cork Harbour

**Table A7.1** The principle shore angling marks in Cork Harbour and the main angling species present (adapted from Dunlop & Green, 1992).

| **Location** | **Main species** **Specimens recorded.* |
|---|---|
| *Seawall, Monkstown* | Codling, conger, ray, dabs, and dogfish |
| *Deepwater Quay* | Conger, ray, codling, whiting*, dabs*, flounder*, coalfish, three bearded rockling*. |
| *Brown's Island* | Thornback ray, plaice, flounder, and dogfish. |
| *Lower Agda Pier* | Flounder, dabs, dogfish and conger. |
| *Carlisle Pier* | Pollack, mackerel, bass, flatfish, codling, thornback ray and homelyn ray. |
| *White Bay* | Plaice*, Bass, flatfish, dogfish, and rays. |
| *Roches Point* | Bass*, pollack, mackerel, conger, three bearded rockling, and ballan wrasse*. |
| *Inch* | Bass*, flatfish, conger, and flounder*. |
| *Ballybranagan* | Bass*, turbot, and flatfish. |

**Table A7.2** The main fishing bait collection areas in Cork Harbour and the main bait species present (adapted from Dunlop & Green, 1992). Distance from proposed storm sewage outfall point is also indicated.

| **Location** | **Main bait species** |
|---|---|
| *Glenbrook* | Crab |
| *Saleen to East Ferry* | Lugworm and peeler crab. |
| *Rostellan to Lower Aghda Pier* | Lugworm |
| *Whitegate Bay* | Lugworm |

# Appendix 3A

# Hydrodynamic and Modelling Report



Mott MacDonald

# Cork Harbour Main Drainage Scheme –

# EIA Modelling Study

**Professor J.P.J. O'Kane PhD, CEng**

**Kevin Barry BE, MEngSc**

Department of Civil & Environmental Engineering

Coláiste na hOllscoile Corcaigh – Ollscoil na hÉireann, Corcaigh

University College Cork – National University of Ireland, Cork



**December 2007**

ucc

Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

# Non-Technical Executive Summary

The lead author of this report was commissioned by Mott MacDonald Pettit (MMP) to undertake a detailed Environmental Impact Assessment of the improvement in water quality as a result of the proposed Lower Harbour Main Drainage Scheme. At present the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline all discharge untreated sewage into Cork Harbour. The proposed scheme will collect this waste and treat it to a secondary standard at a new wastewater treatment plant near Carrigaline. The treated effluent will be discharged through the existing Carrigaline/Crosshaven outfall near Dognose Bank. In spite of increasing population a marked improvement in quality is to be expected for two reasons: (a) the reduction in pollutant load due to the treatment plant, and (b) the increased dilution available downriver when the treated effluent is discharged just inside the mouth of the Outer Harbour. This study quantifies the improvement.



A computer model, called the 'OH_2' model covering an area from the Old Head of Kinsale to the Waterworks weir in Cork City was developed. This model simulates the release, transport and decay of various micro-organisms in Cork Harbour and the surrounding area due to discharges of untreated and treated waste. In order to determine the improvement in water quality the OH_2 model was configured in two different ways. Firstly it was configured to simulate the release of untreated waste from the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline. It was then configured to simulate the release of treated waste from the proposed wastewater treatment plant at Carrigaline.

By comparing the results of these two cases the improvement in water quality can be estimated. A proper comparison requires the same population is used in both cases. In this study we have used the projected population loadings for 2010.

In this Environmental Impact Study three separate micro-organisms have been considered:

1. **Faecal coliform bacteria -** The number of faecal coliforms per 100ml is a recognised standard in the relevant EU Directives. The I (mandatory) and G (guide) values for the Bathing Water Directive are, for faecal coliforms, 2000 counts per 100ml and 100 counts per 100ml respectively. The G (guideline) values for the Shellfish Waters Directive are, for faecal coliforms, less than 300 counts per 100ml in the *shellfish flesh and intervalvular liquid*. We have used the results of the faecal coliform model to predict the concentrations of intestinal enterococci and *Escherichia coli* at the main points of interest in the study.
2. **Norovirus -** The *Norovirus* or "Winter Vomiting bug" is the primary pathogen in outbreaks of gastroenteritis following consumption of raw oysters. There is no standard for seawater at present due to the difficulty of measuring its concentration.
3. **Simple Nitrogen Cascade -** The forcing exerted on the Harbour ecosystem by organic nitrogen, nitrate and ammonia is examined using a simplified nitrogen cascade model.



In this report we have not considered discharges of treated effluent from Carrigrennan, Midleton or Cloyne or the untreated discharges from the outfalls serving the towns on the eastern side of the harbour. Neither have we considered the impact of stormwater overflows. Our results are therefore not representative of absolute water quality. They simply show the improvement to be expected from the proposed treatment plant. As the models in this report are linear, the relative concentrations are with respect to an unspecified background.

We have examined the measurements of background concentrations of coliforms and nitrogen from the harbour. There are no measurements of *Norovirus* in water anywhere in the world. The sampling error and the spatio-temporal variability of coliforms and nitrogen throughout the harbour make any estimate of the background concentrations very uncertain. Consequently, in our

view, it is sufficient to model the improvement in concentrations due to the proposed treatment plant and outfall.

