3.4 Soils, Geology and Hydrogeology

3.4.1 Introduction

This chapter of the EIS describes the Soils, Geology and Hydrogeology in the existing environment surrounding the proposed development. Significant impacts likely to affect soils, geology and hydrogeology are identified and mitigation measures have been proposed where considered appropriate.

3.4.2 Methodology

(i) Existing Environment

Soils and Geology

The methodology specified hereunder was used by the project team to assess the baseline drift geology and bedrock geology environment of the proposed development area. The baseline information that is detailed in this section of the statement was obtained from publicly available information.

Existing literature on soils and geology in the existing environment were reviewed in light of the proposed development. Information on drift and solid geology was obtained from the Geological Survey of Ireland (GSI) database and maps for the area. The following documents and sources were referenced:

- *An Assessment of the Bedrock Geology of South Cork,* Geological Survey of Ireland (GSI; 1994) and Sheet No. 25 (GSI; 1995);
- *General Soil Map of Ireland* 2nd Edition, (1980), the National Soil Survey, An Fóras Taluntais.
- Geological Heritage, consultation with GSI (Sarah Gatley, Senior Geologist, Head IGH Programme)
- *Geology of the Lough Mahon Area, Preliminary Report 1977* (for Cork Harbour Commissioners), T.A. Reilly and A.G. Sleeman. Historical Marine Geology Report.
- Geophysical Survey – Cork Harbour Main Drainage Scheme, November 2007. Minerex Geophysics Ltd.
- *Groundwater and Human Development*, 2002. 'Buried valley ribbon aquifers. A significant groundwater resource of South West Ireland'. Dejan Milenic and Alistair Allen.
- GSI quaternary maps (http://gis3.dcmnronline.ie/imf5104/imf.jsp?site=GSI_Simple)
- *N28 Geotechnical Report*, Priority Geotechnical, October 2006 (part of the N28 Cork to Ringaskiddy Road Scheme)
- National Radon Survey, Cork Map. Radiological Protection Institute of Ireland (http://www.rpii.ie/radon/maps/cork.html)
- *Site Investigation on Lands in Ringaskiddy*, 1977 (carried out for the Industrial Development Authority). E.G. Pettit & Company

- Soil Associations of Ireland and their Land Use Potential, Explanatory Bulletin to Soil Map of Ireland 1980, M.J. Gardiner and T. Radford, the National Soil Survey, An Fóras Taluntais.
- Subsoil map (Teagasc Classification) and 'Soil Parent Material Classification and Map Codes' (Teagasc 2004).

A site walk over of the proposed WWTP site was carried out on 22nd June 2007 and 23rd August 2007. A geophysical investigation was carried out at the site in November 2007. Intrusive subsurface data was not available; however geotechnical borehole and trial pit data from the proposed N28 located directly north of the site has been referenced.

Hydrology, Hydrogeology and Groundwater Chemistry

A desk-based assessment was used to assess baseline hydrology, hydrogeology and groundwater chemistry for the receiving environment of the proposed site.

In addition to those identified above, the following documents and sources were referenced:

- 1:50,000 Discovery Series Maps and 6" maps
- Aquifer classification and vulnerability identification from the Geological Survey of Ireland (GSI web page http://www.gsi.ie);
- GSI well search to determine the location of groundwater wells within a 3 kilometre radius of the WWTP site;
- Water Framework Directive – groundwater classifications (information supplied by the South Western River Basin District (SWRBD) project office.

Impact Assessment Methodology

This section provides an assessment of the environmental impacts of the proposed development on the bedrock geology, drift geology and hydrogeology. Consideration is given to the nature of the underlying limestone bedrock and the implications this may have on the subterranean drainage and groundwater quality. The environmental impacts due to the proposed development are described in terms of predicted impacts during the construction and operational phases of the proposed development.

The importance or sensitivity of the geological and groundwater interest of the study area was determined using the criteria set out below in Table 3.4.1 *Geology and Groundwater Sensitivity.*

Table 3.4.1: Geology and Groundwater Sensitivity

Sensitivity of Geological Interest	Description
High	Areas containing geological or geomorphological features considered to be of national interest, for example, Special Areas of Conservation (SAC). Designated sites of nature conservation importance dependent on groundwater.
Medium	Areas containing geological features of designated regional importance, for example regionally important geological sites, considered worthy of protection for their educational, research, historic or aesthetic importance. Exploitation of local groundwater is not extensive and/or local areas of nature conservation known to be sensitive to groundwater impacts.
Low	Geological features not currently protected and not considered worthy of protection. Poor groundwater quality and/or very low permeabilities make exploitation of the aquifer(s) unfeasible. Changes to groundwater not expected to impact on local ecology.

The assessment of the magnitude of predicted impacts on solid and drift geology and groundwater was based on the criteria defined in Table 3.4.2 *Definition of Magnitude of Impacts Criteria* and the combination of sensitivity and magnitude are used to derive the impact significance as detailed in Table 3.4.3 *Assessment of Significance Criteria for Impacts on Geology and Groundwater*.

Table 3.4.2: Definition of Magnitude of Impacts Criteria

Magnitude of Impacts	Description of Degree of Impact
High	Partial (greater than 50%) or total loss of a geological site, or where there would be complete severance of a site such as to affect the value of the site. Major permanent or long term change to groundwater quality or available yield. Existing resource use is irreparably impacted upon. Changes to quality or water table level will impact upon local ecology.
Medium	Loss of part (between approximately 15% to 50%) of a geological site, major severance, major effects to the setting, or disturbance such that the value of the site would be affected, but not to a major degree. Changes to the local groundwater regime are predicted to impact slightly on resource use but not rule out any existing supplies. Minor impacts on local ecology may result.
Low	Minimal effect on the geological site (up to 15%) or a medium effect on its setting, or where there would be a minor severance or disturbance such that the value of the site would not be affected. Changes to groundwater quality, levels or yields do not represent a risk to existing resource use or ecology.
Negligible	Very slight change from baseline condition. Change hardly discernible, approximating to a 'no change' condition.

Table 3.4.3: Assessment of Significance Criteria for Impacts on Geology and Groundwater

	Magnitude of Impact			
Site sensitivity	**High**	**Medium**	**Low**	**Negligible**
High	Substantial	Substantial	Moderate	Slight
Medium	Moderate	Moderate	Slight	Negligible
Low	Slight	Negligible	Negligible	Negligible

The assessment of the duration of predicted impacts on solid and drift geology and groundwater was based on the criteria defined in Table 3.4.4 *Assessment of the Duration for Impacts on Geology and Groundwater.*

Table 3.4.4: Assessment of the Duration for Impacts on Geology and Groundwater.

Temporary Impact	≤ 1 year
Short-term Impact	1 – 7 years
Medium-term Impact	7 – 15 years
Long-term Impact	15 – 60 years
Permanent Impact	≥ 60 years

3.4.3 Existing Environment

(i) Background

This section of the statement provides the baseline information in relation to geology, soils, and hydrogeology that exists in the vicinity of the proposed development. The proposed new WWTP will be constructed on a green field site in the townland of Shanbally, approximately 11km south of Cork City, 2.24km west of Ringaskiddy and circa 1.06km to the north east of Carrigaline. The N28 (National Primary Road) is 490m from the northern boundary of the site and links Cork City to Ringaskiddy.

Both the geology and soils play an important part in determining the environmental characteristics of a region. The underlying geology has a major influence on landform and rocks provide the parent material from which soils are created. The nature of the rock helps to determine not just the nature and chemistry of the soil formed, but also the rate at which it forms. This in turn strongly affects the natural vegetation and the type of agriculture or horticulture that can be sustained.

(ii) Receiving Environment

The receiving environment is described below for the proposed WWTP site and collection system under the following headings:

- Geomorphology
- Topography

- Drift Geology
- Bedrock Geology
- Marine Geology
- Structural Geology
- Karstification
- Radon
- Geological Heritage
- Hydrology
- Hydrogeology
- Hydrochemistry

Geomorphology

The topography of the South Cork region is controlled by the geological structure, with the anticlines forming upland areas and the synclines occupied by valleys. These valleys were formed during the Pleistocene glaciations (2 million to 10 thousand years ago), as prior to this the regional topography sloped southwards and the region was drained by southerly flowing rivers. This Tertiary drainage was truncated by glaciers advancing outwards from the mountainous regions of western Ireland, preferentially exploiting the weaker shales or karstified limestone coring the synclines, resulting in the development of a large number of broad u-shaped valleys where previously there has only been only north-south drainage patterns. Superimposed on these u-shaped valleys are a number of buried valleys infilled with sand and gravel. At the peak of the last glaciation 15,000 years ago when much of Europe was covered by ice, sea level fell to approximately 130m lower than present day, so the rivers eroded down to the new base level cutting new steep sided gorges. When temperatures subsequently improved towards the end of the Pleistocene glacial epoch (10,000 – 12,000 years ago) the ice sheets receded, sea level rose again and the gorges rapidly became infilled with fluvioglacial sand and gravels as the rivers responded again to changing base level. The south of Ireland continues to sink so sea level carries on rising (estimated 16m over the past 8,000 years) (Milenic & Allen, 2002).

Topography

The proposed site of the WWTP and collection system is located in a coastal region of undulating terrain where the topography in the local area is defined by ridgelines that typically run east west to form a rolling landscape.

The proposed WWTP site consists of portions of two large agricultural fields located on sloping ground. The site covers an area of approximately 7.36ha and is situated on a south facing hillside. The site is essentially of gently sloping south-facing topography and has an elevation of approximately 30m (Ordnance Datum). The two fields range in elevation from approximately 40m in the north to approximately 28m in the south.

Drift Geology

Typical Quaternary deposits across the Cork Harbour region are largely composed of:

- Devonian and Carboniferous sandstone, shale and limestone
- River alluvium and
- Coastal deposits.

Generally within the South Cork area, glacial deposits are thin (1-3m) on the ridges and thicker (up to 30m) in the valley bottoms, the thicker sediment being largely fluvioglacial in origin (deposited by melt-water) and the thinner sediments being tills. Thick melt-water sands and gravels have been identified in the Cork Harbour region (GSI, 1994).

Quaternary mapping is available for the study area; however there is no GSI information on the depth of overburden. The quaternary maps (available on the GSI web page) identify the predominant deposits at the WWTP site as undifferentiated till (denoted as Ut) with glaciofluvial sand and gravels (denoted as G) in the eastern side of the site. The range of Quaternary deposits mapped by the GSI for the collection system includes undifferentiated till, alluvium, colluvium and bedrock close to or at the surface.

The Soil Classification Map identifies one soil association (Acid Brown Earths 70% – Association 13) at Shanbally and the proposed WWTP site. Topography is of gently rolling lowlands. These soils have a wide use and are very suitable for both tillage and grass production. This association is dominated by well drained soils of sandy loam texture and structure. Because of this they are easy to cultivate and can produce a wide range of crops. The climatic advantages of being in a southern location increase both crop and pasture yields. Soil associations are cartographic units used for mapping the landscape and consist of two or more soil types generally formed from the same parent material. Acid Brown Earth is typically formed from glacial drift of mixed Old Red Sandstone (ORS)/Carboniferous limestone composition while the underlying rock is typically Carboniferous limestone (*Soil Association of Ireland and their Land Use Potential*, Gardiner and Radford, 1980). The range of Associations mapped for the collection system includes Acid Brown Earths and Brown Podzolics. Brown podzolics are formed from glacial drift of ORS, shale and slate composition. Elevations range mainly from 30-150m. The soil is well drained sandy loam to loam texture and of low to medium base status. Brown Podzolics have a similar land use range as Acid Brown Earths.

A walkover survey was carried out at the proposed WWTP site in June and August 2007. The topsoil encountered consisted of brown sandy clay. These soils are capable of producing a range of agricultural crops and are good pastureland. The site was well drained and no springs or areas of standing water were observed. Site visits carried out by the design engineers during the winter months of 2006/2007 also confirmed these ground conditions. It should be noted that the rainfall totals for the summer of 2007 were above normal throughout the country. According to Met Éireann it was the wettest summer for at least nine years. A total of between 55 and 65 rain-days was recorded generally for the 3-month period (June, July and August) compared with the normal range for summer of between 45 and 55 days.

A small number of minor ground depressions (one noticeable feature and 3-4 possible features) were observed in the eastern field. The noticeable conical shaped depression was 3-4m diameter and approximately 0.5m deep. An example of this is illustrated in Plate 3.4.1 Ground Depression Located Near the Eastern Field Boundary. Local knowledge of the area suggests that the underlying limestone bedrock may have been subjected to solution weathering and these features may be a surface manifestation of this process. This is discussed in further detail below (Section 3.4.2 *Existing Environment*).

Borehole and trial pit logs directly north of the site (as part of the N28 Cork to Ringaskiddy Road Scheme, Priority Geotechnical, 2006) have been used for reference. Logs in the vicinity of the development site indicate a range of subsurface deposits (summarised on Table 3.4.5 *Borehole Summary Details* and Table 3.4.6 *Trial Pit Summary Details*). The closest borehole (RC 1041) was excavated to a total depth of 18m below ground level. Bedrock was not encountered therefore the depth of overburden extends below this depth.

