5.3 AQUATIC ECOLOGY

5.3.1 CONTEXT

Ecological Consultancy Services Ltd was contracted by McGill Planning Ltd to conduct an assessment of the freshwater ecology of the River Dargle, Bray, Co. Wicklow, with respect to a proposed flood defence scheme.

The proposed flood defence scheme comprises a stretch of approximately 3.5 km, from the N11 bridge down to Bray Harbour, of flood defence measures of varying design, including concrete retaining walls, gabion retaining walls, sheet-piling, embankments and bank excavation, and riverbed re-grading. Some of these measures incorporate the existing flood defences, while the majority will be new measures (See Chapter 2 for more detail on the proposed engineering works).

5.3.2 METHODOLOGY

The freshwater ecological assessments comprised of the following investigations:

a) A survey of macroinvertebrate populations, involving kick sampling at four sites on the River Dargle within the development area.

b) An aquatic macrophyte survey recording aquatic vegetation and habitats at each site.

c) Recording of standard physico-chemical parameters in the field as pH, oxygen levels (% saturation and mg/l of O_2) and conductivity (µS/cm).

d) A survey of salmonid habitats on the River Dargle at macroinvertebrate sampling sites and along the channel adjacent to the proposed development, including investigations of the substrata, macrophytes, water depth and general suitability for spawning, rearing etc.

e) A survey of the estuarine habitat present within the stretch of river adjacent to the proposed development.

f) An otter survey of the study area.

Macroinvertebrates

A freshwater macroinvertebrate survey was undertaken, sampling at four sites on the River Dargle. One macroinvertebrate sample was taken at each site. The samples were collected by 'kick' sampling for 2 minutes in the faster flowing (riffle) areas of the river, using a standard hand net (250 mm width, mesh size 0.5 mm). Stone-washing was also incorporated in sampling effort. Macroinvertebrates collected from each sample were preserved in 70% Industrial Methylated Spirits (IMS) and returned to the laboratory for identification and enumeration. A variety of physical data were recorded at each sampling site reflecting habitat conditions including, substratum type, channel width and channel depth (Appendix C2, Table 3).

Specimens were identified to species level where possible using the following literature, Elliott *et al.* (1988) for Ephemeroptera, Wallace *et al.* (1990) for cased caddis, Edington & Hildrew (1981) for caseless caddis, Hynes (1977) for stoneflies, Friday (1986) for water beetles, Elliott & Mann (1979) for leeches and for general reference to other assorted fauna, Fitter & Manuel (1986), and Nilsson (1996).

Q-indices
The Environmental Protection Agency (EPA) has developed a biological quality ratings index (Q-values) that rates river quality based on the relative abundance of macroinvertebrates that have different sensitivities to organic pollutants (McGarrigle *et al.*, 2002). The indicator groups of sensitivity to pollution are A (sensitive), B (less sensitive), C (tolerant), D (very tolerant) and E (most tolerant). The Q-values derived from this method give an indication of water quality status, with a value of Q5 representing pristine, unpolluted conditions whereas Q1 represents grossly polluted conditions (Appendix C2, Table 4). A Q-value was assigned to each site, where possible, based on the EPA methods (McGarrigle *et al.*, 2002). The Q-index scheme should be based on fauna and other observations from riffles and areas of eroding substrata ideally during late summer months when environmental stressors exert maximum pressure on river systems.

Salmonid habitat survey

Salmonid habitat is well-defined by a number of ecological variables including well-oxygenated water, suitable grade of substratum, suitable temperature and a supply of food and shelter. In addition, other factors such as geology and the physical characteristics of the water body are important in determining its potential as salmonid habitat (Appendix C2, Table 5).

Generally speaking, salmonids migrate to the upper reaches of rivers in order to find environmental conditions suitable for spawning. Salmonids will however also spawn in the lower reaches of streams, and so definitive statements about river stage and spawning potential are difficult to make. Rearing habitats for juveniles can vary from areas of slower flow and small sized substratum to fast flowing areas with substrata composed of larger cobbles and boulders. Optimum conditions usually exist in rivers with a high proportion of pool and riffle sequences to any other morphological feature.

Each of the sites sampled on the River Dargle were assessed for suitability as salmonid spawning and nursery habitats. At each site the habitat quality was assessed for 10 m upstream and downstream. Assessments catalogued the river width, depth, flow type (riffle, glide, pool, cascades), substratum, in-stream vegetation and bankside vegetation. Each was expressed as a percentage at each site. Based on these criteria, the suitability of the habitats at each site for spawning or as nursery areas was assessed. In addition, the general suitability of the river channel along the full length of the proposed flood defence was assessed for suitability for salmonids.

Aquatic macrophytes

The aquatic macrophytes, both bankside and in-stream were surveyed at the macroinvertebrate sampling points and along the river channel generally.

Physico-chemical characteristics of water

Parameters of water quality measured in the field at sample sites were as follows:

- Temperature (°C)

- Conductivity (μS/cm)
- Oxygen (mg/l, % saturation)
- pH (pH units)

Estuarine survey

The estuarine section of the lower River Dargle was surveyed. This comprised the area from the weir downstream to the railway bridge. The species and habitats present were recorded. Data collected in the field and during a previous survey (EcoServe 2005) were used to assign biotopes to the estuarine section.

Otter survey

Otters are protected under a number of pieces of legislation, as well as international conventions. Statutory protection is afforded to the Irish otter population by the Wildlife Act, 1976 and the European Union Habitats Directive (92/43/EEC) (transposed into Irish law by Statutory Instrument 94/1997 European Communities (Natural Habitats) Regulations 1997), where it is listed under Annexes II and IV. The otter is also listed under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendix II of the "Bern Convention" (Convention on the Conservation of European Wildlife and Natural Habitats), both of which Ireland has signed up to.

The current study aimed to record presence of otter (*Lutra lutra*) in the vicinity of proposed development by searching for evidence of otter activity (spraints, footprints and holts) in the area.

Otters are territorial animals, and mark out their territory with droppings (spraints) on prominent features along the river bank, such as large rocks, tree trunks, grassy tussocks or bridge supports. The length of the river bank was examined for any otter sprainting sites. The location of sprainting sites were recorded using a handheld GPS, creating a database for the recorded presence of otters in the surveyed area. This information is important for any future monitoring of the otter distribution within the site.

