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

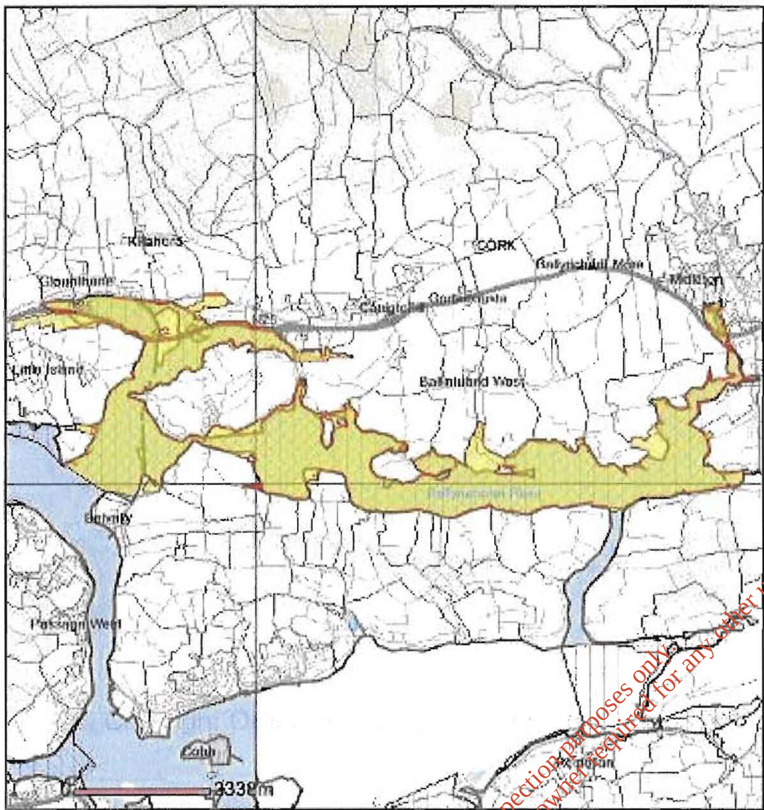

Figure A2.1 Great channel island SAC. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

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

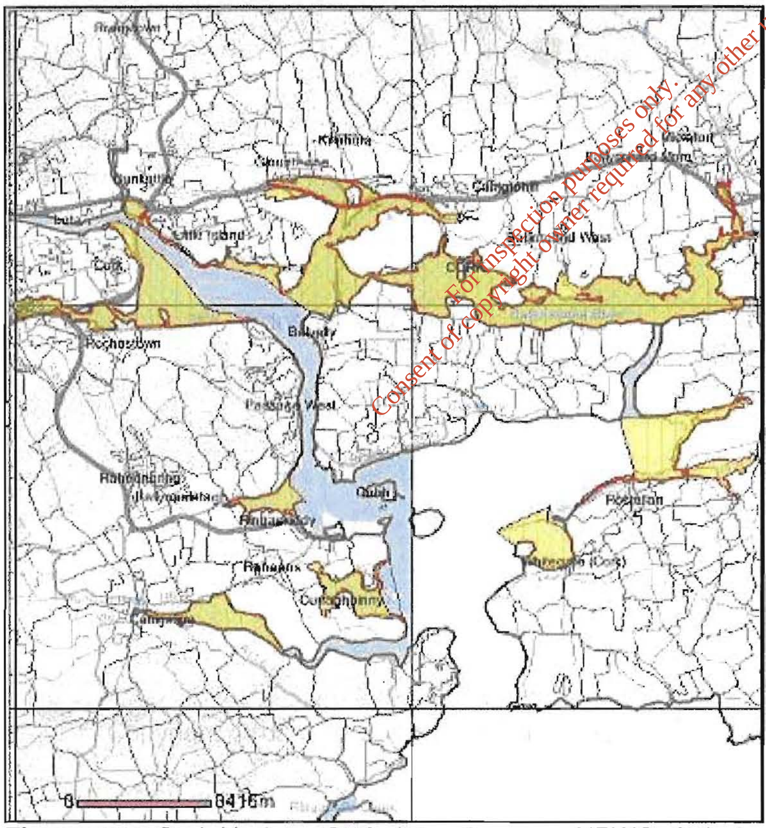

Figure A2.2 Cork Harbour SPA. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

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.