Table 3.4.5: Borehole Summary Details

Borehole Reference Number	Depth Metres OD	Soil Type	Description
RC 1041 Located at field boundary directly north of proposed site	38.94 - 38.64	Topsoil	
	38.64 – 35.49	Gravel	Loose, brown, very silty, very sandy, fine-coarse grained, subangular
	35.49 – 32.94	Clay	Stiff, brown, slightly sandy
	32.94 – 29.94	Silt	Stiff, brown, slightly sandy, slightly gravelly
	29.94 – 27.64	Sand	Medium dense, brown, clayey, fine to medium grained
	27.64 – 25.94	Sand	Dense, dark brown, clayey, fine to coarse grained
	25.94 – 20.94	Gravel (Overburden)	Sandstone and mudstone gravel with rare mudstone cobble
Total Depth – 18.00m			
BH 1042 Located NE of proposed site (adjacent to sports field)	38.92 – 38.62	Topsoil	
	38.62 – 37.42	Clay	Firm, brown, slightly sandy, gravelly
	37.42 – 35.42	Clay	Firm to stiff, brown, gravelly
	35.42 – 34.32	Clay	Stiff, brown, slightly sandy, gravelly
	34.32 – 33.68	Clay	Stiff, brown, slightly sandy, gravelly (Chisel for 1hr at 33.68mOD)
Total Depth – 5.24m			
RC 1043 Located ENE of the proposed site, east of the club house	32.19 – 31.89	Topsoil	
	31.89 – 30.69	Silt	Firm, brown, slightly sandy, slightly gravelly, occasional cobbles
	30.69 – 29.59	Silt	Firm, brown, sandy, gravelly
	29.59 – 28.69	Silt	Firm to stiff, brown, slightly gravelly
	28.69 – 27.69	Silt	Firm, brown, gravelly
	27.69 – 26.19	Silt	Stiff, brown, slightly sandy, gravelly
	26.19 – 24.09	Silt	Firm, brown, sandy, gravely, rare cobbles
	24.09 – 13.19	-	(Poor recovery) Boulder clay & cobbles
Total Depth – 19.00m			

Table 3.4.6: Trial Pit Summary Details

Trial Pit Reference Number	Depth Metres OD	Soil Type	Description
TP 2019 Located at field boundary directly north of proposed site	35.86 – 35.66	Clay	Firm, brown, slightly sandy, slightly gravelly, occasional cobbles
	35.66 – 34.66	Clay	Firm to stiff, brown, slightly sandy, slightly gravelly, with rare cobbles
	34.66 – 33.36	Clay	Firm to stiff, brown, slightly sandy, slightly gravelly, with occasional cobbles and possible weathered rock at 34.36m
	33.36 – 32.16	Gravel	Firm to stiff, brown mottled dark brown, very clayey, very sandy, with occasional cobbles with possible weathered siltstone and limestone rock
Total Depth – 3.70m			
TP 2020 Located just outside field boundary NW of proposed site	38.29 – 37.89	Topsoil	Soft brown
	37.89 – 37.29	Clay	Slightly sandy, slightly gravelly
	37.29 – 35.49	Gravel	Dense, brown, silty, very sandy, large pockets of fine sand with rare cobbles
	35.49 – 34.49	Sand	Brown, slightly gravelly, predominantly fine grained sand, with rare cobbles
	34.49 – 34.29	Silt	Brown, sandy, slightly gravelly
Total Depth – 5.24m			

A geophysical survey was carried out in November 2007 for the WWTP site which provides information on the likely subsoil units and depths. These are based on the conductivity of each unit. As the proposed development has not yet progressed to detailed design stage, no intrusive site investigative work has been completed.

The geophysical survey consisted of EM31 Ground Conductivity, 2D-Resistivity and Seismic Refraction measurements for the proposed WWTP site. The results of this show a thick overburden of soils and subsoils with a gravelly nature (gravelly clay or sand and gravel) overlying clean limestone and mudstone bedrock lithologies. No soft clays or organic muds have been identified at this site. Four layers have been identified in the earth model (described in *Volume III, Appendix 4A*). The results indicated a thick overburden at a depth of 20m and greater below ground level; however at the south eastern corner of the site this has been interpreted at 8m below ground level. This interpretation includes fractured rock. The conductivity values also suggest a well drained overburden which is consistent with the site walkover/visual assessment.

In view of the minor land-take required for the proposed WWTP, the soils which are likely to be affected by the development represent a minor resource in a local context. In a regional context, this soil resource is less significant as such soils occur in abundance over the South Cork region.

Bedrock Geology

The rocks of South Cork were deposited during the later Devonian and Carboniferous periods (370 to 310 million years ago). The ridges and valleys that are visible today mirror the underlying geological structure produced when the rocks were folded some 290million years ago during the Variscan Orogeny (this is discussed in greater detail below under the heading *Structural Geology*).

According to the GSI web page and the 1:100,000 bedrock geology map of South Cork (Geological Survey of Ireland, Sheet No. 25:1995), bedrock underlying and surrounding the proposed location for the new WWTP comprises:

- Dinantian grey mudstone with subordinate sandstone (*Kinsale Formation* – Cuskinny Member which is a flaser-bedded sandstone and mudstone)
- Dinantian massive unbedded fine grained limestone (*Waulsortian Limestone Formation*).

The Kinsale Formation is predominantly mudstone and sand lensed mudstone (linsen) and represents mainly a water depth within reach of wave influence. This formation was deposited on a shallow marine shelf across which sand-bars migrated during frequent storms. Sedimentation in the South Munster Basin generally kept pace with subsidence during the deposition of this thick formation. At a later time the sea deepened due to continued subsidence and a slowing down in the rate of sedimentation.

The growth of carbonate mud mounds (Waulsortian Limestone) are likely to have developed as individual mounds on the sea floor at a depth of at least 200m. These contained abundant crinoids and bryozoa. The mounds maintained high depositional slopes due partly to the binding action of algae. These started to grow in the Ringaskiddy area of Cork harbour earlier than anywhere else in Ireland. Many of the original cavities, including stromatactis cavities, are filled with internal sediments and cements. In the South Cork area the regional cleavage has affected the limestone. In some places there are zones of intense fracture cleavage and structural recrystallisation of the matrix. This deformation affects the internal characteristics of the Waulsortian Limestone and often makes identification of internal features difficult to interpret during ground investigations.

According to the GSI database the Cuskinny Member is the predominant bedrock with Waulsortian limestone only located in the south western and south eastern corners of the site (refer to Figure 3.4.1 *Local Bedrock Geology* and Figure 3.4.2 *Proposed WWTP & Collection System with Underlying Bedrock*). It is possible that the geophysical survey has picked this up in the 2D-resistivity profile (R1) where faulting/fracturing of the rock or karstification of the limestone has been suggested at the eastern side of the WWTP site (refer to *Volume III, Appendix 4A*).

Bedrock geology likely to be present at the proposed collection system footprint is presented below on Table 3.4.7 *Bedrock Geology Summary.* A full description of each Formation/Member is included in *Volume III, Appendix 4B.*

Table 3.4.7: Bedrock Geology Summary

Location	Bedrock Geology
WWTP Site	Cuskinny Member and Waulsortian Limestone
Raffeen Pumping Station	Cuskinny Member
Monkstown Pumping Station	Gyleen Formation
Carrigaloe Pumping Station	Ballytrasna Formation
West Beach Pumping Station	Cuskinny Member
Marine Crossing	Ballytrasna Formation (assumed)
Collection System (Pipeline)	Ballytrasna Formation, Gyleen Formation, Old Head Sandstone Formation, Cuskinny Member, Ballysteen Formation, Pigs Cove Member, Waulsortian Limestone, Lispatrick Formation and White Strand Formation

Marine Geology

A survey was carried out in West Passage by the Voyager in 2005; however no information is available in relation to sediment and bedrock conditions. The GSI were contacted regarding available information for the marine crossing. Historical information is available for a cross section of Marino Point to Lee Carrow House dating back to 1977 (T.A. Reilly and A.G. Sleeman). Although this cross section is further north of the proposed crossing between Carrigaloe and Glenbrook, it demonstrates the extension of the bedrock across the West Passage and the nature of the sediment to depths greater than 20m (refer to Figure 3.4.3 *Marine Cross section* below). Estuarine silts and sands are present above the gravels which in turn overlay the bedrock.

Structural Geology

Over several million years, South Cork has often been the site of large rivers flowing over arid deserts, shallow tropical seas and more recently buried beneath glaciers. According to the GSI major earthquakes are unlikely to have affected this area since the late Tertiary (65-1.6 million years ago). Rock types in the Cork area are sedimentary and were deposited during the later Devonian and Carboniferous Periods (370-310 million years ago). There is considerable complexity in the structure of the rocks. This is reflected in the complex pattern of faults and folds. All these rocks have been weakly metamorphosed (GSI, 1994).

Local uplift from these folding events results in a convex upwards fold (like a ridge), where older rocks are bordered on two sides by younger rocks (anticline structure). When strata is folded in a concave upwards shape, younger rocks are flanked on both sides by older rocks (syncline structure). Faults are also features of folding events where planar fractures appear in the rock across which there is some displacement.

Cork Harbour lies within the very low grade Rheno-Hercynian fold thrust terrain of the late Carboniferous Variscan Orogenic Belt. The area is characterised by a series of horizontal upright east-west anticlines and synclines, the former cored up by Upper Devonian sandstones and shales and the latter by massive Lower Carboniferous reef limestones. The folded sequence is cut by east west thrusts and steep north south compartmental faults. Tropical conditions during the Tertiary resulted in erosion of Mesozoic cover, intense karstification of the highly fractured Carboniferous limestone and the establishment of a north-south drainage pattern (Milenic & Allen, 2002).

Bedrock in the Shanbally area forms part of the Ringaskiddy anticline and the Cloyne syncline. Bedding details indicates relatively shallow to moderate dipping bedding in the Waulsortian Limestone and moderate to steep dipping bedding in the Cuskinny mudstone.

The proposed WWTP site is located in the Ringaskiddy anticline. Faults with a NNW to SSE trend dissect the regional folds in the area close to and at the proposed site (refer to Figure 3.4.1 *Local Bedrock Geology* and Figure 3.4.4 *Structural Geology*). The faults in this area are mainly strike-slip where horizontal movement between the different bedrock formations has occurred. Bedding dip is variable throughout this area because of its intense folding history. The bedding dip in the vicinity of the development site is expected to be steepest in the vicinity of the anticlinal axis. No outcrop is visible within the site.

Karstification

Karst landforms are generally the result of mildly acidic water acting on soluble bedrock such as limestone or dolomite. This mildly acidic water begins to dissolve the surface and any fractures or bedding planes in the bedrock. Over time these fractures enlarge as the bedrock continues to dissolve. It is influenced by the type and solubility of the rock, the degree of jointing, faulting and bedding, the chemical character of the groundwater, the rate of circulation and the overburden cover. Solution results in the development of enlarged joints, conduits and localised groundwater flow, particularly at the water table.

The karstification of a landscape may result in a variety of large or small scale features both on the surface and beneath. The main topographic features of karst areas include:

- swallow holes
- dry valleys
- sparse and intermittent streams
- bare rock
- deep water tables
- caves
- large springs

Karst aquifers indicate a number of problems and difficulties such as:

- Poor predictability of groundwater supplies due to uneven distribution of permeability
- Low storage of groundwater particularly in drained areas
- High vulnerability to pollution because the pollutants can enter the rock fissures readily where the overburden is thin and because the rock itself is unable to attenuate the pollutants

According to the GSI there are two types of bedrock present at the WWTP site. The Cuskinny Member (sandstone and mudstone) is the predominant bedrock with Waulsortian limestone only located in the south western and south eastern corners. Waulsortian limestone is permeable, porous and particularly susceptible to solution. This permeability has developed in response to structural movements and karstification to deeper drainage levels that existed in the past. The limestone at the WWTP site is unconfined and is classified as a minor (locally important) karst aquifer.

In South Cork there are numerous karst features in this limestone lithology i.e., caves, swallow holes, collapse features and large springs. An example of a feature north of the study area is a Waulsortian limestone cave that has been recorded by the GSI in Shanbally (National Grid reference 175544, 64445). During the site walk over, one noticeable depression was observed and a further two to three possible features within the site boundary (located in the eastern field of the proposed site). An example of one of these features is illustrated on Plate 3.4.1 *Ground Depression Located Near the Eastern Field Boundary.*

A geophysical survey (*Volume III, Appendix 4A*) was carried out to determine the ground conditions, depth to rock, existence of karst features and reduce the risk of encountering difficult subsurface conditions. During this assessment an area of possible faulting/fracturing or karstification was identified in the SE corner of the site where strong lateral variations in the model resistivity values were recorded. It is possible that this variation represents the change in bedrock to Waulsortian limestone in the area.

Radon

Radon gas is a naturally occurring radioactive gas, originating from the decay of uranium on rocks and soils. It is a colourless, odourless and tasteless gas and its presence can only be measured using specialist equipment. Radon dissipates readily in open air and is not considered harmful. However, in enclosed spaces, such as a building, radon can accumulate to unacceptably high concentrations. When inhaled, radon particles result in a radiation dose that can cause damage to lungs and eventually lead to lung cancer.

Radon is measured in Becquerel's per cubic metre of air (Bq/m^3). A Becquerel is a unit of radioactivity and corresponds to one radioactive disintegration per second. A High Radon Area is one where more than 10% of houses are predicted to have radon levels in excess of 200 Bq/m^3.

Information on radon levels around the development site was obtained from the *Radiological Protection Institute of Ireland.* Figure 3.4.5 *Radon Levels in Cork Harbour* illustrates that the development site is within a moderate radon area of 5-10%, (i.e. 5-10% of dwellings are predicted to have radon levels in excess of 200 Bq/m^3).

Exposure to natural radon levels in the workplace is governed by the *Radiological Protection Act* (1991) (*Ionising Radiation Order, 2000 (S.I. No. 125 of /2000*). A reference level for radon in workplaces of 400 Bq/m^3 averaged over a period of three months is specified in the Act.

Geological Heritage

A Geological Heritage Area is one which contains geological or geomorphological features considered to be of national interest and recommended for Natural Heritage Area (NHA) designation by the GSI under the *Wildlife (Amendment) Act* (2000).

According to the GSI there are no areas of geological heritage significance which could be impacted on by the WWTP site and collection system. Three sites have been identified in the surrounding area and are referenced in *Volume III, Appendix 4C*.

Hydrology

Cork Lower Harbour is located on a largely low-lying coastal region in the South of Ireland. The proposed site of the WWTP is located adjacent to a coastal area of undulating terrain near Shanbally. The dominant influence on drainage in the area is the Owenboy River flowing east through Carrigaline and the Glounatouig Stream flowing east into Monkstown Creek which ultimately flow into the Lower Harbour (refer to Figure 2.1 *Location of Existing Outfalls and Proposed Outfall*). There are no streams or rivers crossing or adjacent to the development site.

The proposed development lies within Hydrometric Area 19 (Lee, Cork Harbour and Youghal Bay) as defined by the EPA. The hydrodynamics of the Lower Harbour which currently receives all the untreated waste water from this drainage scheme is dealt with in Section 3.3 *Water Quality*.