It is possible to model the background concentrations but this would require substantially more resources and time than were available for this comparative study.

The results of the study may be summarised as follows.

**Faecal Coliform Results**

Our results show that the proposed treatment plant will reduce the number of faecal coliforms in Cork Harbour and the waters outside Roches Point. We have found that a 95% relative reduction in the maximum number of faecal coliforms may be expected for Lough Mahon, the Inner Harbour, the East and West Passages and the area around the Ringaskiddy ferry terminal. For the Outer Harbour we have found that an 80% relative reduction in the maximum number of faecal coliforms may be expected.



For the case of untreated waste being discharged from the relevant towns we found that the maximum concentrations of faecal coliforms ranged across the harbour from 2 to 1500 counts per 100ml. The areas immediately adjacent to the outfalls have the highest concentrations; areas further away have reduced concentrations due to the mixing and decay of the bacteria.

The equivalent range with the proposed treatment plant in operation is from 2 to 400 faecal coliforms per 100ml representing a significant improvement in water quality.

Adverse wind conditions, or longer-lived bacteria, may increase the maximum concentrations from the proposed treatment plant in certain areas of the outer harbour by as much as 60 – 80 faecal coliforms per 100ml.

We have used conservative estimates for the number of faecal coliforms present in treated sewage. When less conservative values were assumed, we found that there may be a 99% relative reduction in the maximum concentrations of faecal coliforms for Lough Mahon, the Inner harbour, the East and West Passages and

Ringaskiddy with a corresponding 96% relative reduction for the rest of the harbour.

We have found that the concentrations of intestinal enterococci with the proposed treatment plant in operation are very small with the exception of the area immediately surrounding the outfall. The concentrations of *Escherichia coli* are the same as for the Faecal Coliforms as the inputs to both models are identical.

The main conclusion to be reached from the results of the OH_2 model is that the proposed treatment plant will significantly reduce the number of indicator organisms in the upper harbour area. It will also reduce the number of indicator organisms in the outer harbour and waters beyond Roches Point but to a slightly lesser degree.

The I (mandatory) and G (guide) values for the Bathing Water Directive are, for faecal coliforms, 2000 counts per 100ml and 100 counts per 100ml respectively. From the results presented in Chapter 4 we may conclude that the contribution from the proposed treatment plant is several orders of magnitude less than these requirements far the bathing areas.



The G (guideline) values for the Shellfish Waters Directive are, for faecal coliforms, less than 300 counts per 100ml in the shellfish flesh and intervalvular liquid.

Oyster bio-accumulate bacteria and viruses form the surrounding waters. Our models do not account for this complex biological process. We therefore cannot predict the concentrations of bacteria within the flesh; only in the surrounding waters.

We can see from the results presented in Chapter 4 that the contribution from the proposed treatment plant is several orders of magnitude less than these requirements.

### *Norovirus* Results

The *Norovirus* was included as part of this study in order to determine the impact of the proposed treatment plant on the oyster farms[1] and water-contact recreational areas in Cork Harbour. It was found that the proposed treatment will significantly reduce the number of *Norovirus* in Cork Harbour and the waters outside Roches Point leading to an improvement in water quality. There is 90 – 95% relative reduction in the maximum number of *Norovirus* at the oyster farm in the North Channel after the construction of the proposed treatment plant.

For Lough Mahon, the Inner harbour, the East and West Passages as well as the area around Ringaskiddy our results show that a 90% relative reduction in the maximum concentrations of *Norovirus* may be expected with the introduction of the treatment plant. For the rest of the harbour and the area outside Roches Point an 80% relative reduction may be expected.



### Nitrogen Results

Nitrogen in different forms is an important nutrient in the coastal zone. Changes in the distribution of nitrogen can have an impact on the ecological and biological status of an estuary or harbour.

We have examined the impact of the proposed scheme on the ecological and biological status of Cork Harbour by using a simplified model containing three species of nitrogen: organic nitrogen, ammonia and nitrate.

The model quantifies the relative effect of the scheme on the concentration of these three species throughout the harbour and adjacent coast over a test period of ten days. The relative effect is with respect to an unaltered background concentration of each species of nitrogen.

The results reported in this report are estimates of the change in forcing, expressed as changes in the concentrations of the three species of nitrogen, due

[1] There are no designated shellfish production areas in Cork Harbour at present although oysters have been produced at two farms in the past. These are the oyster farms referred to in this report.

to the proposed scheme. They are estimates of relative changes. All the models are linear so the concentrations are with respect to an unspecified background. We leave the judgement of the wider consequences of these relative changes in nutrient forcing to the marine ecologists advising the project.

The time series presented in chapter 6 show an improvement in water quality with a marked reduction in concentrations of organic nitrogen, ammonia and nitrate in all of the fifteen points of special interest to the project compared to the unspecified background following the introduction of treatment. In other words the desired improvement has been demonstrated and quantified in the model under the specified conditions of tide, river flow and wind.

The spatially varying maps of concentration showed that the proposed scheme may reduce considerably the forcing on primary production in the inner harbour (Lough Mahon) and in the North Channel behind Great Island. There is also an improvement throughout the Outer Harbour.

When a more conservative treatment plant removal efficiency is assumed we find that the concentrations of all three species of Nitrogen increase.

# Table of Contents

# List of Figures