Field survey work

The field survey work, as detailed above, was carried out on the 6th and 7th of July 2006. The River Dargle was in normal flow conditions, and the weather was changeable, but mostly dry and somewhat overcast.

Criteria for identification of aquatic constraints and assessment of impacts

In assessing the constraints imposed by the aquatic ecology of the River Dargle on the proposed flood defence scheme, a number of elements were investigated for relevance. These included:

- Designated conservation areas and sites proposed for designation within the study area.

- Intertidal and marine areas within the study area.

- Important or potentially important sites for rare or protected flora or fauna that occur within, or in close proximity to, the study area.

- Other relevant conservation designations or programmes (e.g. catchment management schemes, habitat restoration or creation projects, community conservation projects, etc)

- Other features of particular ecological or conservation significance within the study area.

These criteria are based on those presented in the National Roads Authority's Guidelines for Assessment of Ecological Impacts of National Roads Schemes (2006).

The assessment of the magnitude and significance of an impact resulting from the proposed development upon the aquatic ecology of the River Dargle was also made with regard to the guidelines set out in the National Roads Authority's Guidelines for Assessment of Ecological Impacts of National Roads Schemes (2006). The criteria set out in the NRA's guidelines require the evaluation of the site on a scale of importance from Internationally Important to one of low value, locally important. The significance of an impact is based upon the interaction between the value of the site and the duration, character and extent of the impact.

The River Dargle's designation as a salmonid water under the European Communities (Quality of Salmonid Waters) Regulations, 1988 (S.I. 293/1988), which enacts the EU Freshwater Fish Directive (78/659/EEC), and the presence of otters, a species listed under Annex II of the European Union Habitats Directive (92/43/EEC) places the River Dargle as a nationally important site.

5.3.3 DESCRIPTION OF THE RECEIVING ENVIRONMENT

Study area

The River Dargle rises in the Wicklow Mountains, on the slopes of Djouce Mountain. The river flows generally in a north-easterly direction and is joined by a number of tributaries (Glencullen River, Kilmacanoge River and Glencree River) before entering the sea at Bray Harbour.

The River Dargle and its tributaries fall within Hydrometric Area 10 and the Environmental Protection Agency (EPA) has records of the Q-index values for the River Dargle since 1990. These show a downward trend in water quality from Q4-5 (unpolluted, class A) in 1990 to Q3 (moderately polluted, class C) in 2000 for the river 1 km upstream of Bray Bridge.

The section of the river expected to be affected by the proposed flood defence runs from the N11 bridge over the River Dargle down to the Bray Harbour where the river enters the sea. The river bank has been replaced by walls, and other erosion defence measures (boulders and caged rock) at a number of sites along the river section, especially in the lower reaches, below Bray Bridge and at apartment developments upstream. Low water levels occur in the river at times of low rainfall, while the granitic nature of the river catchment causes levels to increase rapidly in times of heavy rainfall, making the River Dargle susceptible to spate conditions.

There is a weir located across the full width of the river channel between Bray Bridge and the Railway. Below the weir, the system is estuarine in nature, supporting brackish water algae and fauna. A number of boulder weirs have been put in place further upstream by the fisheries board to enhance the fisheries potential of the river (Appendix C1, Figure 3; Appendix C3, Plate 2)

The River Dargle is listed as a Salmonid Water under the European Communities (Quality of Salmonid Waters) Regulations, 1988 (S.I. 293/1988), which enacts the EU Freshwater Fish Directive (78/659/EEC).

The River Dargle is one of the rivers that drains the Wicklow Mountains, forming part of the Wicklow Mountains candidate Special Area of Conservation (cSAC) (site code: 002122). The Wicklow Mountains is an extensive, complex upland site and was designated on the basis of the presence of ten habitats listed under Annex I of the EU Habitats Directive, as well as rare and protected plants and animals.

The Glencullen River, a tributary of the River Dargle, flows through the Knocksink Wood cSAC (site code: 000725), which is listed for its petrifying springs and alluvial woodland, both of which are priority habitats.

A third cSAC in the general area is Bray Head (site code: 000714). This site is listed for sea cliffs and of interest for its rare plants and ornithological interest.

The River Dargle flows through the proposed National Heritage Area (pNHA) River Dargle Valley (site code 001754). This designation as a pNHA is based upon it being a fine example of a wooded valley, as well as geological features exposed along the river's course. It is located 2 km downstream of Enniskerry Village.

All the designated sites listed above are a sufficient distance from the development to avoid any potential impact, with the exception of the River Dargle's designation as a Salmonid Water.

Receiving environment

The results of the field surveys carried out (as detailed in the sections above), and also a general discussion of the results and findings are presented below. Kick sample sites are illustrated on the maps in Appendix C1 (Figures 1- 4).

Macroinvertebrates and macrophytes

Site DS1

The kick sample from site DS1, located just upstream of the Swan Stream confluence (Appendix C3, Plate 1), contained 16 species or higher taxa, represented by 2260 individual organisms. Group C taxa (tolerant of organic pollution) were present in excessive numbers (94%) with larvae of the true fly family Chironomidae most common at 54%. Other taxa belonging to Group C included the mayflies *Baetis rhodani*, *Serratella ignita* and *Caenis rivulorum*, the uncased caddis *Rhyacophila dorsalis*, freshwater shrimp *Gammarus* spp., true flies of the families Simuliidae and Tipulidae, adults and larvae of the beetle *Limnius volckmari*, larvae of the beetle *Elmis aenea* and adult *Hydraena gracilis*. Group B taxa (less sensitive to organic pollution) were present in small numbers (2%) and were represented by the stonefly *Leuctra hippopus*. Group A taxa (sensitive to organic pollution) were scarce (<1%), and were represented by the mayfly *Rhithrogena semicolorata*. Group D taxa (very tolerant of organic pollution) were also scarce and represented by the water slater *Asellus aquaticus*. No Group E taxa were present in the sample. The relative proportions of the species groups present in the sample result in a value of Q3 being assigned to the site, indicating moderately polluted, Class C water.

Both banks of site DS1 supported extensive stands of reed canary-grass *Phalaris arundinacea*, with some occurring mid-channel.