According to the Office of Public Works (OPW) National Flood Hazard Mapping – *Flood Report for the Carrigaline Area*, one flood event was recorded (November 2002) within a 1km radius. During this period the entire country received an exceptional amount of rainfall over a short period of time. One of the worst affected regions was the Carrigaline area. The locations closest to the proposed WWTP impacted by the heavy rainfall (recorded by the OPW) were Raffeen Bridge on the R610 and Coolmore Crossroads on the R613. Both of these are at lower elevations than the proposed WWTP site.

As described above (topography section) the site is situated on a south-facing gentle slope at an elevation of approximately 30m OD and is well drained. Surface water is expected to infiltrate the overburden and flow in a southerly direction in the water table to the Owenboy Estuary (which is the nearest water channel located approximately 1km south of the proposed WWTP site). No evidence of flooding has been reported at the site.

Hydrogeology

Hydrogeology looks at how water interacts with geological systems and the distribution and movement of groundwater in the soil and rocks (commonly in aquifers). Groundwater is often thought of as the hidden resource, yet it supplies around 30% of the country's water supply, both public and private.

The GSI identify two distinct hydrogeological environments in the Cork area. The Devonian cored anticlinal ridges and the synclinal valleys composed of carboniferous limestone and overlain by Quaternary deposits. The ridges are characterised by steep slopes, impermeable ground and 'flashy' runoff. The valleys are gently undulating, generally well drained and the rivers have a substantial baseflow. Potential recharge to these aquifers range from 450-750mm/year where the bulk of this recharge is expected to occur between late October and early March (GSI, 1994).

The major aquifers in the Cork Harbour area occur in both bedrock and overburden deposits. The main bedrock aquifers are intensely karstified limestones, coring the Cork-Middleton and Cloyne synclines which possess significant storage capacity and hydraulic conductivity. These limestones represent typical buried karst with a surface outcrop of only 5%. Effective porosity is conservatively estimated as 1% with the depth of karstification of at least 60-100m. Characteristic well yields are in the range of 3-20 litres per second. Intergranular aquifers overlie the limestone and are developed in sands and gravel infilling the buried valleys. Both of these aquifers are in hydraulic connection (Milenic & Allen, 2002).

In general the ORS represents a hydrogeological barrier on a regional scale. Locally, however, a certain amount of groundwater may be contained within the weathered zone to an approximate depth of 10m. Effective porosity is estimated as 0.1%. Furthermore, north-south fracture zones cutting the ORS may act as pathways for groundwater transfer between the two karst aquifers within the adjacent synclines (Milenic & Allen, 2002).

Aquifer Classification and Vulnerability

Rocks which store and transmit groundwater are known as bedrock aquifers. Different bedrock types have differing abilities to store and transmit water, depending on their permeability and fracture intensity. The Geological Survey of Ireland has classified all aquifers in Ireland into three main categories based on potential yield and extent:

- Regionally Important
- Locally Important
- Poor

Provisional information on the hydrogeological classification of the bedrock beneath the proposed WWTP site and pumping stations was obtained from the Geological Survey of Ireland (refer to Table 3.4.8 *Summary of GSI Bedrock and Aquifer Data*).

Table 3.4.8: Summary of GSI Bedrock and Aquifer Data

Location	Bedrock Geology	Aquifer Classification	Aquifer Vulnerability
WWTP Site	Cuskinny Member and Waulsortian Limestone	Ll & Lk	Reclassified as Extreme (GSI mapped as High)
Raffeen Pumping Station	Cuskinny Member	Ll	Extreme
Monkstown Pumping Station	Gyleen Formation	Ll	Extreme
Carrigaloe Pumping Station	Ballytrasna Formation	Ll	Extreme
West Beach Pumping Station	Cuskinny Member	Ll	Extreme
Marine Crossing	Ballytrasna Formation (assumed)	-	-

The Cuskinny Member (sandstone and mudstone) beneath the proposed new WWTP site is considered by the Geological Survey of Ireland to be a ***locally important bedrock aquifer (Ll)*** and the Waulsortian limestone beneath the proposed new WWTP site is considered by the Geological Survey of Ireland to be a ***locally important karst bedrock aquifer (Lk)***; both described below.

1. *(Ll) Locally Important Bedrock Aquifer, Moderately Productive only in Local Zones:* Aquifers with a limited and relatively poorly connected network of fractures, fissures and joints, giving a low fissure permeability which tends to decrease further with depth. A shallow zone of higher permeability may exist within the top few metres of more fractured/weathered rock, and higher permeability may also occur along fault zones. These zones may be able to provide larger 'locally important' supplies of water. In general, the lack of connection between the limited fissures results in relatively poor aquifer storage and flow paths that may only extend a few hundred metres. Due to the low permeability and poor storage capacity, the aquifer has a low 'recharge acceptance'. Some recharge in the upper, more fractured/weathered zone is likely to flow along the relatively short flow paths and rapidly discharge to streams, small springs and seeps. Groundwater discharge to streams ('baseflow') can significantly decrease in the drier summer months.

2. *(Lk) Locally Important Karstified Bedrock Aquifer:* Essentially it is similar to the Regionally Important Karstified Bedrock Aquifer (Rk), but with a smaller continuous area (<c.25 km^2). Although the properties imply that this aquifer can supply 'excellent' yields, the smaller size limits the amount of recharge available to meet abstractions.

There are further sub-categories based on the geology of the subsoil, the type of recharge (i.e. either point or diffuse) and the thickness of the unsaturated zone through which potential contaminants can move. The Geological Survey of Ireland uses a matrix comprising four groundwater vulnerability categories - extreme, high, moderate and low - for mapping purposes and in the assessment of risk to groundwater. The categories are based on the thickness of cover (overburden), which provides some attenuation for contaminants migrating toward the groundwater table from the surface or near sub-surface. A detailed description of the vulnerability categories can be found in the *Groundwater Protection Scheme* document (DELG/EPA/GSI, 1999) and on Table 3.4.9 *Vulnerability Mapping Guidelines* below.

Table 3.4.9: Vulnerability Mapping Guidelines (GSI, 1999)

Vulnerability Rating*	Hydrogeological Conditions				
	Subsoil Permeability (Type) & Thickness			Unsaturated Zone	Karst Features
	High Permeability (sand & gravel)	Moderate Permeability (e.g. sandy subsoil)	Low Permeability (e.g. clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0 m	0 - 3.0 m	0 - 3.0 m	0 - 3.0m	-
High (H)	> 3.0 m	3.0 - 10.0 m	3.0 - 5.0 m	> 3.0 m	N/A
Moderate (M)	N/A	> 10 m	5.0 - 10.0 m	N/A	N/A
Low (L)	N/A	N/A	>10.0m	N/A	N/A

* This system assumes unconfined hydraulic conditions which are not always present in nature.

Where the overburden is less than 3m thick or karst features are present (which is the case for this assessment – potential karst feature at the south eastern portion of the site), the Matrix Vulnerability Rating of the aquifer is considered extreme (i.e., the potential for contamination to reach the aquifer is extremely high). Where the overburden is greater than 10m thick and has a low permeability, the vulnerability is considered to be low.

The hydrogeological significance of the Quaternary deposits at the site is dependent on overburden permeability and thickness. An open quarry exists to the northeast of the site which suggests that groundwater at the site is likely to be encountered at a deep level. Vulnerability for the WWTP site is classified by the GSI as High. However, it should be noted that because of the potential for karst features at the eastern side of the proposed site, this area has been reclassified for the purposes of this EIS as extreme vulnerability.

A number of groundwater wells have been identified within a 3km radius of the proposed site (*Volume III, Appendix 4D Well Search conducted by the Geological Survey of Ireland, November 2007*). Local topography suggests that the groundwater flow direction is southerly towards the Owenboy River. No supply wells are located within 500m radius of the proposed development or hydraulically down gradient of the WWTP (i.e. from the WWTP towards the Owenboy River).

Typically across the Cork area the water table is generally within 10m of the surface except for the more elevated parts of the limestone aquifers and the annual fluctuation is less than 6m. The geophysical survey carried out at the WWTP site in November 2007 (following a wet summer) suggests an absence of groundwater 10-15m below ground level.

Groundwater Chemistry

According to the GSI total hardness of the groundwaters in the South Cork sandstones and sand and gravels (derived from non-calcareous strata) is typically less than 200mg/l (as $CaCO_3$). The hardness of the limestone and sand and gravel (where derived from limestones) waters usually range from 200-400mg/l (as $CaCO_3$). The harder and more mineralised groundwaters in the Cloyne Syncline and eastern part of the Cork Syncline is characteristic of areas where vertical recharge is prevented or reduced by an overlying cover of poorly permeable Quaternary deposits. The chloride levels in these aquifers are likely to be higher than inland aquifers because of their proximity to the coast. The groundwaters in these strata are generally of potable quality with the exception of small local areas where they have been contaminated by effluent from mainly organic wastes. Groundwaters in most of the synclines have been identified as vulnerable to pollution (GSI, 1994).

As part of the Water Framework Directive (WFD) the South Western River Basin District (SWRBD) group has categorised the groundwater body for the WWTP site (reference IESWG072) as '1b' (*probably at significant risk*). This is primarily attributed to diffuse pressures which include mobile chemicals and nutrients (resulting from existing industry and waste water treatment regimes).

Contaminated Land

Based on the site walk-over it is considered that the risk of encountering contaminated materials or soil is low.

3.4.4 Impact Assessment

This assessment focuses on predicted impacts in relation to bedrock geology, drift geology and hydrogeology. The assessment relates to impacts occurring both during the construction and operational phase.

(i) Construction Phase Impacts

Drift Geology & Topography

Development works proposed for the site will not radically change the existing topography in a local or regional context. It is intended that the slope afforded by the existing topography of the site and its surrounds will be used to advantage in the design of the WWTP to minimise pumping.

It is expected that much of the topsoil and a smaller percentage of the subsoil at the proposed development site will be removed to allow for construction of the WWTP and a new access road. The specimen design identifies that to optimise the use of the sloping nature of the site, the preliminary treatment and primary settlement stages would be located at the higher elevations on site and constructed for the most part below ground level where only the tops of the chamber walls would be visible. In addition the storm water settlement tanks, aeration tanks and secondary settlement tanks would be constructed in part below ground level, with only the top one metre of the side walls emerging above the finished ground levels.

Given the relatively small quantity which will be removed it is not considered to be a resource of any regional significance. It is expected that all of the excavated topsoil and the majority of the subsoil (where the maximum estimated volume of surplus material from the excavation of the site for the WWTP tankage is in the order of 10,000m^3) will be reused in landscaping throughout the site. A risk assessment will be carried out as to the suitability of this material in advance of these works. The impact on soils locally as a result of the development will not be significant (low to negligible impact).

The soil classifications in the Cork Lower Harbour area will not be impacted on. Construction activities have the potential to impact on soil quality of the local drift deposits. This could occur due to leakage or spillage of construction related materials e.g. oils and fuels on site. Potential impacts could result in the introduction of substances such as diesel range organics (DRO), mineral oils, polycyclic aromatic hydrocarbons (PAH), heavy metals etc.

Many substances used at construction sites, such as lubricants, fuels and oils, are harmful to the environment and can cause soil contamination. Soil contamination from re-fuelling of vehicles or inadequate storage of fuels could occur in the absence of appropriate mitigation measures. The significance of this impact would be moderate and long term in duration.

There is potential for construction activities to impact on soil erosion. Soils can be disturbed and eroded by vehicular activity. Winds and heavy precipitation can also impact on non-vegetated areas (e.g. stockpiles) resulting in soil disturbances, which can enter water bodies as runoff. The significance of this impact in the absence of appropriate mitigation measures would be slight to moderate and long term in duration.

The effects of soil stripping on water resources have the potential to cause leaching of contaminants into the groundwater. This could have a significant (*moderate*) negative impact on groundwater quality.

Marine Sediment

The marine crossing (pipeline route) traverses an area where the thickness of sediment is currently unknown. From the historical available information it suggests that marine sediment could be in the region of 20m deep in the channel and decreasing to shallow depths at the eastern side of the West Passage. It is envisaged that the pipelines will be laid by either:

- open cut techniques (laid below the surface of the sediment bed and backfilled to the original profile, pipes are likely be encased in concrete for protection) or
- tunnelled (where there would be less sediment disturbance).

Open cut methods are considered to have greater impact on marine sediment and are dealt with here as a worst case. The route of the proposed pipeline is limited in its extent and in the overall context will involve minimal *temporary* disturbance to marine sediments and is anticipated to have a *slight* negative impact.

Sediment dredging will be required for open cut pipeline installation. Sampling of these sediments will be carried out in consultation with the Marine Institute. Consultation will also take place with respect to the disposal plan for these materials. It is not anticipated that construction-related activities will result in a significant chemical impact to local natural sediments (i.e. a *negligible impact* is anticipated).

It will be the responsibility of the Contractor to ensure that there is minimal impact on the sediment for the length of the pipeline. In addition, a method statement for construction will be developed in advance in consultation with the National Parks and Wildlife Service (NPWS). A foreshore application will be required for the proposed structures on the foreshore from the DAFF.

Other potential works in the foreshore, which may involve marine sediment disturbance or removal, are the pipelines associated with emergency overflows and storm water overflows. It is anticipated that these works will involve minimal *temporary* disturbance to marine sediments and is anticipated to have *slight* negative impact. It is not anticipated that construction-related activities will result in a significant chemical impact to local natural sediments (i.e. a *negligible impact* is anticipated). It should be noted that construction of outfall facilities for waste water or storm water will require separate planning approval (Part 8, *Planning and Development Regulations*, 2001). Method statements will be generated in advance of any works in consultation with the NPWS and the DAFF.

Bedrock Geology

The depth to bedrock beneath the proposed waste water treatment site is expected to range between 8m below ground level in the in the south east corner of the site to 20m (refer to *Volume III, Appendix 4A*- Geophysical Survey). No blasting is anticipated to be required. It is expected construction of the site will not affect the bedrock.