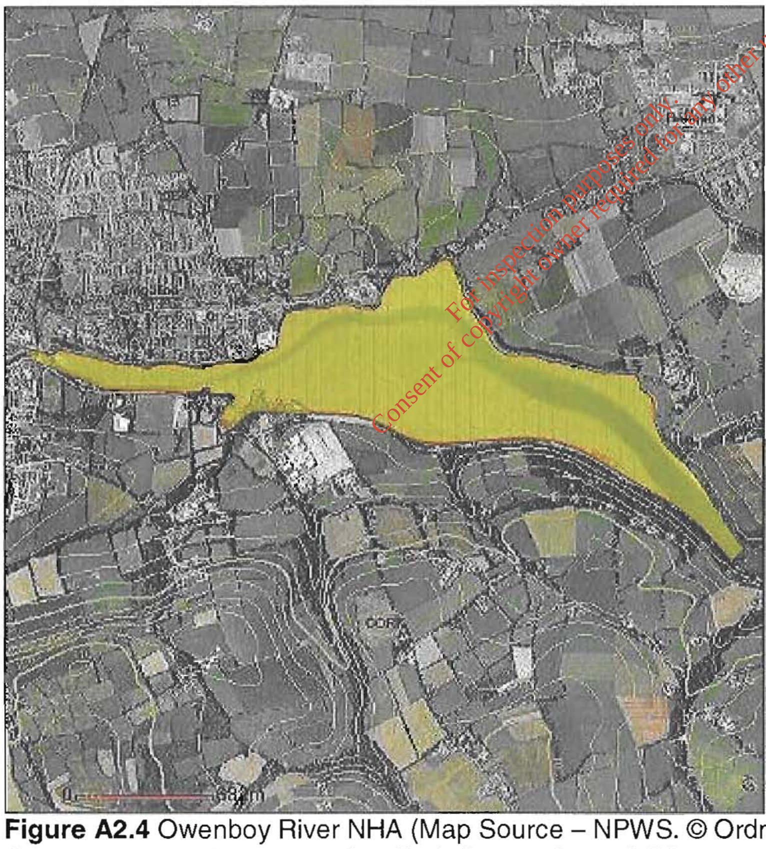

Figure A2.4 Owenboy River NHA (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

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 austrails*												
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.