Site DS2

The kick sample from site DS2, located between Coburg and Killarney Glen, contained 19 species or higher taxa, represented by 1176 individual organisms. Group C taxa were present in excessive numbers (95%), with the mayfly *Baetis rhodani* most common at 35%. Other taxa belonging to Group C included the freshwater shrimp *Gammarus* spp., the mayflies *Serratella ignita* and *Caenis rivulorum*, the uncased caddis *Hydropsyche siltalai* and *Rhyacophila dorsalis*, true fly larvae of the families Chironomidae, Simuliidae and Tipulidae, larvae and adults of the water beetle *Limnius volckmari* and larvae of *Elmis aenea* and the family Hydroporinae, and a mite of the order Hydracarina. Group B taxa were present in small numbers (2%) represented by the mayfly *Alainites muticus* and the stonefly *Leuctra hippopus*. Group D taxa were present in small numbers also (2%) and represented by the water slater *Asellus aquaticus* and the snail *Lymnaea peregra*. No Group A or E taxa were present in the sample. The relative proportions of the species groups present in the sample result in a value of Q3 being assigned to the site, indicating moderately polluted, Class C water.

At site DS2, the left bank supported stands of reed canary-grass *Phalaris arundinacea*, with a small patch also occurring mid-channel.

Site DS3

The kick sample from site DS3, located just upstream of The Slang, was the most species rich sample, containing 21 species or higher taxa, represented by 480 individual organisms. Group C taxa were present in excessive numbers (91%), with the mayfly *Baetis rhodani* most common at 29%. Other taxa belonging to Group C include the mayflies *Serratella ignita* and *Caenis rivulorum*, the uncased caddis *Hydropsyche instabilis*, *Rhyacophila dorsalis* and *Philopotamus montanus*, true flies of the families Chironomidae, Simuliidae and Tipulidae, the freshwater shrimp *Gammarus* spp., the snail *Potamopyrgus jenkinsi* and larvae and adults of the water beetle *Limnius volckmari*, and larvae of *Elmis aenea*. Group A taxa were present in small numbers (2%) and represented by the mayflies *Rhithrogena semicolorata* and *Electrogena lateralis*. Group B taxa present in small numbers (2%) and were represented by the stonefly *Leuctra hippopus* and the cased caddis *Sericostoma personatum*. Group D taxa were present in small numbers (3%) and were represented by the leech *Dina lineata* and the snail *Lymnaea peregra*. No Group E taxa were present in the sample. The relative proportions of the species groups present in the sample result in a value of Q3 being assigned to the site, indicating moderately polluted, Class C water.

No aquatic macrophytes were recorded at site DS3.

Site DS4

The kick sample from site DS4, located adjacent to the western end of the La Vallee apartment complex, contained 15 species or higher taxa, represented by 680 individual organisms. Group C taxa were present in excessive numbers (98%), with true fly larvae and pupae of the family Simuliidae most common at 44%. Other Group C taxa included the mayflies *Baetis rhodani*, *Serratella ignita*, and *Caenis rivulorum*, the uncased caddis *Rhyacophila dorsalis*, the freshwater shrimp *Gammarus* spp., true flies of the families Chironomidae and Tipulidae, and larvae and adults the water beetle *Limnius volckmari*, and larvae of *Elmis aenea*. Group B taxa were present scarce (<1%) and represented by the stonefly *Leuctra hippopus*. Group A taxa were also scarce (<1%) and represented by the mayflies *Rhithrogena semicolorata* and *Electrogena lateralis*. No Group D or E taxa were present in the sample. The relative proportions of the species groups present in the sample result in a value of Q3 being assigned to the site, indicating moderately polluted, Class C water.

No aquatic macrophytes were recorded at site DS4.

Water physico-chemistry

Water chemistry as measured in the field is presented in Appendix C2, Table 3.

Dissolved oxygen levels in the River Dargle ranged from 10.1mg/l (106% saturation) at DS1 to 11.0mg/l (110%) at DS4.

The water temperature varied from 15.8°C at DS4 to 16.4°C at DS1.

Conductivity ranged from 310 microsiemens per centimetre (μS/cm) at DS4 to 326 μS/cm at DS1. pH ranged from 8.13 at DS1 to 8.20 at DS4.

Salmonid habitat survey

Site DS1

River morphology was characterised by a large riffle area, with glides upstream and downstream. The riverbed consisted mainly of cobbles (90%), with some pebbles (10%) and slight sedimentation beneath. There was little in-stream vegetation other than a small stand of *Phalaris arundinacea* as well as filamentous algae growing on the cobbles. The flow type at this site was characterised by riffles (70%) with a small area of glides (30%), while no pool features were present. The channel was not shaded by overhanging vegetation, with the banks supporting *P.arundinacea*, *Buddleja davidii,* sorrel, grass and nettles. The left bank was backed by a high wall approximately 2m from the river.

The salmonid habitat at this site would be suitable only for migration, as there was a lack of pools or refuges to provide nursery habitat or gravel beds to facilitate spawning. The water quality at this site was rated at Q3, indicating moderately polluted, Class C water, which is generally considered only capable of supporting coarse fish. However, the River Dargle does support a good population of trout and trout fry were observed in the glide upstream of site DS1, indicating that this area is a nursery site for this species.

Site DS2

The river at site DS2 is characterised mainly by riffles. The riverbed at this site consisted of cobbles (90%) and pebbles (10%). The only in-stream macrophyte recorded was *Phalaris*, which formed a small stand mid-channel and along the margins of the left bank. The left bank was the end of a residence's garden with mown grass, nettles and sorrel. The right bank supported trees, including young beech, which provided shade for the channel, as well as grass, nettles and sorrel.

The glides upstream and downstream of this site would be suitable habitat for adult trout and as a nursery area for juveniles. Juvenile trout were seen between DS1 and DS2.

Site DS3

The river at site DS3 is characterised mainly by riffles. The riverbed at this site consisted of cobbles (90%) and pebbles (10%). No in-stream vegetation was recorded. The left bank supported sycamore and *B. davidii*, while the right bank was wasteland with scrub, grass, nettles etc. The trees on the left bank provided some shade for the river channel.

The glides upstream and downstream of this site would be suitable habitat for adult trout and as a nursery area for juveniles. Trout were frequently seen jumping in the glide upstream of DS3 (Appendix C3, Plate 4). Downstream of the riffle was much more open, with the left bank formed by caged rock placed to prevent erosion, and thus less suitable for trout.