The proposed collection system (series of piped routes) is generally routed along existing roads, road verges or other hard core areas therefore it is unlikely that the trench excavations will impact on the bedrock geology. According to GSI publicly available information a number of the proposed major pumping stations are located in areas where bedrock may be close to the surface (<3m). There is no proposal for blasting; however should bedrock be encountered there may be a need for rock breaking. It is expected that construction of the proposed WWTP, collection system and the marine crossing will not affect the bedrock in this area (*negligible impact*).

No sites or features designated or identified as being of geological interest will be affected by the WWTP or collection system (including the marine crossing). The geology in the locality is of low sensitivity and therefore predicted effects will have negligible or no significance to geology. In addition, consultations with the Geological Survey of Ireland addressed no concerns about potential impacts on the integrity of the geomorphological and geological heritage of the Cork Lower Harbour landscape.

Marine Bedrock Geology

The depth to bedrock below the marine sediment is currently unknown. As mentioned previously, historical information suggests that marine sediment could be in the region of 20m deep in the channel and decreasing to shallow depths at the eastern side of the West Passage. Should bedrock excavation be required as part of the construction phase, it is anticipated that this work will entail a permanent impact to the underlying strata. It is considered that open cut techniques will have a greater impact on the bedrock geology as the quantity of rock disturbed/excavated will be greater than that required for tunnelling. In the context of the proposed development, construction activities relating to the pipelines are not expected to have a significant impact (i.e. *negligible*) on both regional and local bedrock geology. The proposed works are not anticipated to significantly alter the quality of the marine geological landscape or geological environment.

Other potential works in the foreshore, which may involve bedrock removal, are the pipelines associated with emergency overflows and storm water overflows. It is anticipated that these works will involve minimal disturbance to bedrock geology and is anticipated to have *negligible* impact. The proposed works are not anticipated to significantly alter the quality of the marine geological landscape or geological environment. It should be noted that construction of outfall facilities for waste water or storm water will require separate planning approval (Part 8, *Planning and Development Regulations*, 2001).

Hydrology and Hydrogeology

Karst groundwater (the water in a karst aquifer) is a major water resource in many regions. Karst aquifers have specific hydraulic and hydrogeologic characteristics that render them highly vulnerable to pollution from human activities. Karst groundwater becomes polluted more easily and in shorter time periods than water in non-karstic aquifers. Thus, protection measures are required to preserve the quality and quantity of karst groundwater that specifically consider the vulnerability of the karst environment. In order to preserve karst groundwater, it will be necessary to control and eliminate sources of pollution. No groundwater discharges are proposed and the site is located in an area where saline or brackish water would be anticipated (hence a low value for drinking water supply). Arising from the karstified nature of the aquifer, additional precautionary measures will be implemented to ensure any accidents or spillages will not negatively impact on the groundwater quality.

The geophysical survey carried out at the WWTP site in November 2007 (following a wet summer) suggests an absence of groundwater 10-15m below ground level. It is not anticipated that any of the construction works will extend to this depth and therefore it is unlikely that direct contact with the water table will be made. At detailed design, the site investigation will identify the depth to the water table level. If the final excavation depths are within 3m of the water table, a risk assessment will be required by an experienced hydrogeologist.

During the construction phase, there is a possibility of a spillage of contaminants such as fuels and oils to exposed fractured rock excavation which in turn could negatively impact on the quality of the receiving water body (i.e. the potential exists for pollution of the groundwater in the area to occur). With an appropriate emergency response plan and staff training, mitigation measures can be put in place to minimise the possibility of groundwater pollution from the spillage of fuels and oils.

The excavation and construction activities will cause quantities of excavated materials to be reused on site or, only where deemed unsuitable, removed from site for disposal or recovery. It is not anticipated that these activities will have any adverse impacts on the groundwater quality or quantity in the vicinity of the proposed development. Overall, there are no anticipated significant impacts predicted from the construction of the proposed development from a hydrological/hydrogeological perspective.

(ii) Operational Phase Impacts

Topography, Drift & Bedrock Geology

The soil classification in the Cork Lower Harbour area will not be impacted on by the operational phase of the proposed development. Operational impacts are not considered relevant in the context of geological bedrock or topography due to the nature and scale of the proposed development. The impacts from the operational phase of the proposed development are considered to be negligible as the drift geology in the locality is of low sensitivity.

On a more regional basis, the operational phase of the proposed development should have a positive impact on soils. It is acknowledged that in the *Sludge Management Plan for County Cork*, agricultural land in the Cork Harbour tidal area is unsuitable for landspreading of the biosolids product as this area displays a nutrient surplus in terms of phosphorus. However, based on phosphorus balances undertaken for the *Sludge Management Plan for Cork County*, there is sufficient spare capacity in County Cork as a whole to facilitate the landspreading on agricultural land of all of the municipal waste water sludge produced in the county. Ultimately the contractor will be responsible for operating the WWTP and may therefore transport the biosolids further afield from Region 19 (Cork County has been subdivided into Regions 18-22 for the purposes of municipal waste water sludge treatment) for landspreading on suitable agricultural land. The most attractive option would be to produce a biosolids product for use in agriculture as in the waste hierarchy it is considered to be a recovery activity due to the nutrient benefits arising from same.

The sludge produced at the site is a valuable fertiliser due to the nitrogen and phosphorus content. The reuse of the material in agriculture will reduce the use of inorganic fertilisers. Also controls will be put in place to ensure the proper application of the sludge in accordance with best practice.

Marine Sediment

It is not expected that there will be any significant impact on the physical properties of the marine sediments during the operational phase.

Hydrology and Hydrogeology

The operational phase of the development is not expected to pose any significant risk to groundwater flow or the prevailing hydrological conditions in the locality. It is not anticipated that there will be any adverse impact on the prevailing groundwater quality as there will be no discharges from the proposed site to groundwater at this location.

However, a possibility exists that contamination of the groundwater may occur as a result of the accidental release of potential pollutants (e.g. waste water treatment chemicals) at the site or along the effluent pipelines. Any leakage has a high probability of percolating directly into the soil or rock strata below. If the rock is fissured the potential risk is higher as a direct pathway allows potential pollutants to reach the groundwater table below. All storage tanks will be bunded and areas of potential spillages will be drained to the waste water treatment facilities for containment and treatment. In the event of a leak along the effluent pipelines, it is likely that this could generate a localised contamination event. However, this scenario is considered to be unlikely to occur as it is proposed to utilise materials proven through extensive use in waste water infrastructural projects coupled with pressure testing and flow monitoring and telemetry systems. In the event of there being a significant variance in flow readings, remedial action will be implemented immediately to identify the source of, and repair the leak.

Without appropriate mitigation measures as detailed in Section 3.4.5 *Mitigation Measures*, the impact on the local groundwater quality could be *moderate* in the event of an accidental localised spill of untreated effluent or fuel/oil.

A public water supply will be available to the site and, as such, it is not intended to install boreholes to extract groundwater.

Marine

Impacts on groundwater in the marine environment are considered to be limited in significance as the treated waste water is more likely to be dispersed in the overlying coastal waters. In any event groundwater in the coastal environment is likely to be saline or brackish and as such not suitable for potable (drinking) requirements.

(iii) 'Do Nothing' Impact

If the proposed development does not proceed at this location, agricultural activities are likely to continue at the site. This, coupled with any future development activities in the area may alter the water quality in the existing environment. It is not anticipated that there would be any significant impacts on the soils, geology and the hydrogeological regime.

(iv) 'Worst Case Scenario' Impact

Where the mitigation measures outlined in Section 3.4.5 *Mitigation Measures* are not implemented correctly or fail, worst case impacts on the existing environment may include a significant deterioration in groundwater quality and the soil/sediment characteristics of the receiving environment, both during construction and operational phases of the proposed development. These impacts could be moderate in magnitude and long term in duration.

3.4.5 Mitigation Measures

Mitigation measures proposed in this section relate primarily to the preservation of the existing subterranean drainage regime, the protection of groundwater and also the re-use of excavated materials.

(i) Construction Phase

In advance of construction a drilling programme is recommended to verify the ground conditions under the site, the depth to bedrock, depth of water table and confirm the presence/absence of karstified rock (particularly at the south eastern corner of the site). If the final excavation depths are within 3m of the water table, a risk assessment (including any additional mitigation measures) will be required by an experienced hydrogeologist.

Where it is necessary to remove overburden or topsoil to facilitate construction, where possible and in the context of an agreed landscaping plan, any soils removed to allow for construction of development will be reused for the construction of landscaping features around the development site. These measures will ensure that any loss of existing topsoil or overburden resource is minimised. An assessment will be carried out as to the suitability of this material in advance of these works.

In the case where the Contractor is required to dispose of surplus or unsuitable excavated materials, this will be to an appropriately licensed landfill site or permitted recovery facility in order to comply with the *Waste Management Acts,* (1996-2005) and associated regulations. Strict control of erosion and sediment generation and other pollutants associated with the construction process will be implemented particularly where works will be taking place close to water bodies.

The effects of soil stripping and soil stockpiling on water resources will be minimised by the removal of topsoil during dry conditions, where possible reducing the possible effects of leaching to ground water. During initial construction land will be stripped in phases in order to limit the length of time the soil will be exposed to erosion.

The effects of soil erosion will be minimised by ensuring that all ground disturbances or excavations are completed and re-vegetated/covered as soon as practical. Soil erosion effects will be evaluated prior to commencement of the works to prevent silts and fine fractions becoming mobilised and from becoming mobilised and entering waterbodies. Fills or stockpiles which are likely to erode into nearby water-bodies, will be covered temporarily e.g. with polyethylene sheeting. Eroded sediments will be retained on site with erosion and sediment control structures such as sediment traps and silt fences. Where possible the land will only be stripped in dry weather to reduce nutrient loss, sustain soil condition and reduce the generation of silt-laden run-off. Care will be taken to ensure that the bank surfaces are stable to minimise erosion.

The main threat posed to soils and groundwater arising from the development is the potential for soil contamination from construction materials. For all activities involving the use of potential pollutants or hazardous materials, there will be a requirement to ensure that material such as concrete, fuels, lubricants and hydraulic fluids will be carefully handled and stored to avoid spillages. In most cases, good housekeeping (daily site clean-ups, use of disposal bins, etc.) on the project site, and the proper use, storage and disposal of these substances and their containers can prevent contamination. Potential pollutants will be adequately secured against vandalism and will be provided with proper containment. Any spillages will be immediately contained and contaminated soil removed from the site and properly disposed of.

Possible soil contamination from re-fuelling of vehicles will not occur, as this will be undertaken in specific designated areas with interceptors in place. In the event of hydrocarbon leakage from on-site plant, a supply of hydrocarbon absorbent material will be maintained locally and immediately applied to the affected area and will be appropriately disposed of.

Construction works will be engineered to ensure all current discharges will be maintained until the WWTP is capable of accepting flows.

The potential for spillages and the possibility for materials to enter the groundwater will be mitigated by proper construction management on site. Other measures which will be implemented include;

- An emergency response plan
- Training for on-site personnel

A method statement will be developed in consultation with the NPWS to help minimise any temporary impacts associated with the marine crossing and all pipeline construction. The DAFF will also be consulted on the proposed methodology, timing and duration of these works. Any areas subject to clearing as a result of construction will be returned to a stable grade. This will be carried out bearing in mind that backfilled and settled sediment materials will be arranged differently than the original configuration. Heavier particles will settle first as they descend from the water column most rapidly. The finest sediments (smallest, lightest particles) from the dredged material, will settle out last, blanketing the marine bed.

If applicable, analysis on the marine crossing footprint in advance of excavation/dredging works will be required to confirm the presence/absence of contaminants in the material likely to be excavated during the construction process. The results of this analysis will be interpreted to assess the required management of the excavated materials (in accordance with the *Waste Management Acts* (1996-2005) and associated regulations as amended).

The collection system will be designed using standard materials proven through extensive use in waste water infrastructural projects. All pipelines and chambers will be pressure tested to industry standard in order to ensure correct assembly and installation. In addition flow monitoring and telemetry systems will be installed to immediately identify any problems with the conveyance of waste water to the WWTP.

The Contractor will be required to prepare a Construction Environmental Management Plan (CEMP) in advance of any works being carried out at the site. This will identify all potential control measures to avoid impacts on the soils, geology and hydrogeology.

(ii) Operational Phase

As there are no foreseeable impacts on geology, no mitigation measures are recommended. The proposed development is therefore considered to have a *negligible* impact on the existing geological environment.

The potential for accidental spillages will be mitigated by proper management on site. Measures which will be implemented include:

- Establishment of bunded oil and chemical storage areas
- An emergency response plan

- Training for on-site personnel

3.4.6 Residual Impacts

According to EPA guidelines, Residual Impact is described as *'the degree of environmental change that will occur after the proposed mitigation measures have taken place.'* The mitigation strategy above recommends actions which can be taken to reduce or offset the scale, significance and duration of the impacts on the known and potential soils and geological resource. Many aspects of the soils and geological resources are non-renewable and once impacted upon cannot be replaced.

The purpose of this statement is to specify mitigation measures where appropriate to minimise the 'risk factor' to all aspects of soils and geological resources such as to minimise the potential for hydrocarbons to contaminate the ground, reduce the risk of erosion, etc. This 'risk factor' is reduced or offset by recommending the implementation of a mitigation strategy in each area of the study. On effective implementation of this mitigation strategy, the potential for impact will be lessened. As a result, when the recommended mitigation is implemented, it is considered that there will be no significant residual negative impacts on the soils or geological/hydrogeological environment.