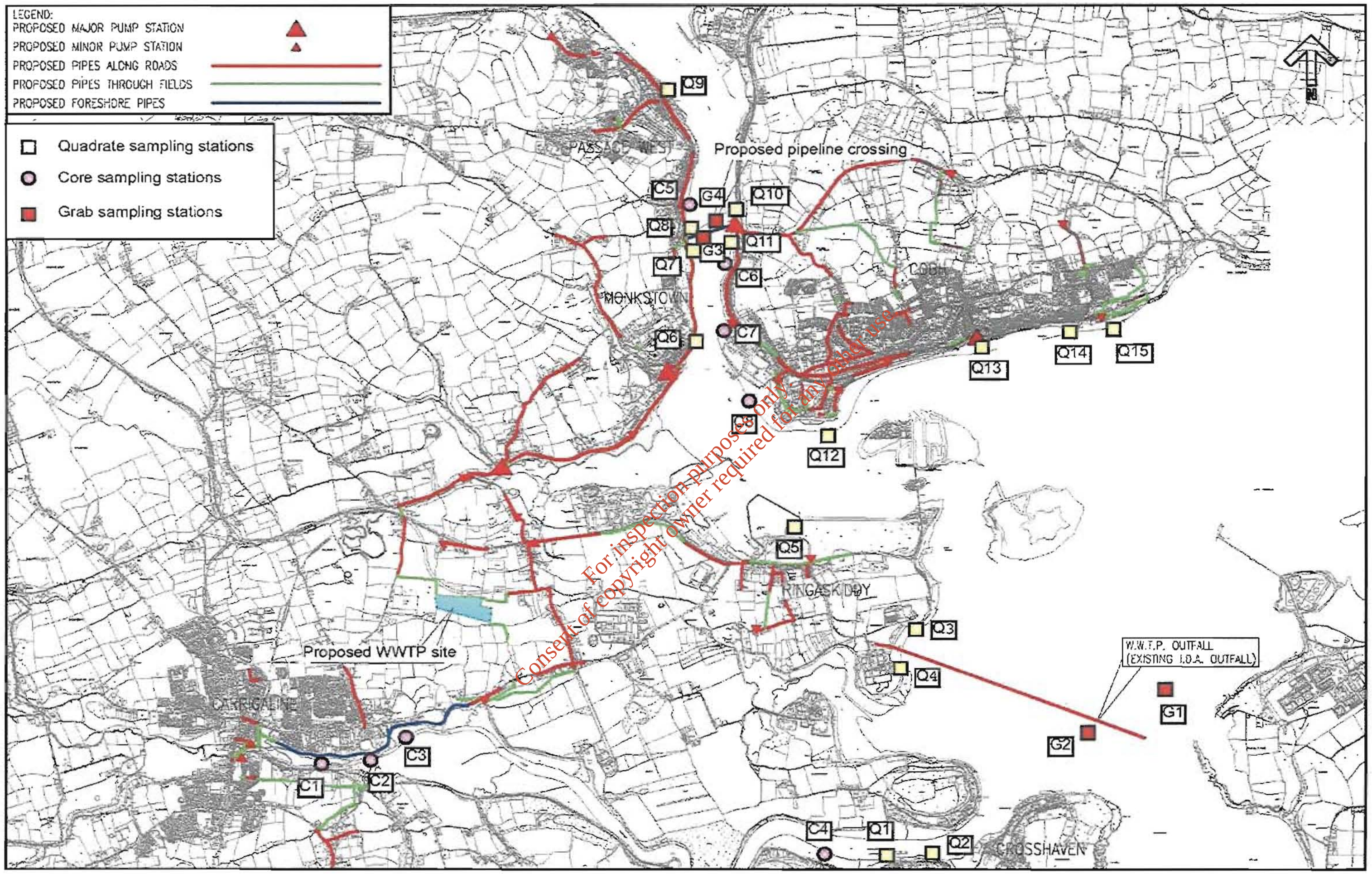

Figure A6.1 Location of marine / estuarine sampling sites.

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															
Lekanesphaera 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															
Lekanesphaerea 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

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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.

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Non-Technical Executive Summary

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Chapter 1 Introduction

1.1 The background

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 aims to collect all of this waste and treat it to a secondary standard at a waste water treatment plant to be located near Carrigaline. The treated effluent is to be discharged through the existing Carrigaline/Crosshaven outfall near Dognose Bank.

As part of the study a computer model which covers an area from the Old Head of Kinsale to the Waterworks weir in Cork City has been developed (Fig. 1.1). This model simulates the discharge, transport and decay of bacteria, viruses and three species of nitrogen from all the relevant outfalls. By simulating the discharge of untreated waste and comparing it with the discharge of treated waste an informed assessment of the improvement in water quality can be made. The boundary conditions for this model are provided by data from the Proudman Oceanographic Laboratory (POL), UK as described in section 2.2.3.

The hydrodynamic parameters of this model are based on a calibration and validation of a model covering a smaller area which reaches from Roches Point to the Waterworks weir (Fig. 1.2). The boundary conditions for this model are provided by recorded water levels from Roches Point in section 2.2.2.

The larger model has been labelled the 'Old Head_2' model (OH_2) in this report while the smaller model is referred to as the 'Roches Point_2' model (RP_2).

The OH_2 model has been validated against measurements of water level taken at Cobh and Tivoli. The error is within 20cm which is a satisfactory agreement between the modelled and measured data.

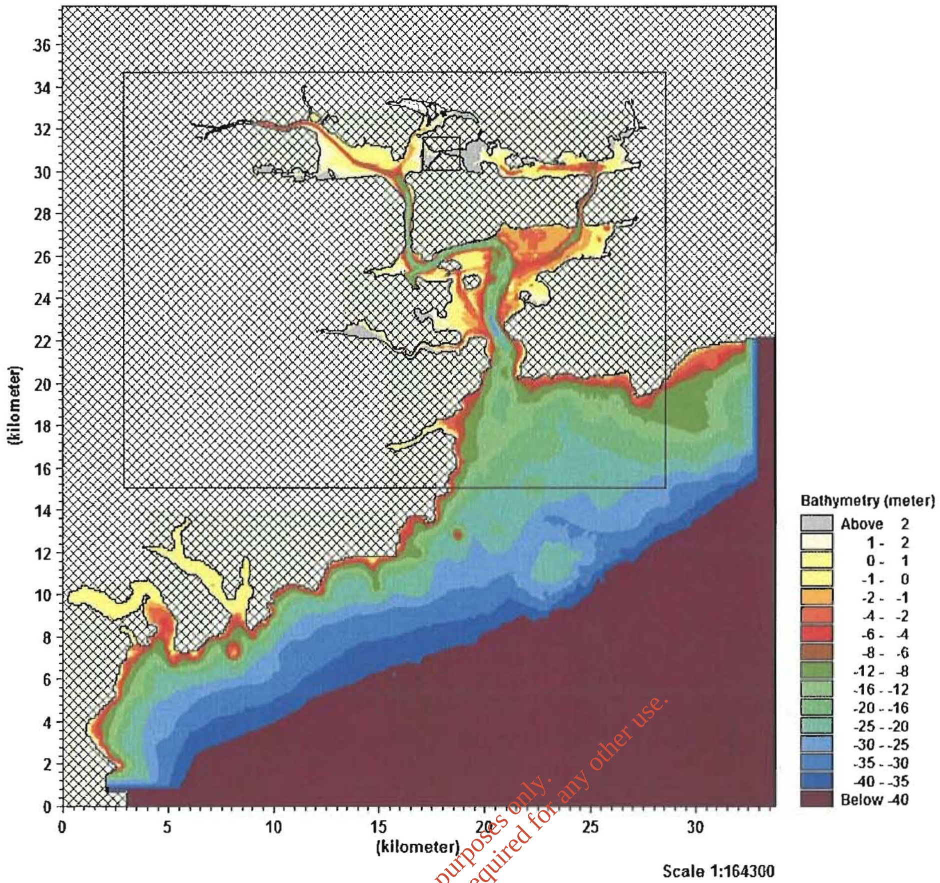

Fig. 1.1 Layout of the OH_2 model. The resolution of the 3 nested grids are 90m, 30m and 10m