Site DS4

The river at site DS4 is characterised mainly by riffles. The riverbed at this site consisted of boulders (50%) and cobbles (50%). No in-stream vegetation was recorded. The left bank has been engineered using boulders and rock gabion (Appendix C3, Plate 5) to provide erosion protection for La Vallee apartment complex, and supported B. davidii, brambles, and nettles. The right bank has been extensively eroded, with forming a clay cliff >10m high, with woodland on top. The site is quite shaded by trees and buildings.

The fast flowing waters and rocky nature of the channel here would not be suitable for nursery or spawning. Adult trout may use the flow to drift feed on invertebrates washing downstream.

Estuarine survey

The section of the River Dargle below the weir (Appendix C3, Plate 8) between Bray Bridge and the railway bridge is estuarine in nature. The left bank of the river along this section consisted of a high wall with *Ulva* spp. growing above a zone of horned wrack *Fucus ceranoides*. The right bank consists of a muddy substratum with cobbles beneath. Again *Ulva* spp. covered the upper zone with *F. ceranoides* below (Appendix C3, Plate 9). A small zone of yellow lichen was recorded on the mid-stream support of the railway bridge (Appendix C3, Plate 10). The hard surfaces around the bridge supported abundant *F. ceranoides* (Appendix C3, Plate 11). The ragworm *Hediste diversicolor* was recorded from the mud on the right bank during the previous survey (EcoServe 2005), while no fauna was recorded from the area of mixed sand and cobble adjacent to the wastewater treatment plant.

Otter survey

Otter spraints (Appendix C3, Plate 7) were recorded at two locations on the right bank just downstream of the N11 bridge (Appendix C3, Plate 8) (Appendix C2, Table 7). Consultation with the NPWS ranger for North Wicklow suggested that, while otters do occur along the lower reaches of the River Dargle, they are resident in upstream areas.

Discussion

No macroinvertebrate species of particular conservation interest were found during the surveys. The macroinvertebrate assemblage at sites DS1-DS4 indicated that the river was moderately polluted (Q3). Previous EPA data on this stretch of the River Dargle have shown that the water quality of the river has deteriorated over the last 16 years, from Q4-5 (unpolluted water, Class A) in 1990 to Q3 (moderately polluted, Class C) in 2000. The current survey indicates there has been no improvement in the water quality status of the River Dargle in the last 6 years.

The aquatic macrophyte community of the River Dargle along this section was very poorly developed with only three species recorded: reed canary-grass *Phalaris arundinacea*, bulrush *Typha latifolia*, and sedge *Carex* spp. Apart from the occasional stand of *P. arundinacea*, no macrophytes occured in-stream. The low diversity and density of aquatic macrophytes is likely to be the result of a number of factors, including water quality, river flow conditions, substratum, the anthropogenic alterations to the river bank, and competition with scrub species, adapted to disturbed environments.

According to the Council Directive (78/659/EEC) on the quality of freshwater needing protection or improvement in order to support fish life, dissolved oxygen levels should be above 7 mg/l at all times and it is imperative that values remain above 9 mg/l at least 50% of the time in waters designated as salmonid waters. The oxygen levels at all sites

were above 9 mg/l at the time of sampling. It is clear that, at the recorded levels, oxygen levels in the River Dargle pose no threat to the salmonid populations in the river. This may not be the case during times of low flow and high temperatures, when oxygen levels would be lower than those recorded. Similarly, the pH levels recorded at all sites fall within the range of 6-9, as required by the Fish Directive.

Juvenile trout were seen in the River Dargle between sites DS1 and DS2, indicating that this area of glide is suitable for fulfilling the nursery requirements of trout. The cobble substratum supports numerous macroinvertebrate species for feeding, and shade is provided on the right bank by trees and scrub. Larger trout were seen jumping from the water to feed, particularly in the glide upstream of DS3. This area had deeper water, and more overhanging vegetation, providing cover for the trout. Trout are noted for their tendency to feed on terrestrial insects that fall into water, mainly from overhanging trees, as well as aquatic species.

While areas suitable to act as nurseries and to support larger trout were observed in the section of the River Dargle surveyed, no areas suitable for spawning were noted. Salmonids require a gravel river bed suitable for the construction of spawning redds. The riverbed of the River Dargle along this stretch consists mainly of cobbles, and occasional boulders, with boulders more frequent in the area of La Vallee, where bedrock also occurs.

The presence of the otter (*Lutra lutra*), a legally protected species, was recorded at the upstream end of the study area. The area over which otters range is highly variable, and depends on such things as river width and intraspecific competition, and has been expressed in terms of river channel length, and also area in km^2. Ranges of up to 50km of river channel have been recorded in Britain by Durbin (1996), while in terms of density one otter per $25km^2$ was recorded by Harris *et al.* (1995). The diet of the otter is varied, exploiting mainly fish, but also crayfish, amphibians and small birds and mammals (Preston *et al.*, 2006, Chanin, 2003). The otters of the River Dargle are likely to exploit the trout population, as well as other fish species.

Conductivity is the measurement of the ability of water to conduct an electric current and is directly related to the amount of ions in solution (APHA, 1989). High conductivity values are often correlated with hard waters and high pH values. The conductivity of freshwaters generally ranges between 50 and 1500 µS/cm. Therefore the conductivity values recorded during these surveys are within normal limits for freshwaters.

The presence of frequent and extensive stands of Japanese Knotweed (*Fallopia japonica*) (Appendix C3, Plate 3) along the banks of the River Dargle is of considerable ecological concern. This plant is a highly invasive, exotic species imported from eastern Asia as a garden plant, and has become a major problem in the United Kingdom and Ireland owing to its ability to spread and out-compete native species. In the UK, this plant has been recognized as such a problem that legislation has been brought in to deal with it, making it illegal to plant or cause Japanese knotweed to grow in the wild, and also classing it as controlled waste. Its ability to grow from a small fragment of plant makes river banks particularly susceptible to being colonised by this plant, as fragments wash down from upstream and establish themselves as new stands. Its root system is particularly robust (from which it derived its name) and the plant grows vigorously, causing damage to structures, including flood defences.

From an aquatic ecology point of view, the impact of further spread of Japanese knotweed is undesirable from a number of standpoints. This is further discussed in the impacts section below.