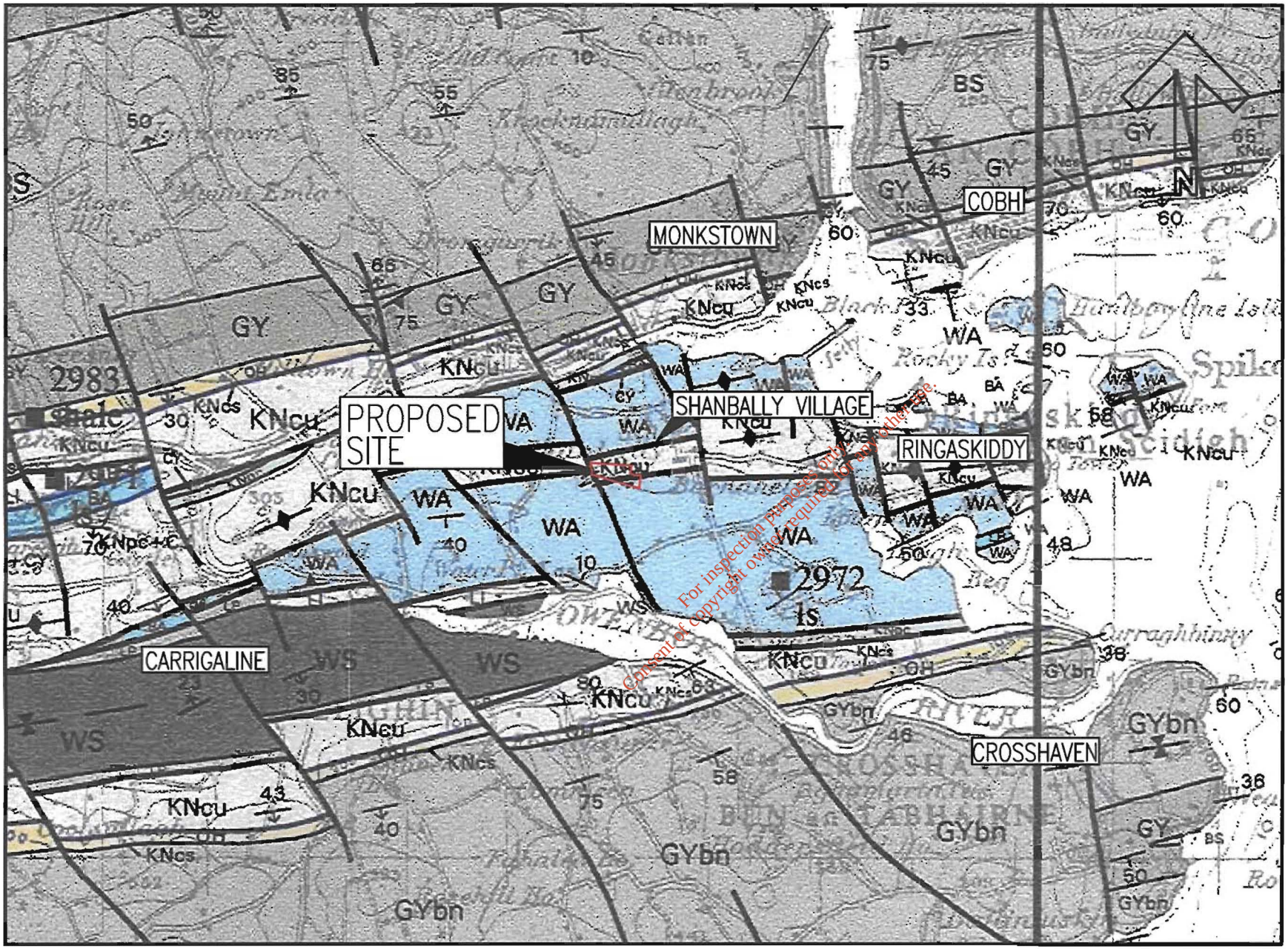

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FIGURE 3.4.1 LOCAL BEDROCK GEOLOGY

CORK HARBOUR MAIN DRAINAGE SCHEME
ENVIRONMENTAL IMPACT STATEMENT
JOB NR. 234541
DRG NR. 5670FG141

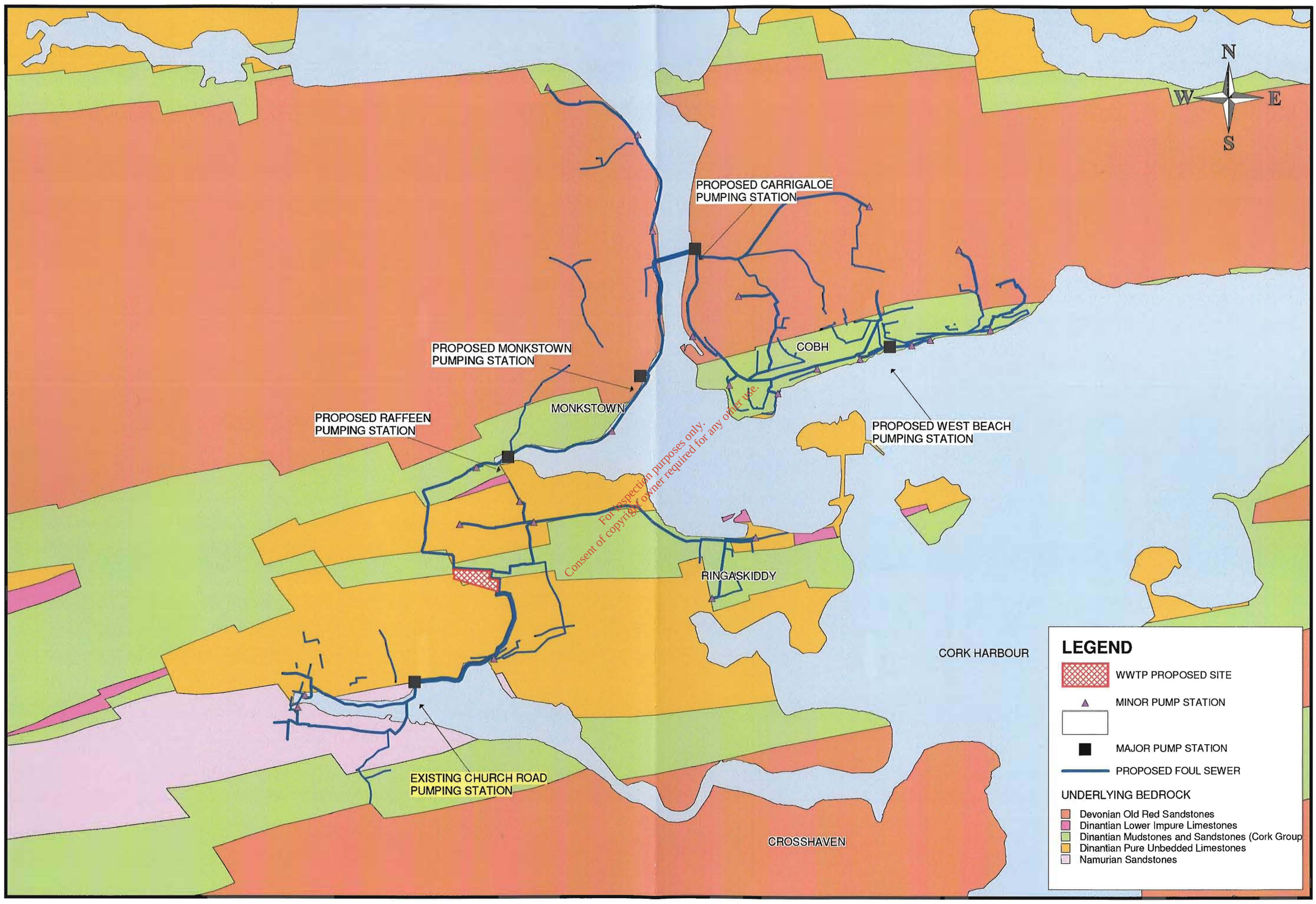

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FIGURE 3.4.2 - PROPOSED WWTP & COLLECTION SYSTEM with UNDERLYING BEDROCK

Extraction from GSI Geology of South Cork
Cork Harbour Main Drainage Scheme
Environmental Impact Statement
Job Nr. A5670
P:\Cork\DESIGN\acad\Mapinfo\23454I\Workspaces\bedrock.wor

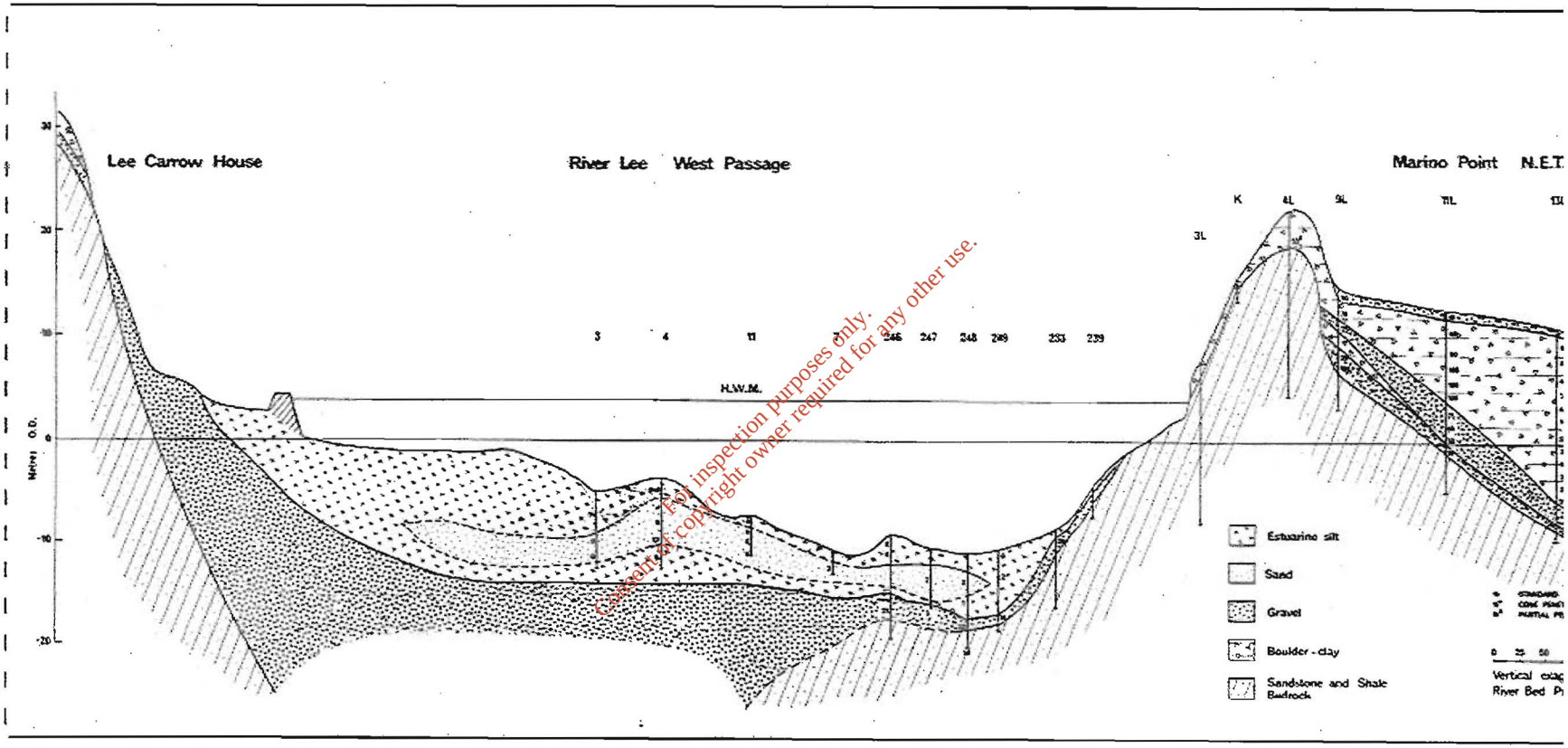

FIGURE 3.4.3 MARINE CROSS SECTION (MARINO POINT TO LEE CARROW HOUSE).

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CORK HARBOUR MAIN DRAINAGE SCHEME
ENVIRONMENTAL IMPACT STATEMENT
JOB NR. 234541
DRG NR. 5670FG142