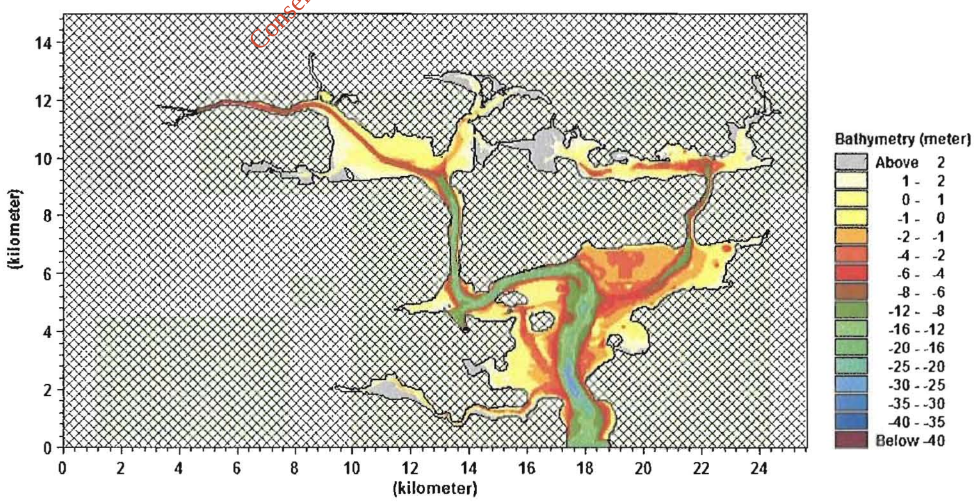

Fig. 1.2 Layout of the RP_2 model. The resolution of the 2 nested grids are 30m and 10m

The OH_2 model consists of two parts: the hydrodynamic model and the advection-dispersion model. The hydrodynamic model is based on the concepts and scientific principles of geometry and classical physics[2], and on relevant data[3]. It predicts the numerical variation in water level and the speed and direction of currents throughout Cork Harbour. We have achieved satisfactory agreement with measurements of these quantities. Pilots and sailors have also identified and confirmed the location of transient tidal eddies predicted by the model. We can predict with confidence, many, but not all, aspects of the motion of the waters of Cork Harbour under different conditions of tide, wind and river inflow.

The second part is the advection-dispersion model. This model simulates the release, transport and decay of particles discharged at any location in the harbour. We have considered faecal coliforms, intestinal enterococci, *Escherichia coli*, nitrogen and *Norovirus* for this study.

1. **Faecal Coliforms**
   - The number of Faecal Coliforms per 100ml is a recognised standard by which water quality is assessed in the relevant EU Directives.
2. **Intestinal enterococci**
   - The number of Intestinal enterococci per 100ml is a recognised standard by which water quality is assessed in the relevant EU Directives.

---

[2] These are represented as partial differential equations, expressing conservation of mass and linear momentum, with attendant boundary and initial conditions, and environmental forcing functions.

[3] Bathymetry of the Harbour from the Waterworks Weir to the Old Head of Kinsale; wind speed and direction; river flow and the tide at the mouth.

3. *Escherichia Coli*

- The number of *E. coli* per 100ml is a recognised standard by which water quality is assessed in the relevant EU Directives.

4. Simple Nitrogen Cascade

- The forcing exerted on the Harbour ecosystem by organic nitrogen, nitrate and ammonia is examined using a simplified nitrogen cascade model. Nitrogen has been included in this Environmental Impact Statement because the Water Framework Directive aims for good ecological status of all waters. High concentrations of nitrogen, when limiting, may lead to the over-fertilisation, or eutrophication, of aquatic ecosystems resulting in excessive growth of algae.

5. *Norovirus*

- The *Norovirus* or "Winter Vomiting bug" is the primary pathogen in outbreaks of gastroenteritis following consumption of raw oysters. The *Norovirus* is endemic in many countries. Outbreaks of "winter vomiting" may occur all year round and are often made public in Ireland by the closure of hospitals to visitors.

The models predict the changing concentration of the bacteria, three species of nitrogen, and *Norovirus*, under various physical forcing by the tide, wind and river flows. The variation in concentration at any site within the harbour may then be examined. From this it may be determined if the concentrations of the micro-organisms from the proposed scheme satisfy the water quality standards as stipulated in the relevant EU Directives:

- Bathing Water Directive (2006/7/EEC)
- Shellfish Waters Directive (79/923/EEC)

We understand there are no designated bathing water areas within Cork Harbour. The nearest one is at Fountainstown 5.25 km outside the harbour mouth. At present there are also no designated shellfish production areas within

Cork Harbour although oyster production has occurred in the past in the North Channel and Outer Harbour.