Giant hogweed (*Heracleum mantegazzianum*) was also recorded during the survey, mainly along the banks between La Vallee and the N11 bridge. Like Japanese knotweed, giant hogweed is also an exotic, invasive species. The sap of this plant is toxic and can cause severe burns, while from an ecological standpoint, it out-competes native species. A treatment regime similar to that for Japanese knotweed is necessary to eradicate this plant.

The species found in the course of the estuarine survey were not of specific conservation importance, and all are commonly found in estuaries around the Irish coast (EcoServe, unpublished data). The species richness of the estuary was low. This is often the case, due to the stressful environment presented by the fluctuating salinity and water levels present in estuaries. With the exception of the ragworm *Hediste diversicolor*, only algal species were recorded in the estuary. These included *Fucus ceranoides* and *Ulva* spp. which are commonly recorded in estuaries around Ireland and areas influenced by variable salinity.

5.3.4 POTENTIAL IMPACTS

The potential impacts of the proposed flood defence scheme on the River Dargle can be considered as being related to two main areas:

1. Those related to the impact of the construction of the proposed flood defence on the River Dargle.

2. Those related to the continued operation of the proposed flood defence after construction has been completed.

Construction phase

(i) Erosion and sedimentation/siltation

Construction works associated with the development, including riverbed re-grading, riverbank re-profiling, embankment construction, etc., have significant potential to cause the release of sediments into surrounding watercourses, particularly due to removal and storage of topsoil. The release of suspended solids could result in direct and indirect fishery impacts. Direct impacts include the clogging of fish gills with sediment, while indirect impacts include the alteration of habitat (hydrology and substratum), reduced visibility for feeding and impacts on food supply, especially on aquatic macroinvertebrates. Effects on aquatic macroinvertebrates would include clogging of habitats, such as riffles, and smothering of organism with settling sediment, which would lead to an alteration on the community structure (species and relative abundance).

(ii) Loss/alteration of riparian habitat

The proposed flood defence will result in the alteration and loss of riparian habitats along the length of the river channel within the proposed development area. Previous flood defence structures, mainly the river walls from the western end of the People's Park to the harbour on the left bank, and from the western end of The Maltings on the right bank to the harbour, have become somewhat naturalised by means of deposited material forming banks, and riparian vegetation growing. These banks are characterised mainly by disturbed land plant species such as *B. davidii*, nettles, brambles, etc. These banks, and other more natural banks upstream, will be significantly altered by the excavation and re-profiling and building of retaining walls, embankments, etc. The loss of

riparian vegetation will impact on the food supply of aquatic macroinvertebrates (many of which are detritivores, feeding on leaf-fall) and salmonids, as well as removing shading and cover for salmonids. The cover this vegetation provides for otters would also be lost, at least temporarily.

(iii) Loss/alteration of in-stream habitat

Negative impacts of the engineering works on the River Dargle include the disturbance of the river bed for almost the entire length of the study area due to extensive re-grading, which will affect the macroinvertebrate populations directly and thus indirectly impact on any fish feeding on these macroinvertebrates.

The channel of the River Dargle, from the N11 bridge down to Bray Bridge, currently has a well-developed riffle-glide-riffle sequence. These hydrological conditions are important for salmonids, providing habitat, prey species and oxygenation of the river water. The construction of the flood defence measures, including the riverbed re-grading, has the potential to alter this flow character, and render the stretch less suitable for salmonids.

Widening of the river channel could result in a reduction in water depth, which could restrict passage for salmonids during times of low flow.

(iv) Pollution

Pollutants and chemicals used during the construction phase could have toxic impacts on the fauna and flora in the adjacent waters. The likely sources of chemical contamination would be from site machinery and vehicles. Pollution could occur in a number of ways, neglected spillages, the improper storage, handling and transfer of oil and chemicals and refuelling of vehicles. Accidental leakage or discharge of chemicals and pollutants could cause changes in the pH of the water and could have a direct toxic impact on the fauna and flora in the watercourses on site and further downstream. If waters become polluted, species more tolerant to pollution can extend their distribution, thus altering the species composition of the watercourse. Polluted waters are generally lower in biodiversity. Pollution of the adjacent freshwaters from on-site sewage could have a toxic impact on the fauna and flora. An increase in nutrients, organic matter and various toxins at the point of pollution would be likely to occur, which could result in a loss of species, particularly those sensitive to pollutants, from that area. Salmonids are sensitive to pollutants entering the water, as are otters, whose distribution in the UK was greatly reduced owing to historical pollution, mainly by pesticides.

(v) Disturbance to Otters (*Lutra lutra*)

The operation of machinery and plant has the potential to disturb otters utilising the stretch of river within the construction area. This could reduce the area available to otters to forage for food. A major potential impact of construction along the river bank would be the destruction of an otter holt. No otter holts were identified in the course of the field survey, however the can be difficult to identify visually, without radio-tracking studies (Chanin, 2003).

(vi) Spread of Japanese knotweed (*Fallopia japonica*)

Owing to the current widespread occurrence of Japanese knotweed (*Fallopia japonica*) along the section of the River Dargle within the proposed flood defence area, there is great potential for the spreading of this highly invasive, exotic species along greater stretches of the River Dargle within the development area, and also to other areas distant from the site. This plant reproduces by means of vegetative reproduction, where

small fragments of plant or rhizome (root structure) are moved away from the parent plant and set down roots. It is this form of reproduction that has allowed Japanese knotweed to spread rapidly, especially along linear paths such as rivers and roads. Japanese knotweed has the potential to impact on the aquatic environment in a number of ways. Owing to its ability to out-compete native plants (during the growing season it can grow at a rate of 8 cm per day (Beerling *et al.* 1994)), Japanese knotweed quickly forms a monoculture stand, excluding all other plants. This prevents the development of a normal zone of riparian vegetation. The fact that the plant dies back during the winter removes all cover and shading for fish during this period. As few or no insects feed on Japanese knotweed, the supply of terrestrial insects to the river, as exploited by young trout, is reduced greatly.

Operation phase

Following the completion of the construction phase of the flood defence scheme on the River Dargle, the development will continue to impact upon the river in a number of ways, with a timescale varying from short-term to longer term. These impacts mainly include those associated with the loss/alteration of riparian and in-stream habitats.