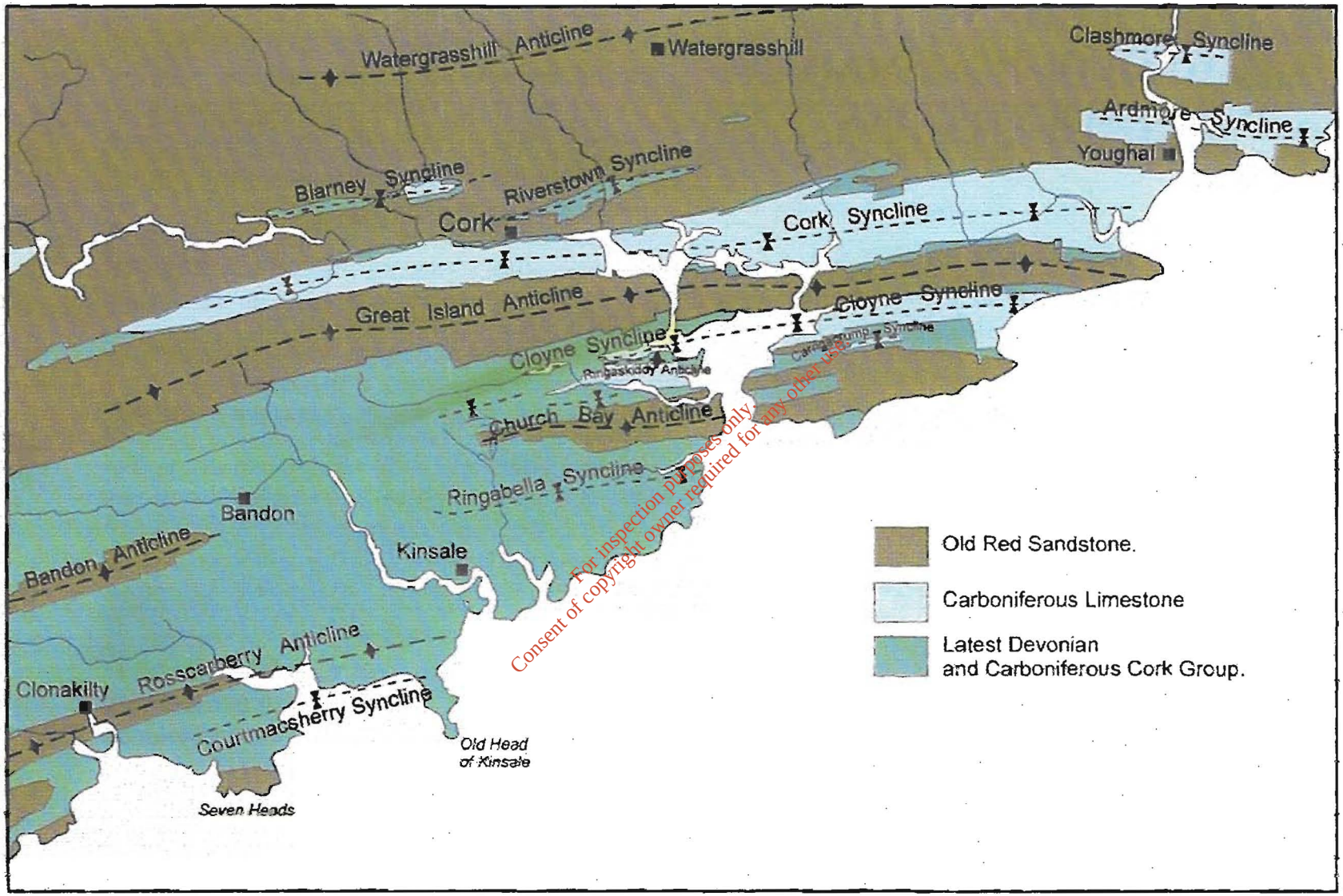

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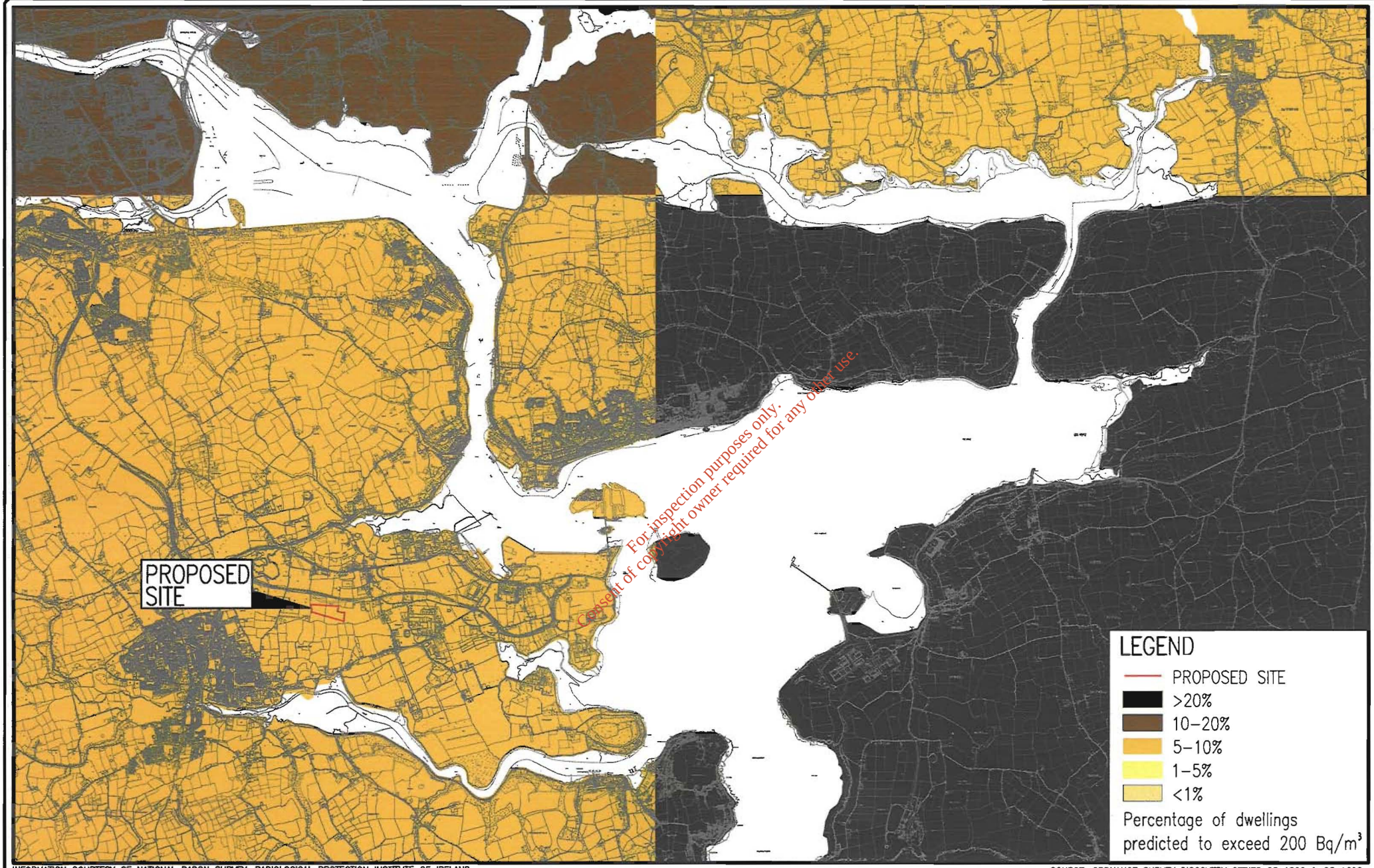
FIGURE 3.4.4 STRUCTURAL GEOLOGY

CORK HARBOUR MAIN DRAINAGE SCHEME
ENVIRONMENTAL IMPACT STATEMENT
JOB NR. 234541
DRG NR. 5670FG143



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SOURCE: ORDNANCE SURVEY DISCOVERY SERIES OS 1806 & OS 1606

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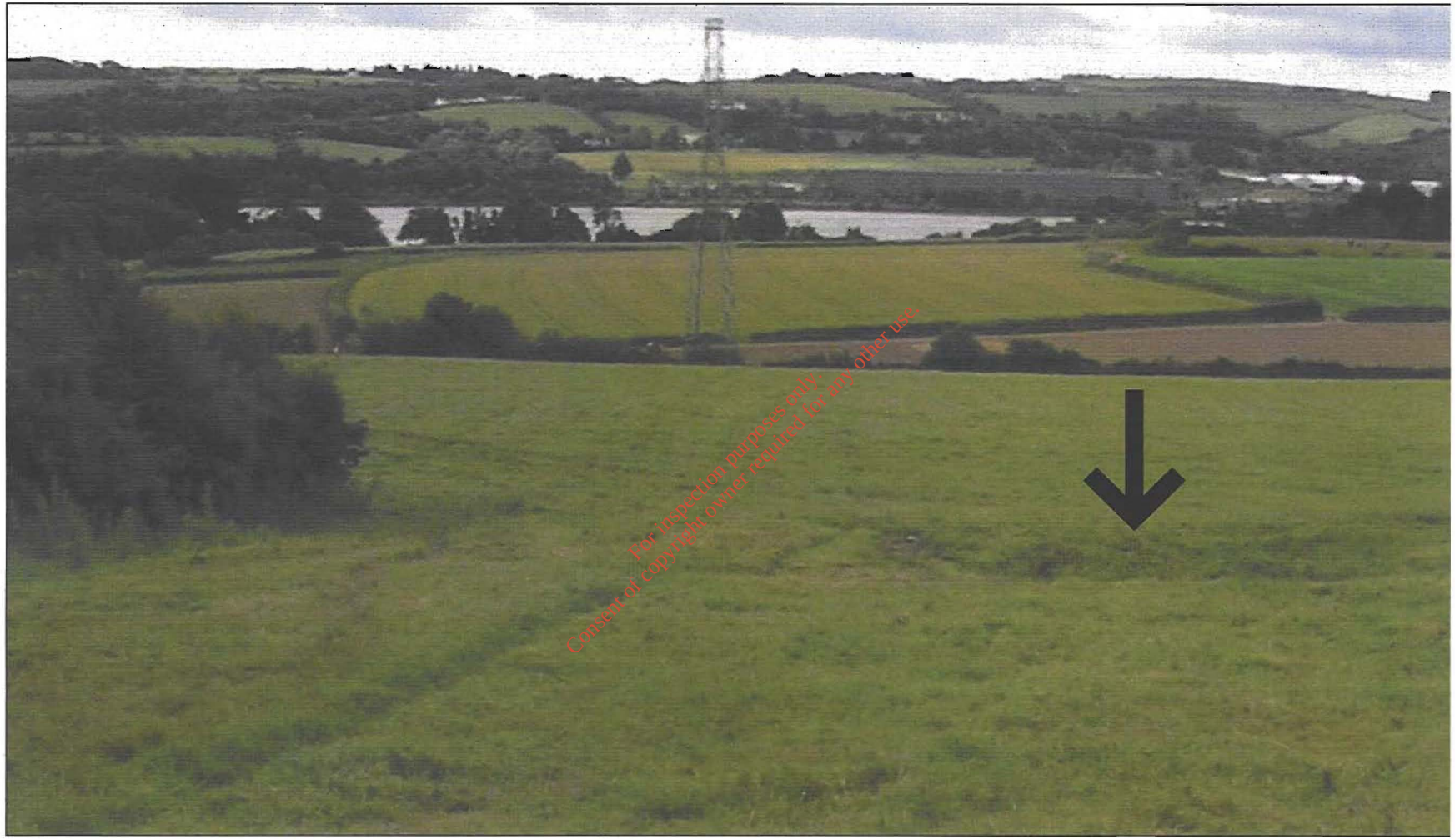
FIGURE 3.4.5 RADON LEVELS IN CORK HARBOUR

CORK HARBOUR MAIN DRAINAGE SCHEME
ENVIRONMENTAL IMPACT STATEMENT
JOB NR. 234541
DRG NR. 5670FG105



Mott MacDonald

PLATE 3.4.1 GROUND DEPRESSION
LOCATED NEAR THE EASTERN FIELD BOUNDARY

CORK HARBOUR MAIN DRAINAGE SCHEME
ENVIRONMENTAL IMPACT STATEMENT
JOB NR. 234541
DRG NR. 5670FG140

3.5 Material Assets

3.5.1 Introduction

Material assets comprise physical resources in the environment, which may be of human or natural origin. The objective of the assessment is to determine the impact of the proposed development on the material assets in the area and to ensure they are used in a sustainable manner with respect to the proposed development.

3.5.2 Methodology

MMP conducted a desk-based assessment of material assets in the vicinity of the proposed WWTP and the footprint of the collection system for the Cork Lower Harbour area. The required information on material assets was obtained from:

- The National Roads Authority
- Department of Environment, Heritage and Local Government
- An Bord Pleanála
- Bord Gáis
- Eircom
- Cork County Council
- Geological Survey of Ireland

The impact assessment for this section of the report is based on the *Guidelines on the Information to be contained in Environmental Impact Statements* and the *Advice Notes on Current Practice (in the Preparation of Environmental Impact Statements)* published by the Environmental Protection Agency (EPA) in March 2002 and September 2003 respectively. The criteria used include the quality, magnitude and duration of impacts.

Criteria for assessing impact quality, magnitude and duration are described in Tables 3.5.1, 3.5.2 and 3.5.3 respectively.

Table 3.5.1: Criteria for assessing the quality of impacts

Impact type	Criteria
Positive impact	A change is likely to improve the quality of the environment.
Neutral	No effect.
Negative impact	The change is likely to adversely affect the quality of the environment.

Table 3.5.2: Criteria for assessing impact magnitude

Impact Magnitude	Definition
No change	No discernible effect on human beings.
Imperceptible Impact	An impact capable of measurement but without noticeable consequences.
Slight Impact	An impact which causes noticeable changes in the character of the environment without affecting its sensitivities.
Moderate Impact	An impact that alters the character of the environment in a manner that is consistent with existing and emerging trends.
Significant Impact	An impact which, by its character, magnitude, duration or intensity alters a sensitive aspect of the environment.
Profound Impact	An impact which obliterates sensitive characteristics.

Table 3.5.3: Criteria for assessing impact duration

Temporary Impact	≤ 1 year
Short-term Impact	1 – 7 years
Medium-term Impact	7 – 15 years
Long-term Impact	15 – 60 years
Permanent Impact	≥ 60 years

3.5.3 Existing Environment

Material assets which may be affected by the proposed development are described under the following headings:

Assets of Human Origin:

- Towns, villages, settlements and residential clusters
- Recreational facilities
- Transport infrastructure
- Public utilities

Assets of Natural Origin:

- Natural Resources
- Natural Amenities
- Natural Heritage

Cultural Assets

- Archaeological and Built Heritage

Towns, villages, settlements and residential clusters

The towns and villages in the vicinity of the proposed development site are described in detail in Section 3.1 *Human Beings* and are listed below.

WWTP: The towns closest to the WWTP site include Shanbally, Carrigaline and Ringaskiddy. The village of Shanbally is located approximately 625m to the northeast. The nearest towns include Carrigaline, 1.06km southwest of the development site, and Ringaskiddy, which lies 2.24km to the east. Residential clusters exist along the LS472, L2490 and L6470 minor roads and along the N28 and R613. Planning permission has been granted for residential development at a site 134m east of the WWTP site.

Collection System: The towns nearby the proposed pipelines and pumping stations include Carrigaline, Shanbally, Ringaskiddy, Monkstown, Raffeen, Passage West and Cobh. The majority of the pipelines are proposed along existing roads and residential dwellings are present alongside these roads (see Figure 2.1 *Location of Existing Outfalls and Proposed Outfall*).

Recreational facilities

WWTP: Fernhill Golf and Country Club is located approximately 640m to the west of the proposed site. Facilities include an 18-hole golf course, sauna, steam room, swimming pool, gym and tennis court. Hibernian AFC sports grounds and clubhouse are located approximately 80m east of the site boundary and Shamrocks GAA sports grounds and clubhouse are located approximately 295m to the north east of the site.

Collection System: Cork Lower Harbour provides a location for water-based activities such as sailing, angling and fishing. Recreational facilities within the Harbour area include boat yards, mooring facilities and marinas for boats. The Royal Cork Yacht Club, based in Crosshaven, is the oldest yacht club in the world. Every second year it hosts Cork Week, a major sailing regatta of international significance. GAA clubs are present in Carrigaline, Passage West and Cobh. Marina facilities situated in the town of Crosshaven to the southeast; there are launching and mooring facilities in Ringaskiddy, Monkstown, Cobh, Aghada and Ballinacurra for smaller boats and jet skis. Recreational Walking is a popular activity e.g. Passage West to Monkstown/Raffeen Creek is a popular walking route in the locality. Cork Lower Harbour has a number of beaches utilised by locals and/or tourists visiting the area. These include Fountainstown, Myrtleville, Church Bay, Robert's Cove and Ringabella Bay on the western shores and White Bay on the eastern shore.