For this study we have not considered the discharges of treated effluent from Carrigrennan, Midleton or Cloyne. Neither have we considered the untreated discharges from the outfalls serving the towns on the eastern side of the harbour such as Rostellan, Farsid, Aghada and Whitegate. Stormwater overflows have not been included. The results presented in the report are therefore not representative of the absolute water quality in the harbour and surrounding waters. They present the contribution from the outfalls considered in the simulation runs.

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.

In order to illustrate the overall benefit of the proposed scheme four separate cases have been considered in the study and are listed in the following table.

	Year	Treatment	Total Flow Rate
Case 1 – no treatment 2001	2001	None	7,516 m^3/d
Case 2 – no treatment 2010	2010	None	10,371 m^3/d
Case 3 – With treatment 2010	2010	Secondary – 90% removal of organic matter	10,371 m^3/d
Case 4 – With treatment 2030	2030	Secondary – 90% removal of organic matter	14,873 m^3/d

Table 1-1 The four cases considered in the study

The loading on each outfall was determined by Mott MacDonald Pettit as part of a detailed and comprehensive preliminary study into the proposed scheme[4]. The loadings for the future years were calculated based on the predicted growth in population and industry for the relevant towns[5]. We have used the values from this report in our numerical model. Table 1-1 lists the values used for the 2001 situation, case 1 in the table above.

For case 2 we have assumed that the combined flow of 10,371m^3/d is divided between the outfalls as in the 2001 situation. Cases 2 and 3 have been simulated with the model. Because the model is linear, cases 1 and 4 can be calculated easily by rescaling.

Outfall Location	**UTM** E	**UTM** N	**Flow (DWF)** m3/day	**Flow (DWF)** m3/sec	**Faecal Coli Conc (raw)** fc/ m3
Carrigaline/Crosshaven	550249	5740738	4,075	0.04716	1E+11
Passage West	545351	5747371	547	0.00633	1E+11
Glenbrook	546006	5745605	327	0.00379	1E+11
Monkstown	546081	5744680	185	0.00215	1E+11
Pilots Pier Outfall (Cobh)	549632	5744757	353	0.00410	1E+11
Corbett Outfall (Cobh)	549277	5744708	178	0.00206	1E+11
Kings Quay Outfall (Cobh)	548854	5744611	444	0.00515	1E+11
West Beach Outfall (Cobh)	548647	5744568	668	0.00774	1E+11
White Point Outfall (Cobh)	547098	5743748	634	0.00735	1E+11
Ringaskiddy Village Outfall	547064	5742895	101	0.00117	1E+11
Total Catchment			7,515	0.087	

Table 1-2 Loading on outfalls from MMP report

[4] Cork Harbour Main Drainage Scheme Preliminary Report, Volumes 1-5, E.G., Pettit & Company

[5] The growth in population was estimated by considering the Cork Area Strategic Plan as well as the future development plan for each individual town as reported by E.G., Pettit & Company in the report referenced above.

1.2 Previous study of the *Norovirus* by the Authors

The lead author of this report was asked by Cork County Council in 2006 to carry out an objective study into the contamination of the oyster farm in the North Channel of Cork Harbour by the *Norovirus*. The primary objective of the study was to estimate the relative contribution of all significant sources of municipal and domestic effluent to the contamination of the oyster bed.

A number of computer models, similar to the models used in this Environmental Impact Assessment, were developed as part of the study. These models simulated the transport and decay of *Norovirus* in Cork Harbour from all the relevant outfalls. This study is referenced on a number of occasions in this report.

1.3 Model Assumptions

The advection-dispersion models described in this report have a number of inherent assumptions. Models are a simplification of reality; there is always something missing. It is a matter of judgement what to include and what to exclude. The following are the most important assumptions:

1. The densities of bacteria and *Norovirus* are approximately the same as seawater and are neutrally buoyant.
2. Adsorption of *Norovirus* and bacteria onto sediment is not included in the models. The interaction of sediment and micro-organisms in the marine environment is a complex process and is incompletely understood in the scientific literature. Simple assumptions are appropriate in this case.
3. Density gradients and stratification due to variations in salinity are excluded. These are unlikely to occur in the areas of interest in the outer harbour and outside the mouth.

1.4 Structure of the report

Chapter one introduces the study and the models. Chapter two summarises the various datasets that were used in the development of the 'Old Head_2' model.

Chapter three describes the model and its parameters. The results for faecal coliforms, *Norovirus* and Nitrogen are given in chapters 4, 5 and 6 respectively.

Chapter 2 The Datasets

2.1 Introduction

The data used to develop the Old Head_2 model are listed below and described in section 2.2.