(i) Loss/alteration of riparian habitat

The proposed flood defence will result in the alteration and loss of riparian habitats along the length of the river channel within the proposed development area. Previous flood defence structures, mainly the river walls from the western end of the People's Park to the harbour on the left bank, and from the western end of The Maltings on the right bank to the harbour, have become somewhat naturalised by means of deposited material forming banks, and riparian vegetation growing. These banks are characterised mainly by disturbed land plant species such as *Buddleja*, nettles, brambles, etc. These banks, and other more natural banks upstream, will be significantly altered during construction by the excavation and re-profiling of banks and building of retaining walls, embankments, etc. The loss of riparian vegetation will impact on the food supply of aquatic macroinvertebrates (many of which are detritivores, feeding on leaf-fall) and salmonids, as well as removing shading and cover for salmonids. The cover this vegetation provides for otters would also be lost along many sections. These impacts, which will be caused during construction, will continue through into the operation phase, especially where the bank is removed completely and the river will extend to the retaining wall.

(ii) Loss/alteration of in-stream habitat

The proposed construction works will result in a significant change to the in-stream habitat of the lower River Dargle, which will continue into the operation phase. The removal of the weir between Bray Bridge and the Harbour is likely to alter the freshwater/seawater balance of the estuary, with saltwater likely to intrude further up the channel. The impact of this engineering measure will increase the length of the estuarine habitat in the lower River Dargle, returning the area to a more natural state that would have existed prior to the construction of the weir.

Negative impacts of the works include the disturbance of the river bed for almost the entire length of the study area due to extensive re-grading, which will affect the macroinvertebrate populations directly and thus indirectly impact on any fish feeding on these macroinvertebrates.

The channel of the River Dargle, from the N11 bridge down to Bray Bridge, currently has a well-developed riffle-glide-riffle sequence. These hydrological conditions are important for salmonids, providing habitat, prey species and oxygenation of the river water. The construction of the flood defence measures, including the riverbed re-grading, has the potential to alter this flow character, and render the stretch less suitable for salmonids.

Widening of the river channel could result in a reduction in water depth, which would restrict passage for salmonids during times of low flow.

The construction of the proposed Debris Trap will result in the permanent loss of a small area of riverbed habitat, and the alteration of the flow characteristics around the structures may result in the habitat immediately surrounding the structures to be altered, e.g. alteration of sediment grain size, current velocity, etc.

The altered flow characteristics, coupled with the retaining wall enclosing the channel at many areas will act to slow down any naturalisation of the channel by the normal riverine processes.

(iii) Impact on otters

The removal of banks and riparian vegetation as discussed above may make the lower River Dargle less suitable for supporting foraging otters. The retaining walls, and lack of a bank at places would provide the otter with no cover, and it is seen as a shy species.

Loss of potential prey species would make the river less suitable for otters.

5.3.5 MITIGATION MEASURES

A number of mitigation measures should be implemented to reduce or remove any potential negative impacts on the River Dargle as a result of the proposed development. These mitigation measures take into account those of the Eastern Regional Fisheries Board for the protection of fisheries habitats (ERFB, 2006).

(i) Erosion and sedimentation/siltation

Measures will be implemented to reduce the release of sediment into the watercourse. Any storage of sand/gravel/soil should be located away from watercourses. Grading adjacent to watercourses should be kept to a minimum and surface water run-off should be collected in specially designed settlement lagoons or silt/gravel trap to remove suspended solids before being discharged to watercourses. Best practice should be followed at all times. Little can be done to prevent the release of suspended solids into the river during in-stream works, however the timing of the works to coincide with those recommended by the ERFB (ERFB, 2006) would go some way to protecting one of the more important ecological elements of the River Dargle, its salmonid populations.

(ii) Pollution

All fuels or chemicals kept on the construction site will be stored in bunded containers. All machinery must be well-maintained and refuelling carried out within bunded enclosures. Oil interceptors must also be installed. Accidental spillages should be contained and cleaned up immediately. Remediation measures should be carried out in the unlikely event of pollution of the adjacent watercourse in accordance with best practice. During the construction phase, contained chemical toilets will be used and all

sewage removed from the site to an authorised treatment works. In this way, no sewage would be discharged to watercourses. Best practice will be followed at all times.

(iii) Loss/alteration of in-stream and riparian habitat

The loss/alteration of habitat is inevitable owing to the proposed flood defence works, however efforts should still be made to minimize the impacts of these works. Only the minimum amount of habitat necessary to implement the rehabilitation works should be affected. Natural banks and riparian vegetation should be left in place, and flood defence structures constructed back from the immediate banks.

Due to the nature of the engineering works involved in the flood protection scheme it will be necessary that machinery operate in-stream. However these works should be kept to the minimum area possible and machinery should operate within the previously disturbed areas as the works progress along the channel. Any works that can be carried out by machinery operating from the banks should be carried out in this way.

Any works to widen the channel should ensure that, even in times of low flow, that there is sufficient depth of water for the passage of salmonids upstream. The proposed low flow fisheries channel to be excavated in the riverbed will maintain sufficient water depth for the movement of salmonids along the river at times of low flow.

Prior to any riverbed re-grading works, the upper layer of the substratum will be removed and stored, so that it can be reinstated on the completion of the re-grading works. This will result in a more natural river bed being re-established more quickly, and has also been recommended by the Central Fisheries Board (as stated in Section 2.5.4).

The river works should be carried out in sections in a downstream direction from the N11 Bridge. In this way, recolonisation of the altered habitat can occur from upstream as works are completed. The migration of fish downstream to the areas currently utilised as nursery habitat will occur as the works are completed in each section, along with the downstream drift of aquatic macroinvertebrates on which the fish species feed. Again, the reinstatement of stored riverbed material is important for the reestablishment of macroinvertebrate and fish populations post-construction.

(iv) Impacts on fish populations

Every effort should be made to maintain the current flow regime of a riffle-glide-riffle sequence, a flow type identified as being very important to salmonids. Sections of glide on the lower River Dargle have been identified as nursery habitats for young trout, and should be protected from all potential negative impacts.

As the proposed works include a programme prepared by the Central Fisheries Board aimed at improving the suitability of the River Dargle for salmonids, every effort should be made to prevent any negative impacts on fish populations during the construction and operation phases. The period May-September is the only time in-stream river works should be allowed in a salmonid river (ERFB, 2006) (See Appendix C2, Table 6). Even during times where in-stream works are permitted, conditions suitable for fish passage must be maintained at all times (ERFB, 2006). This has been taken into account in the construction plan (Section 2.5).