Transport Infrastructure

WWTP: Existing roads in the area surrounding the development site include the N28 National Primary Route 490m to the north; the R613 610m to the south; the R611 ca. 1.7km to the west and a number of minor roads to the east and west of the proposed site. Access to the WWTP site will be via the LS472 (Raffeen/Cogan's Rd.) minor road 405m west of the site. The LS472 is a local road with a speed limit of 80km/hr. The LS472 is a two-lane narrow country road with a narrow grass verge. The road has a tarred surface and there are no bridges or lay-bys on the road. The access road to the site is un-surfaced gravel and is in poor condition. It currently provides access to the Bord Gáis substation at the south west boundary of the WWTP site. It is proposed to widen/upgrade a section of the access road into the site. A 10m right of way has been acquired for this purpose.

Cork County Council is promoting the development of the Cork-Ringaskiddy Road Scheme. It is proposed to improve the existing N28 from the Bloomfield Interchange at Rochestown on to Ringaskiddy village. The improved road will have a greater capacity to cater for high traffic volumes (NRA, 2004). The preferred route will traverse lands 100m north of the WWTP site. Communications with the relevant road authorities indicate that it is not envisaged to provide direct access from the WWTP to the N28. This will result in the decommissioning of the northern section of the LS472 (Cogan's Rd.) and access to the site from the N28 will be from the south via the L2490 (Fernhill Rd.) to the junction with the LS472.

Collection System: The majority of the pipelines will be installed along existing roads. Figure 2.1 *Location of Existing Outfalls and Proposed Outfall* illustrates pipelines which will run along existing roads. Cross River Ferries Ltd. operate a car and passenger ferry between Carrigaloe and Glenbrook in Cork Harbour and the marine crossing for the pipeline is in close proximity to this ferry crossing.

Public Utilities

WWTP and Collection System: The public utility of most relevance to this EIS is the existing drainage network. The existing network for the Cork Lower Harbour area, which is primarily combined (waste water and storm water), can be divided into the following sewerage networks:

- Cobh and environs
- Monkstown / Passage West
- Carrigaline
- Ringaskiddy
- Crosshaven

There is an existing IDA marine outfall servicing industries in the Ringaskiddy area. This outfall extends eastwards terminating at Dognose Bank on the eastern side of the mouth of Cork Harbour. The location of the existing discharge point is shown in Figure 2.1 *Location of Existing Outfalls and Proposed Outfall.* Other public utilities include the water supply network, the electricity distribution network, gas network, telecommunication and broadband internet network.

Natural Resources

WWTP and Collection System: The site of the WWTP is a green-field site, used for agriculture at present. The lands surrounding the site are predominantly agricultural and form part of the metropolitan green belt between Cork City and Carrigaline. The proposed site is located on a south facing hill, at approximately 30m altitude (Malin Head Datum). The surrounding topography is undulating due to ridgelines which run from east to west. The development of a WWTP at the proposed site is consistent with the objectives of the *Carrigaline Electoral Area Local Area Plan* (2005) and adopted amendments (January 2007).

Rock types in the Cork area are sedimentary and were deposited during the later Devonian and Carboniferous Periods (370-310 million years ago). The bedrock underlying and surrounding the proposed location for the new WWTP site comprise Dinantian massive unbedded fine grained limestone (*Waulsortian Limestone Formation*); and Dinantian grey mudstone with subordinate sandstone (*Kinsale Formation* – Cuskinny Member which is a flaser-bedded sandstone and mudstone).

The proposed site is located in an anticlinal structure. Faults dissect the regional folds in the area close to the proposed site in a north/north-west to south/south-west direction. No outcrop is visible within the site. A geophysical survey (refer to *Volume III, Appendix 4A*) was carried out to determine the ground conditions, depth to rock, existence of karst features and reduce the risk of encountering difficult subsurface conditions. During this assessment an area of possible faulting/fracturing or karstification was identified in the SE corner of the site where strong lateral variations in the model resistivity values were recorded. It is possible that this variation represents the change in bedrock to Waulsortian limestone in the area. Refer to Section 3.4 *Soils, Geology and Hydrogeology* for a detailed assessment of soils, geology and hydrogeology.

Natural Amenities

WWTP and Collection System: Cork Harbour is the second largest natural Harbour in the world, in terms of navigational area. Cork Harbour provides excellent shelter for recreational and commercial boat traffic. The Harbour is a major asset to the Cork region and has significant potential with respect to marine leisure activities. Cork Harbour is made up of many islands and inlets which combine to make it an area of considerable natural beauty, with cliff faces and attractive sandy beaches.

Cork Harbour is a birdwatcher's dream. It is of major international importance due to the number of wintering migrants and for its international population of Redshank and is among the top five sites for wintering waterfowl in Ireland. There are at least 15 wintering species that have populations of national importance, including a nationally important colony of Common Tern which has been breeding here since 1970. Several of the species which occur regularly are listed in Annex I of the *EU Birds Directive (79/409/EEC)* and include Whooper Swan, Golden Plover and Bar-tailed Godwit. Cork Harbour in its entirety has therefore been designated as a Special Protection Area (SPA) for birds and a Ramsar site of international importance.

Currabinny Woods are largely deciduous woods and are sensational in autumn but make a pleasant walk at any time of year. It is situated in the south-eastern tip of the Ringaskiddy Peninsula which looks across the water to Crosshaven. The woods originally belonged to a private house, and there is a gazebo in the centre where the owners used to take tea. At the highest point in the woods there is a pre-historic burial cairn in rather bad condition, known locally as the Giants Cave. The forest trails here are unusual in that they were originally laid out for horse and carriage so that they are wide and airy, with none of the enclosed feeling that dense woodland can produce.

Owenboy River: The Owenboy estuary is designated as an area of visual/scenic importance. The river and estuary is a proposed Natural Heritage Area (pNHA), and includes a number of enclosed tidal inlets and areas of steeply wooded slopes. It is primarily of interest as a habitat for wildfowl and waders.

Scenic routes (views and prospects) are designated under the *Cork County Development Plan, 2003*. Views from scenic routes are to be preserved or improved. Scenic routes, which are situated in the general vicinity of the site are:

- Road between Carrigaline and Crosshaven (Item No. A56): The R612 road linking Carrigaline to Crosshaven has been identified in the *Cork County Development Plan* (2003) as a scenic route, the view from which is to be preserved or improved. This route extends along the Owenboy Estuary, with views of tidal inlets such as Drakes Pool and a number of steep wooded slopes. The road then rises towards Crosshaven, offering extended views of the Harbour. The route is popular with walkers who use the specially developed path (a former railway line) running alongside the route. The proposed development site is visible from this road.
- Road between Passage West and Ringaskiddy (Item No. A54): The road linking Passage West and Ringaskiddy has been identified in the *Cork County Development Plan* (2003) as a scenic route, the view from which is to be preserved or improved. This route extends from Passage West in the north, through a mixture of rural and urban areas, along the shoreline through Monkstown. The views available include the east and north of the Harbour. The latter section of this route (N28) extends from Raffeen Bridge through Shanbally and to Ringaskiddy through the industrial zone. The proposed development site is not visible from this route.

Scenic views and routes are detailed in Section 3.9 *Landscape and Visual Assessment*.

Natural Heritage

WWTP and Collection System: There are no conservation designations immediately adjacent to the WWTP site. However, several pNHAs and the Cork Harbour SPA occur in the vicinity. The pipeline along the northern shore of the Owenboy Estuary borders the Owenboy River pNHA and the proposed location for the Raffeen pumping station is adjacent to the Monkstown Creek pNHA. Section 3.2 *Terrestrial and Marine Ecology* describes the conservation sites, species and habitats of conservation importance in the area.

Archaeological and Built Heritage

WWTP: Section 3.8 *Cultural Heritage* details sites and structures of archaeological importance within the study area. Immediately outside the boundary of the WWTP site there are two recorded archaeological features (Recorded Monuments and Places or RMPs). Both are enclosures and likely to be ringforts.

Collection System: A total of 25 archaeological/architectural constraints were identified in relation to the pipelines and pumping stations and these include ring forts, holy wells, lime kilns, mill, graveyards and churches, souterrains and fulacht fia.

3.5.4 Impact Assessment

(i) Construction Phase Impacts

Towns, villages, settlements and residential clusters

WWTP and Collection System: The construction of the WWTP and ancillary works will have short-term negative impacts on the surrounding towns and villages in terms of increased noise, dust and construction traffic. However, these impacts will cease on completion of construction. A short-term positive impact for the surrounding towns will be an increase in revenue due to the sourcing of construction materials and also an increase in employment to the area.

Recreational Facilities

WWTP: Fernhill golf club, Hibernian AFC and Shamrock GAA sports grounds and clubhouses are all located within 1km of the site. Short-term impacts may include increased noise, dust, vibrations and increased traffic during the construction phase of the development.

Collection System: Foreshore and in-stream works may have temporary moderate-significant negative impacts on recreation, depending on the method of construction. An application will be made to the Department of Agriculture, Fisheries and Food (DAFF) for approval of this work and a schedule and method of works developed in consultation with the DAFF and other relevant bodies and stakeholders, including the Port Authority and Cross River Ferries Ltd.

Transport Infrastructure

WWTP: There will be an increase in traffic volumes associated with the construction phase of the development, which will have a short-term slight negative impact. Access to the site will be via the LS472 (Carrigaline Middle/Cogan's Road). Increased traffic volumes will be due to deliveries to site or disposal of surplus excavated material off-site by HGVs. Increased movements will also be generated by construction employees travelling to and from work. Impacts will include increased noise, vibration levels, visual impact, odour and dust impacts from HGVs.

Collection System: The routes of the pipelines are primarily concentrated along existing road infrastructure. The laying of pipes in these areas will result in slight temporary negative impacts due to traffic disruption. During the construction phase, the laying of pipelines along the shoreline and the marine crossing may have temporary moderate-significant negative impacts on river/Harbour traffic. The impacts will be temporary; however, the magnitude of the impacts will depend on the method of construction. An application will be made to the DAFF for approval of this work and a schedule and method of works developed in consultation with the DAFF and other relevant bodies and stakeholders, including the Port Authority and Cross River Ferries Ltd.

Public Utilities

WWTP: The proposed development will require a power source for most aspects of the facility and therefore the development will require connection to the electricity supply, provided by the ESB. A water supply will also be required. Impacts of the proposed development on public utilities are expected to be neutral.

Collection System: The pumping stations will require an electricity and water supply also and the impact associated with this will be neutral. The construction of a new collection system will have a long-term positive impact on the drainage network.

Natural Resources

WWTP: The construction of the WWTP will result in the permanent loss of 7.36ha of agricultural land. The land has been zoned for Utilities and Infrastructure and the impact is considered to be neutral.

Collection System: The pumping stations at Monkstown and Carrigaloe will not result in a loss of natural land resources. However, the stations at Raffeen and West Beach, Cobh will be located on reclaimed land at Raffeen and West Beach, Cobh and will result in a permanent loss of reclaimed land in these areas. Construction of the marine crossing will result in moderate to significant temporary impacts on the Harbour area in terms of disruption to Harbour traffic and recreational use. An application will be made to the DAFF for approval of this work and a schedule and method of works developed in consultation with the DAFF and other relevant stakeholders, including the Port Authority and Cross River Ferries Ltd.

Natural Amenities

WWTP: The construction of the WWTP will result in slight, negative impacts on the scenic route (A56) between Carrigaline and Crosshaven.

Collection System: The construction of the marine crossing will have moderate-significant temporary negative impacts on Cork Harbour. Impacts will include disruption to Harbour traffic.

Natural Heritage

WWTP: It is considered that construction of the WWTP will not result in any impacts on Natural Heritage.

Collection System: The Owenboy River and Monkstown Creek are pNHAs and during the construction of the collection system, temporary negative impacts may affect these pNHAs and Cork Harbour SPA. Birds are likely to avoid feeding in these areas due to increased noise and disturbance. Consultation with the National Parks and Wildlife Service (NPWS) will be required prior to construction, due to these areas being important for waterfowl.

Archaeological and Built Heritage

WWTP: Two archaeological features were identified at the boundary of the WWTP site. One of the features may be directly impacted during construction.

Collection System: 25 features of archaeological/architectural constraints were identified for the pipelines and pumping stations. The majority of the potential impacts are indirect, in that the Zone of Archaeological Potential may be impacted. Details are available in Section 3.8 *Cultural Heritage*.

(ii) Operational Phase Impacts

Towns, villages, settlements and residential clusters

WWTP and Collection System: A moderate long-term positive impact of the WWTP and collection system will be improved water quality in the Cork Harbour area thereby facilitating continued growth and development in the surrounding towns and villages. During the operational phase it is recommended that low level lighting is chosen for external lighting around the treatment plant. Locally directed on-site lighting will be provided for access and maintenance purposes and on the access roads and other locations, as required, for safety and security reasons. This will have imperceptible impacts on the surrounding towns and villages.

Recreational Facilities

WWTP: At present, discharge effluent entering the waters of Cork Harbour is untreated. Therefore, the operational phase of the WWTP will result in improved water quality entering Cork Harbour, thereby positively impacting on recreational facilities in the area.

Collection System: At present there are many waste water outfalls to the receiving waters at locations used for recreational activities (refer to Figure 2.1 *Location of Existing Outfalls and Proposed Outfall*). The construction of the proposed WWTP and associated pumping stations and rising mains will eliminate these outfalls resulting in a long-term positive impact on water quality and recreation. Where outfalls are to be retained, these shall operate only during storm conditions.

Transport Infrastructure

WWTP: During the operational phase of the development, there will be a slight negative impact on transport due to a slight increase in vehicular traffic entering and exiting the WWTP.

Collection System: Maintenance of the pumping stations will result in occasional additional traffic movements of light goods vehicles (LGVs) and this will have a neutral impact on traffic in the areas affected.