Data type	Format	Period	Source
Bathymetric data of Cork Harbour (type 1)	X,Y,Z soundings	-	Irish Hydrodata
Bathymetric data of the Belvelly Channel (type 2)	X,Y,Z stereoscopic data	-	DLR (German Aerospace Agency)
Water level recordings from the harbour	Time series	Feb – Mar 1992	Irish Hydrodata / Port of Cork
Current speed & direction recordings from the harbour	Time series	Feb – Mar 1992	Irish Hydrodata
Hydrodynamic output from CS3 model	Time series	Jan- Dec 2004	Proudman Laboratory (UK)
River flows from the Lee, Owenacurra and Owenboy Rivers	Time series	Jan - Dec 1992 & 2004	ESB/EPA
Wind speed & directions from Cork Airport	Time series	Jan - Dec 1992 & 2004	Met Eireann
Location of each outfall	UTM coordinates	-	MMP
Flow Rates from the Various Outfalls	Values in m^3/sec	-	MMP
No of fc per cubic metre	Spreadsheet	-	MMP
Efficiency of the proposed treatment plant	Spreadsheet	-	MMP

Table 2-1 Datasets

2.2 Datasets

2.2.1 Bathymetric data

Irish Hydrodata Ltd. undertook a bathymetric survey of Cork Harbour in 1992 as part of a study of locations for an outfall from the Cork Main Drainage Scheme. A number of other surveys have since been carried out by Irish Hydrodata Ltd. for smaller localised areas. These surveys were commissioned by different parties to update the bathymetry in site-specific areas as part of various modelling studies. The main bathymetric datafile used in this study is an amalgamation of all these surveys and represents the most up-to-date dataset of the harbour bed profile that exists at present. A comprehensive quality-assurance of the dataset was carried out as part of the authors' previous study of the *Norovirus* in Cork Harbour[6].

2.2.2 Water Level & Current Speed Direction Recordings – 1992

In conjunction with the bathymetric survey undertaken for the 1992 outfall study, Irish Hydrodata Ltd placed a number of gauges in the harbour to record water levels, current speeds and current directions. Six automatic level recorders were deployed for a period of three months from the 6th of December 1991 until the 14th of March 1992. Readings were taken every minute. The current speed and direction meters recorded data from mid-December to mid-February, a period of approximately 65 days at 10 minute intervals. A number of the water level gauges shifted on their mountings during the first month of deployment and these data were discarded. Fig. 2.2 shows the location of the gauges. Table 2-2 lists the grid coordinates and dates of deployment.

These data were used to calibrate and validate the RP_2 and OH_2 models which are described in the following chapter. A comprehensive quality-assurance of the dataset was carried out as part of the authors' previous study of the *Norovirus* in Cork Harbour.

[6] O'Kane, J.P.J., & Barry, K. J., Modelling the *Norovirus* contamination of an oyster farm in Cork Harbour, Final Report to Cork County Council