(v) Preventing the spread of Japanese Knotweed (*Fallopia japonica*)

Without proper management, the planned flood defence works could result in the spread of Japanese Knotweed along the entire stretch of the River Dargle to be affected

by the works. A Code of Practise for the management, destruction and disposal of Japanese Knotweed, produced by the Environment Agency in the United Kingdom is presented in Appendix C4. This code should be the basis of any management plan developed for the control of Japanese Knotweed along the River Dargle. Consultation with UK organisations with experience in the management and eradication of Japanese Knotweed will be carried out.

5.3.6 RESIDUAL IMPACTS

Based upon the potential impacts, and the implementation of the appropriate mitigation measures, it is predicted the following impacts will occur during the construction and operation of the flood defence scheme. Again they are divided between those occurring during the construction and operation phase.

Construction phase

(i) Erosion and sedimentation/siltation

Construction works associated with the development, including riverbed re-grading, riverbank re-profiling, embankment construction, etc., will result in the release of sediments into surrounding watercourses, particularly due to the in-stream regrading works. The release of suspended solids could result in direct and indirect fishery impacts. Direct impacts include the clogging of fish gills with sediment, while indirect impacts include the alteration of habitat (hydrology and substratum), reduced visibility for feeding and impacts on food supply, especially on aquatic macroinvertebrates. Effects on aquatic macroinvertebrates would include clogging of habitats, such as riffles, and smothering of organism with settling sediment, which would lead to an alteration on the community structure (species and relative abundance). This impact is likely to be a significant, negative impact of short-term duration.

(ii) Loss/alteration of riparian habitat

The proposed flood defence will result in the alteration and loss of riparian habitats along the length of the river channel within the proposed development area. Previous flood defence structures, mainly the river walls from the western end of the People's Park to the harbour on the left bank, and from the western end of The Maltings on the right bank to the harbour, have become somewhat naturalised by means of deposited material forming banks, and riparian vegetation growing. These banks are characterised mainly by disturbed land plant species such as *Buddleja*, nettles, brambles, etc. These banks, and other more natural banks upstream, will be significantly altered by the excavation and re-profiling of banks and building of retaining walls, embankments, etc. The loss of riparian vegetation will impact on the food supply of aquatic macroinvertebrates (many of which are detritivores, feeding on leaf-fall) and salmonids, as well as removing shading and cover for salmonids. The cover this vegetation provides for otters would also be lost along many sections. This impact is likely to be negative, of moderate magnitude, with its duration dependant on the section. In those sections where retaining walls will be built and the bank excavated up to the wall, the impact will be permanent. Where retaining walls are not built, or where an area of natural bank is left on the river side of the wall, the impact is likely to be of short-term duration, as the bank will recolonise.

(iii) Loss/alteration of in-stream habitat

Negative impacts of the engineering works include the disturbance of the river bed for almost the entire length of the study area due to extensive re-grading, which will affect the macroinvertebrate populations directly and thus indirectly impact on any fish feeding on these macroinvertebrates. With the reinstatement of the existing substratum as outlined in the mitigation measures, this will be a significant negative impact of short-term duration.

The channel of the River Dargle, from the N11 bridge down to Bray Bridge, currently has a well-developed riffle-glide-riffle sequence. These hydrological conditions are important for salmonids, providing habitat, prey species and oxygenation of the river water. The construction of the flood defence measures, including the riverbed re-grading, will alter this flow character, and render the stretch less suitable for salmonids. With the careful planning and execution of the riverbed re-grading, in conjunction with the reinstatement of the riverbed substratum removed prior to re-grading, this impact would be a significant, negative impact of short-term duration.

Widening of the river channel will result in a reduction in water depth, which would restrict passage for salmonids during times of low flow. The inclusion of a low flow channel in the design has removed this potential negative impact.

The construction of the proposed debris trap will result in the loss of a small area of riverbed habitat, and also some change to the a habitat immediately surrounding the structures, however the area of habitat that would be affected would be small and the effect minor, therefore this is seen as a slight negative impact, of permanent duration.

(iv) Disturbance to Otters

As there is no evidence that otters are resident in the lower River Dargle, it is not expected that there will be a significant negative impact on the species within the River Dargle catchment due to the construction of the flood defence. The nocturnal nature of the otter means that it can still move along the stretch of river within the study area outside of working times. It is possible that otters may not frequent the stretch of river to be affected by the flood defence works for the duration of the works, but this will be a temporary situation, and they would be expected to return following the completion of works.

(v) Pollution

Once the suggested mitigation measures are put in place and best practice is followed, pollution is not likely to cause a significant negative impact.

(vi) Spread of Japanese knotweed (*Fallopia japonica*)

The implementation of a proper management plan for this exotic, invasive species should result in the prevention of its spread along the banks of the River Dargle and to other distant areas. The control and eradication of this plant from the River Dargle would be a significant positive impact.

Operation phase

(i) Loss/alteration of riparian habitat

As described in the predicted construction phase impact section, many of the riparian areas impacted during the construction phase will continue to be impacted post-construction. Areas where the existing natural/semi-natural banks will be replaced by retaining walls will be permanently negatively impacted.

(ii) Loss/alteration of in-stream habitat

Similarly, the in-stream habitat that is lost or altered during the construction phase is likely to be impacted upon negatively, even after construction works have been completed. The removal of the natural/semi-natural banks of the river, along with the in-stream re-grading, will cause alterations to the flow regime of the River Dargle. While the reinstatement of the riverbed material will provide the riverine processes with the material to reshape its channel and create a more natural situation, this process will take time, and the artificial walled banks will restrict the degree to which the river can return to a natural state. Taking this into consideration, this impact has been classified as a moderate negative impact of medium-term duration.

The removal of the weir between Bray Bridge and the Harbour is likely to alter the freshwater/seawater balance of the estuary, with saltwater likely to intrude further up the channel. The removal of the weir will return the lower River Dargle channel to a more natural state, as existed prior to the construction of the weir, allowing the establishment of estuarine species of flora and fauna further up the channel and the creation of a more natural temporal salinity cycle, with the interaction between the river and the tides. In addition to the alteration of the species composition and the habitat, the movement of salmonids migrating through the lower reaches is likely to be made easier with the removal of the weir. It may also ease the smoltification process for trout migrating to sea, as the salinity gradient will be smoother, allowing the fish to maintain position in conditions most appropriate to the degree of physiological change that has occurred in their preparation to move from freshwater to seawater. This impact will be a positive, permanent impact.