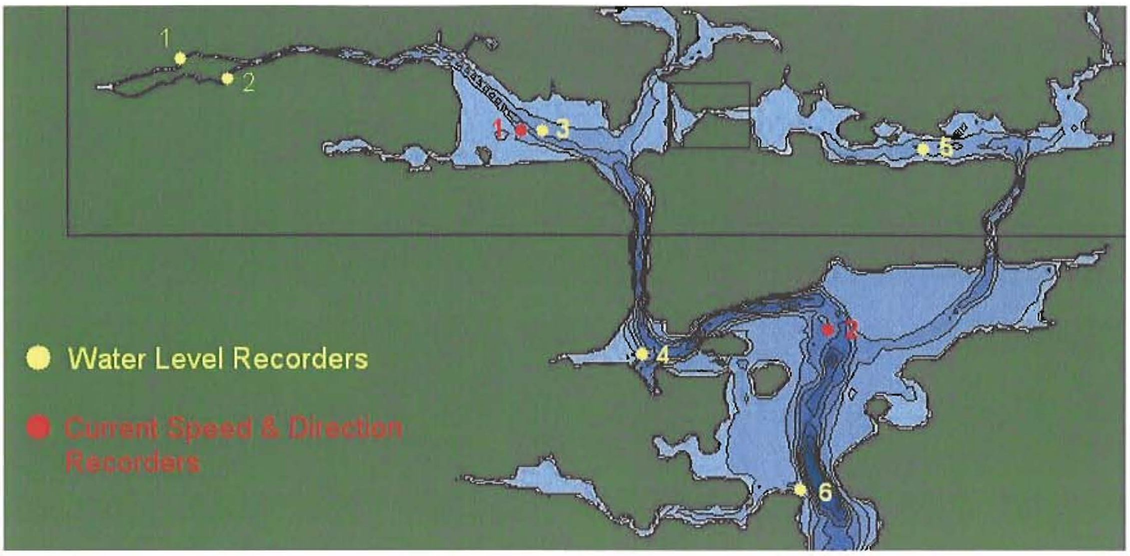

Fig. 2.1 Location of Gauges in Harbour

Site	From	To	Comments	I.N.G. Coordinates	
Lee Maltings	06 Dec 1991	06 Jan 1992	Not used	166760	71885
	06 Jan 1992	07 Feb 1992	Not used	166760	71885
	19 Feb 1992	16 Mar 1992	Not used	166760	71885
Albert Quay	06 Dec 1991	06 Jan 1992	Not used	167990	71750
	06 Jan 1992	06 Feb 1992	Not used	167990	71750
	10 Feb 1992	11 Mar 1992	Not used	167990	71750
Lough Mahon	06 Dec 1991	08 Jan 1992	Data invalid	175225	70400
	09 Jan 1992	06 Feb 1992	-	175225	70400
	10 Feb 1992	14 Mar 1992	-	175225	70400
Pfizer Jetty	06 Dec 1991	08 Jan 1992	Data invalid	177550	65225
	10 Jan 1992	26 Jan 1992	-	177550	65225
	08 Feb 1992	13 Mar 1992	-	177550	65225
Belvelly	06 Dec 1991	07 Jan 1992	-	183830	69580
	07 Jan 1992	08 Feb 1992	-	183830	69580
	08 Feb 1992	11 Mar 1992	-	183830	69580
Fort Camden	09 Dec 1991	08 Jan 1992	-	180870	62000
	09 Jan1992	07 Feb 1992	-	180870	62000
	07 Feb 1992	11 Mar 1992	-	180870	62000

Table 2-2 List of Water Level Gauges

Site	From	To	Comments
Spit Bank	08 Dec 1991	14 Feb 1992	4m above bed
Lough Mahon	15 Dec 1991	14 Feb 1992	2m above bed

Table 2-3 List of Current Speed and Direction Gauges

2.2.3 The POL CS3 model – Boundary Conditions of the OH_2 model

The Applications Group at the Proudman Oceanographic Laboratory (POL), UK, supplies hindcasts[7] of (a) tide-plus-surge, and (b) tide-only levels on a grid covering part of the North Atlantic Shelf at frequencies of 1 hour for (a) and 20 minutes for (b) respectively. The centre uses its POL CS3 model to provide the annual hindcast at the end of each calendar year. Hindcasts are available from 1992 onwards. The model makes use of meteorological data from the UK Met Office Operational Storm Surge Local Area Model (1992 to 1998) and the Mesoscale model (1999 onwards). The hindcasts from the POL CS3 Model use a combination of measured and modelled meteorological data. Surface elevations and currents in component form are provided at each grid point. The POL CS3 numerical model grid, which covers part of the North Atlantic Shelf, has a resolution of approximately 12km (Fig. 2.2). The level data has a relative accuracy of approximately 3% of the sea level range[8]. The absolute accuracy is unknown on the southern Irish Coast. A previous study[9] (1997-2001) of the Cashen Estuary in the outer Shannon showed that such data could provide very good boundary conditions for hydrodynamic models of Irish coastal waters. The Cashen/Feale model agreed with measurements within the estuarine network to within 10cm.

Two years of hindcast data (1992 & 2004) were purchased from POL for this project. Data from the three points closest to the mouth of Cork Harbour were selected from the CS3 grid and used to drive the hydrodynamics of the 'Old Head_2' hydrodynamic model by acting as the boundary conditions. The locations of these points relative to Cork Harbour are highlighted in Fig. 2.3.

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[7] A hindcast is where a numerical model is run for a fixed historic period of time in the past with recorded forcing functions (measurements of tide, wind etc) from that period.

[8] Smith, J. A. (1994). The Operational Storm Surge Model Data Archive, Proudman Oceanographic Laboratory, Report, No 34, 34pp

[9] Martin, J., 2002, De-Watering the Lower Feale – "A Virtual Water World", *Ph.D. Thesis*, Department of Civil and Environmental Engineering, National University of Ireland, Cork

Minor adjustments to the data provided by the Proudman Laboratory in this study.