(iii) Impact on otters

While the removal of riparian vegetation and some areas of natural bank could potentially make the area less suitable for supporting foraging otters once construction is completed, this is seen as a slight negative impact. Some areas of bank will recolonise post-construction, through the operation phase, while, even in its existing altered state, otters have been seen along the River Dargle on occasion, therefore are likely to continue to do so post-construction.

5.3.7 THE 'DO NOTHING' SCENARIO

Should this project not proceed, the 'do nothing' scenario' with regard to aquatic ecology would result in the aquatic ecology of the lower River Dargle remaining the same in the absence of any new impact. The impact of two flood cycles was considered during the preparation of this proposal. Firstly a 1:100 year river flood event and secondly a 1:200 year tidal flood event. The impact that either of these events would have on the aquatic ecology of the River Dargle would be similar in many ways, though would vary in magnitude.

1:100 year river flood event

The main impact this flood event would have on the aquatic ecology of the river would be the release of a variety of pollutants into the water. Flood waters would cause sewers to overflow and release their load, having a major impact on the quality of the water, and subsequent knock on effects on fish and macroinvertebrate communities. Flood waters would also carry pollutants from road and car park surfaces, such as oil, petrol, diesel, heavy metals, etc., into the river, as well as quantities of soil. These substances all impact negatively on the water quality and its suitability for the survival of aquatic organisms.

The lower three kilometres of the river would be significantly, negatively impacted upon in this scenario, with the impact increasing downstream.

1:200 year tidal flood event

This flood even would have a similar impact on the river as the 1:100 year river flood event, however the impact is likely to be reduced owing to the smaller area affected by the flood waters, and the shorter length of river channel affected. Waters carrying sewage, hydrocarbons, heavy metals, chemicals, soils, etc. would flow in to the river, causing a significant reduction in the water quality along this section of river. These substances have toxic lethal and sub-lethal effects on aquatic organisms. The incursion of marine floodwater would impact negatively on the macroinvertebrate community, though this impact would be temporary in nature as recolonisation would occur from upstream areas.

A combination of these two flood event types would results in greater negative impact owing to the greater area of the flood plain affected by the floodwaters.

5.3.8 THE WORST CASE SCENARIO

The worst case scenario for the proposed flood defence scheme, with respect to potential impacts upon the aquatic ecology of the lower River Dargle would result from the complete failure of the proposed mitigation measures during the construction phase resulting in the accidental discharge of large quantities of suspended solids and/or other pollutants, such as hydrocarbons, into the river channel, resulting in lethal and sub-lethal impacts upon the macroinvertebrate, macrophyte, fish and otter populations of the River Dargle. Such discharges would greatly reduce the suitability of the lower River Dargle habitats to support these species for a long period of time.

The failure to carry out the recommended reinstatement of the river bed substratum after the completion of river re-grading works would also result in a long-term, negative impact upon the ability of the River Dargle to re-establish more natural river channel habitat, which is capable of supporting the species currently recorded in the area.

5.3.9 POSITIVE IMPACTS

Positive impacts of the proposed scheme would be mainly the result of removing the negative impacts associated with the 'do nothing' scenario. By preventing the flood waters from extending outside the river channel, the release of sewage from flooded sewers, suspended solids and hydrocarbons from road surfaces, parks, etc, would be prevented, thus the negative impact of a flood event on the lower River Dargle would be greatly lessened.

In addition, the removal of the weir downstream of Bray Bridge will allow a more natural estuarine habitat to form, with its associated flora, fauna and environmental conditions.

5.3.10 REINSTATEMENT

Following the completion of the flood defence scheme, or sections thereof, a programme of habitat reinstatement should be initiated. The most important element of this will be the return of the riverbed material removed prior to the re-grading of the river. This material, cobbles, sand and gravel, will provide the material necessary for the river to recover more quickly to a more natural state, and one more suitable for the support current macroinvertebrate community and salmonid population.

Where the riverbank is to be left in place, or merely re-profiled suitable terrestrial works should be considered to encourage the recolonisation of the banks by riparian vegetation, to allow more a more natural riparian zone emerge and to reduce the input of suspended solids into the river from bare soil on the river banks.

5.3.11 MONITORING

Monitoring forms a key part of the Environmental Impact Assessment process, allowing the accuracy of the predictions and effectiveness of mitigation measures to be assessed. To this end it is recommended the following monitoring programme be implemented during the construction of the River Dargle Flood Defence Scheme, and for a period of time after the completion of works.

Macroinvertebrate monitoring

The macroinvertebrate community should be sampled as described in the methodology section (Section 5.2.3.1) during the construction phase and for a period after the completion of the engineering works. This will allow an assessment be made of the impact that the construction has had on the macroinvertebrate population of the River Dargle and to gauge its recovering following the completion of works.

Otter monitoring

The section of the River Dargle, just downstream of the N11 bridge, where evidence of otter activity should be re-examined periodically during the construction phase and for a period after the completion of the engineering works to ascertain if there is continued otter activity in the area through the construction phase and on into the operation phase.

Salmonid habitat monitoring

On completion of the flood defence scheme, following the reinstatement works, the suitability of the lower River Dargle for supporting salmonids should be reassessed. The area should be surveyed following the methodology set out in Section 5.2.3.1), in order to assess any degradation of the salmonid habitat during construction and its recovery post-construction.

Table 5.3.1 contains a recommended timetable for the monitoring programme, assuming the project follows the timetable set out in Section 3.5.2

Table 5.3.1
Recommended monitoring time table

Time	Macroinvertebrate monitoring	Otter monitoring	Salmonid habitat monitoring
2008 - summer/winter	Yes/Yes	Yes/No	Yes/Yes
2009 - summer/winter	Yes/Yes	Yes/No	Yes/Yes
2010 - summer/winter	Yes/Yes	Yes/No	Yes/Yes
2011 - summer	Yes	Yes	Yes
2012 - summer	Yes	Yes	Yes
2015 - summer	Yes	Yes	Yes

The duration and frequency the monitoring surveys could be altered as the programme proceeds, depending on the results of the surveys. The minimum period of monitoring recommended would be up to and inclusive of 2010.