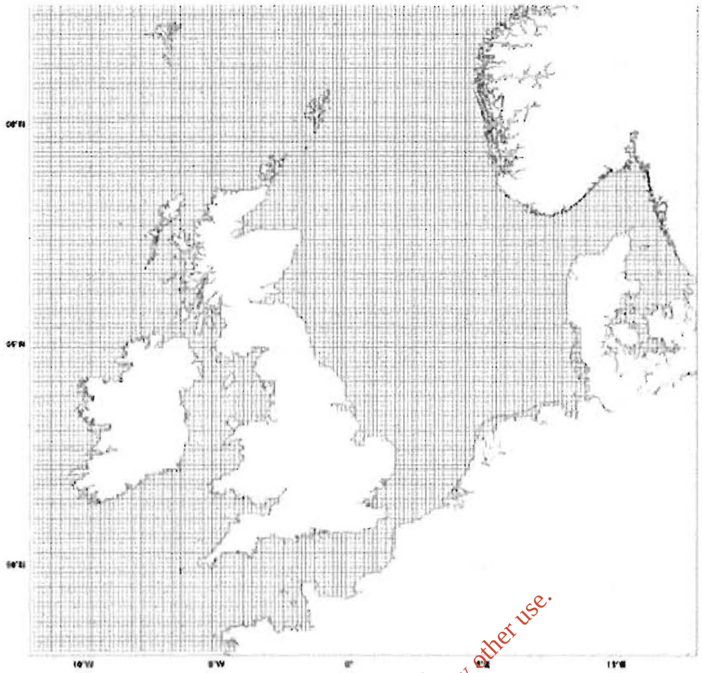

Fig. 2.2 CS3 grid (12km resolution)

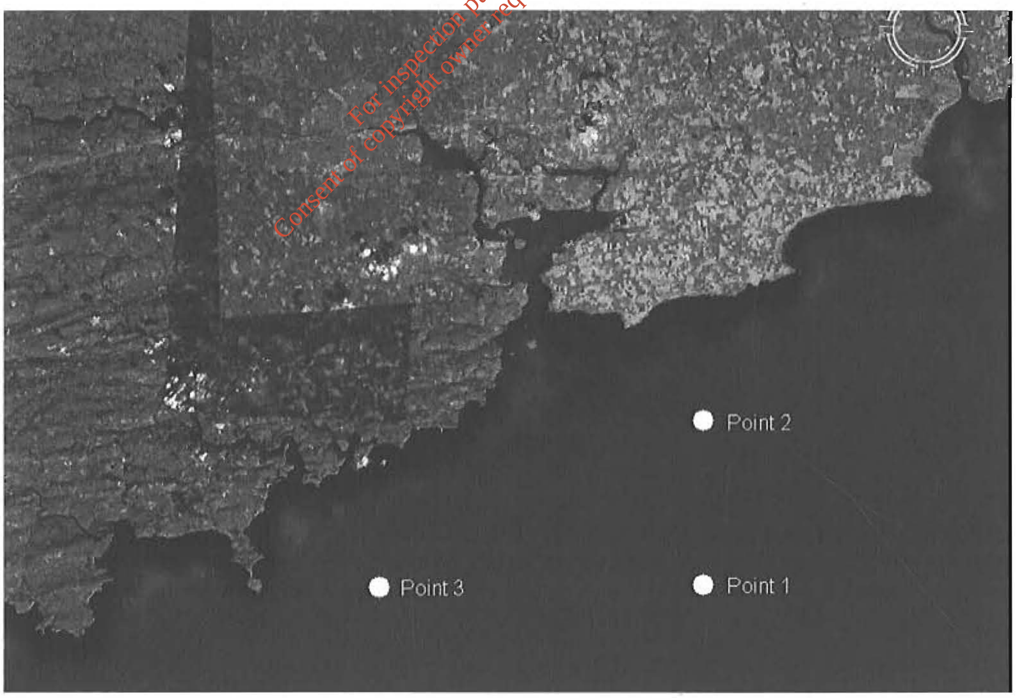

Fig. 2.3 Location of points on the CS3 grid used for the OH Hydrodynamic model boundary conditions (Image from Google Earth)

2.2.4 River & Wind Files

River flows and wind influence the hydrodynamics of the estuary. Cork County Council, EPA, OPW and the ESB supplied measurements of flow in all the rivers discharging into Cork Harbour for 1992 and 2004. In this Environmental Impact Statement we have included the influence of the River Lee, Owenboy and Owenacurra rivers.

The archive of the 1992 survey carried out by Irish Hydrodata Ltd contained the wind records at Cork Airport (Met Eireann), Roches Point (Met Eireann). and Ringmahon Point (Bord Gais/Cork Corporation). The 1992 survey report by Irish Hydrodata Ltd states that the Cork Airport and Roches Point datasets "show very similar wind patterns". It also states in reference to the Cork Airport and Ringmahon Point sites that there is "little difference between the sites". Consequently, we have relied on the data from Cork Airport exclusively.

2.2.5 Water level recordings from Cork Harbour

The Port of Cork supplied time series of water level from the gauges they maintain at Tivoli and Cobh. This data has been used to validate the OH_2 model.

2.2.6 Outfall Loading

As part of the preliminary investigation carried out for the proposed scheme, Mott MacDonald Pettit undertook a comprehensive study of the population and industry serving each outfall in 2001[10]. We have used the values given in this report in our models. The projected loadings for 2010 and 2030 were also taken from this report.

[10] Cork Harbour Main Drainage Scheme, Volumes 1-5, EG Pettit & Company