Public Utilities

WWTP and Collection System: The most significant positive impact of the WWTP and Collection System on public utilities will be the improvement in the waste water collection system. It is expected that the WWTP and Collection System will have a neutral impact on electricity and water supplies.

Natural Resources, Natural Amenities and Natural Heritage

WWTP and Collection System: The operation of the waste water collection and treatment plant will have a significantly positive impact on water quality in Cork Harbour. At present, untreated effluent is being discharged into Cork Harbour. The discharge of untreated effluent is a threat to this valuable resource and thus threatens the internationally important wetlands which form Cork Harbour SPA.

Archaeological and Built Heritage

WWTP and Collection System: The pumping station at West Beach, Cobh may have a slight negative visual impact on the cultural town of Cobh, however, sensitive design of this structure should mitigate for this impact.

(iii) 'Do Nothing' Impact

In the event that the proposed development does not proceed, water quality in Cork Harbour would expect to remain variable and eutrophic in parts. The effects of an increasing population coupled with increased housing demands in the Lower Harbour area would be an increase in the amount of untreated discharges entering the Harbour.

Impacts would include deterioration in water quality and this would affect:

- recreational activities due to poor water quality;
- revenue to the towns and villages in the area may decrease due to potentially reduced numbers of tourists;
- development in the Lower Harbour area would be inhibited due to a lack of appropriate drainage and waste water treatment infrastructure;
- conservation sites, including the internationally important Cork Harbour SPA

(iv) 'Worst Case Scenario' Impact

Where the mitigation measures are not implemented correctly, or fail, a potential exists for the WWTP to pose a safety risk, generating significant air quality impacts, uncontrolled effluent discharges or noise impacts. However, these situations are unlikely to occur on effective construction and operational management of the development and the implementation of the mitigation measures proposed in the appropriate sections of this statement.

3.5.5 Mitigation Measures

(i) Construction Phase

Towns, villages and residential clusters

WWTP and Collection System: A detailed Construction Environmental Management Plan (CEMP) will be developed for all construction activities to be carried out on the site of the WWTP and on the sites required for the laying of pipelines, sewers, marine crossing and pumping stations. This management plan will address activities likely to affect aspects of the environment e.g. noise, dust, odour, traffic, run-off, spillages, effluents etc. and will include environmental protection measures such as monitoring, protection barriers, operational procedures and contingency measures.

Recreational Facilities

WWTP: Dust abatement measures will be incorporated into the CEMP to mitigate against any potential air quality impacts on the nearby sports facilities.

Collection System: The construction of the marine crossing may result in temporary moderate-significant negative impacts on tourism and recreation. The impacts will be temporary; however, the magnitude of the impacts will depend on the method of construction. In order to mitigate for any negative impacts, a schedule and method of works will be agreed with the DAFF and other relevant bodies and stakeholders, including the Port Authority, local fishing interests (commercial and angling) and Cross River Ferries Ltd.

Transport Infrastructure

WWTP and Collection System: A Traffic Management Plan will be implemented to ensure the control of movements of materials, plant and labour to and from the site in order to minimise disruption to other road users and local residents. To minimise disruption to river traffic, a schedule and method of works agreed with the DAFF and other relevant bodies and stakeholders, including the Port Authority and Cross River Ferries Ltd.

Public Utilities

WWTP and Collection System: No mitigation measures are deemed necessary as no negative impacts associated with the proposed development are predicted.

Natural Resources and Natural Amenities

WWTP: In advance of construction a drilling programme is recommended to verify the ground conditions under the site, the depth to bedrock, depth of water table and confirm the presence/absence of karstified rock (particularly at the south eastern corner of the site).

WWTP and Collection System: An application will be made to the DAFF for approval of foreshore and marine work and a schedule and method of works developed with the DAFF and other relevant stakeholders, including the Port Authority, local fishing interests and Cross River Ferries Ltd. Mitigation measures described in Section 3.9 *Landscape and Visual Assessment* will be adhered to in order to mitigate for any negative visual impacts of the development.

Natural Heritage

WWTP: As no designated natural heritage areas are located directly adjacent to the proposed WWTP site no mitigation measures are deemed necessary.

Collection System: Prior to any works within or directly adjacent to pNHAs, consultation with the NPWS will be required and a programme and method of works developed.

Archaeological and Built Heritage

WWTP and Collection System: Mitigation measures for archaeological and architectural monuments and structures are addressed in Section 3.8 *Cultural Heritage* and will be adhered to.

(ii) Operational Phase

Towns, villages and residential clusters

WWTP: The Preliminary treatment at the WWTP must include for Septicity Control in addition to Screening and Grit Removal due to the length of the conveyance system. It is recommended that inlet channels and chambers be covered, vented and connected to an odour control system. The appointed contractor will be required to comply with the *Waste Water Treatment (Prevention of Odours and Noise) Regulations* (2005) *(S.I. No. 787 of 2005)*.

Collection System: It is essential that the pumping stations include for Standby power arrangements to prevent the overflow discharge of raw effluent to the Harbour. At a minimum an automated control operating system should be put in place to ensure that if a downstream pumping station fails to operate, the upstream pumping station will cease pumping.

Recreational Facilities, Natural Amenities and Natural Resources

WWTP and Collection System: The appointed contractor will be required to comply with the *Waste Water Treatment (Prevention of Odours and Noise) Regulation* (2005) *(S.I. No. 787 of 2005).* The pumping stations should include for Standby power arrangements to prevent the overflow discharge of raw effluent to the Harbour. At a minimum an automated control operating system should be put in place to ensure that if a downstream pumping station fails to operate, the upstream pumping station will cease pumping.

Transport Infrastructure, Natural Heritage, Archaeological and Built Heritage

As there are no significant impacts, no mitigation measures are proposed in relation to the above.

3.5.6 Residual impact

If the proposed mitigation measures are implemented, no significant negative residual impacts are expected to occur as a result of the proposed development.

3.6 Air Quality, Odour and Climate

3.6.1 Introduction

This chapter of the EIS describes the Air Quality, Odour and Climate in the existing environment along with the impacts and any mitigation measures proposed for the development.

Odour Monitoring Ireland Limited (OMI) was commissioned to conduct an assessment into likely impact on the air quality, odour and the climate associated with the proposed development. The specialist brief was to assess the current climate and air quality in the region and to predict the impacts of the proposed development on air quality in future years. Copies of the specialist reports are included in *Volume III Appendix 5A, B and C* of this statement.

3.6.2 Methodology

(i) Air Quality

A baseline air quality assessment has been carried out in the area (between the time periods July to August 2007) in the vicinity of the proposed WWTP development for benzene, toluene, ethyl benzene, p/o xylene (BTEX), nitrogen dioxides (NO_2), sulphur dioxide (SO_x), carbon monoxide (CO; EPA data), total depositional dust and particulate matter (PM_{10}), hydrogen sulphide (H_2S) and speciated volatile organic compounds (VOC's). In addition, a baseline speciated VOC survey was performed in the vicinity of five major pumping stations located along the drainage network (four proposed and one existing). These included Raffeen, West Beach, Monkstown, Church Road (existing) and Carrigaloe pumping stations. The purpose of this survey was to identify existing pollutant trends in the vicinity of the proposed development(s), and to assess the potential impact of the proposed development(s). This will establish sufficient spatial information in order to determine compliance with relevant ambient air quality legislation. Additionally, comparison with longer period limit values can be used to establish trends and are important in defining baseline air quality.

A total of twelve sample locations were chosen to represent the baseline air quality for named parameters in the vicinity of the proposed development(s). These locations are listed in Table 3.6.1 *Description of Air Monitoring Locations* and presented in Figure 3.6.1 *Overview of Monitoring Locations A1 to A7* and Figure 3.6.2 to 3.6.6 for pumping station locations.

Table 3.6.1: Description of Air Monitoring Locations

Reference	X Co-ordinates (Irish National Grid)	Y Co-ordinates (Irish National Grid)	Description of Monitoring
A1-WWTP	174861	63796	NO_2, SO_2, BTEX, PM_{10}, Total depositional dust, H_2S-Monitored using passive diffusion tubes, Partisol PM_{10} analyser, Jerome analyser and Bergerhoff gauges.
A2-WWTP	175341	63619	NO_2, SO_2, BTEX, Total depositional dust, H_2S-Monitored using passive diffusion tubes, Jerome analyser and Bergerhoff gauges.
A3-WWTP	175267	63938	NO_2, SO_2, BTEX, Total depositional dust, H_2S-Monitored using passive diffusion tubes, Jerome analyser and Bergerhoff gauges.
A4-WWTP	175071	63891	NO_2, SO_2, BTEX, Total depositional dust, H_2S-Monitored using passive diffusion tubes, Jerome analyser and Bergerhoff gauges.
A5-WWTP	174850	63999	NO_2, SO_2, BTEX, Total depositional dust, H_2S-Monitored using passive diffusion tubes, Jerome analyser and Bergerhoff gauges.
A6-WWTP	174907	63837	Speciated VOC's and H_2S-Monitored using pumped sorbent tube and Jerome analyser.
A7-WWTP	175257	63805	Speciated VOC's and H_2S-Monitored using pumped sorbent tube and Jerome analyser.
A8-Raffeen Pumping Station	175442	65188	Monitored using pumped active sorbent tube. Monitoring of H_2S using Jerome metre at 5 locations around the pumping station.
A9-West beach Pumping Station	179799	66426	Monitored using pumped active sorbent tube. Monitoring of H_2S using Jerome metre at 5 locations around the pumping station.
A10-Monksland Pumping Station	176977	66081	Monitored using pumped active sorbent tube. Monitoring of H_2S using Jerome metre at 5 locations around the pumping station.
A11-Carrigaloe Pumping Station	177607	67511	Monitored using pumped active sorbent tube. Monitoring of H_2S using Jerome metre at 5 locations around the pumping station.
A12-Church Rd Pumping Station (existing)	174405	62628	Monitored using pumped active sorbent tube. Monitoring of H_2S using Jerome metre at 5 locations around the pumping station.

The methodology for the description of the general air quality in the existing environment is also based on a desk based review of the relevant literature, with particular reference to the publication from the EPA (2007) *Air Quality in Ireland, 2006 – Key indicators of Ambient Air Quality.*

(ii) Odour

Dispersion Model: In order to obtain odour emission data for the site, library based odour data collected in accordance with EN13725:2003 European Standard on olfactometry was used to construct the basis of the dispersion modelling scenarios. Utilising the indicative design and site library odour emission data; dispersion-modelling techniques were used to establish maximum allowable odour emission rates from the proposed sites in order to limit any odour impact on the surrounding population.

Two odour emission scenarios were developed to take account of the specimen design of the Cork Harbour Main Drainage Scheme WWTP and pumping station operations with the implementation of odour mitigation strategies. These odour emission rates and specified source characteristics were input into AERMOD Prime in order to determine any overall odour impact from the proposed development.

The AERMOD model was developed through a formal collaboration between the American Meteorological Society (AMS) and U.S. Environmental Protection Agency (U.S. EPA). AERMOD is a Gaussian plume model and replaced the ISC3 model in demonstrating compliance with the National Ambient Air Quality Standards (Porter et al., 2003) AERMIC (USEPA and AMS working group) is emphasizing development of a platform that includes air turbulence structure, scaling, and concepts; treatment of both surface and elevated sources; and simple and complex terrain. The modelling platform system has three main components: AERMOD, which is the air dispersion model; AERMET, a meteorological data pre-processor; and AERMAP, a terrain data pre-processor (Cora and Hung, 2003). A full description of the model is included in *Volume III, Appendix 5B*.

Cork airport meteorological station Year 1993 to 1997 inclusive was used for the operation of AERMOD Prime. This allowed for the determination of the worst-case meteorological year for the determination of overall odour impact from the proposed Cork Harbour Main Drainage Scheme WWTP and each of the five pumping stations on the surrounding population.

Topography affects in the vicinity of the WWTP site were accounted for within the dispersion modelling assessment using a topography file. All significant deviations in terrain are examined in modelling computations through terrain incorporation using AERMAP software. All building wake effects within the propose WWTP and Pumping stations were accounted for in the modelling scenarios (i.e. building effects on point sources) as this can have a major effect on the odour plume dispersion at short distances.

- In the case of the proposed Cork Harbour Main Drainage Scheme WWTP, all significant odour sources (waste water handling and sludge handling operations) capable of generating offensive odours will be enclosed, sealed and negatively ventilated to an odour control system. Only the aeration tankage, secondary settlement tankage and storm water tankage within the proposed WWTP will be open to atmosphere. All other odour sources will be enclosed, sealed and abated using odour treatment system (two stages of treatment for biological treatment unit as first stage).
- For all pumping stations, an odour management system will be implemented to ensure that no uncontrolled release of fugitive odours occurs.

For the WWTP odour impact assessment, the 99.5th percentile of hourly averages is used to complement the 98th percentile of hourly averages to take account of predicted downwind odour concentrations during short time worst-case meteorological conditions thereby providing added protection to the public at large. This was not performed upon the pumping station odour impact assessment as the predicted plume spread as assessed using the 98th percentile assessment criterion concluded negligible odour impact.

Selection of Odour Annoyance Thresholds: Odours from WWTP's / pumping station operations arise mainly from the volatilisation of odorous gases from:

- The surfaces of non-quiescence processes including overflow weirs, returned pumped centrate/liquor above the working height of the tank/channel etc.
- Positive displacement of odours from tankage as a result of inlet waste water flow and pressure effects induced by wind flows
- Anaerobic decay of floating organic debris upon quiescence surfaces including organic matter attached to grit and rags, organic matter carryover to secondary tanks etc.
- Sludge handling operations including dewatering, thickening, digestion, drying, storage and transport of raw/processed sludge's offsite
- Anaerobic digestion processes and emissions of sour gas
- Turbulent processes within the inlet works and storage of screens (i.e. grit and rags removal)
- Inefficient odour control/abatement equipment operation and design including loose fitting covers, inefficient extraction and odour control unit failure

An odour impact criterion defines the odour threshold concentration limit value above baseline in ambient air, which will result in an odour stimulus capable of causing an odour complaint. There are a number of interlinked factor, which causes a nearby receptor (i.e. resident) to complain. These include:

- Odour threshold concentration, odour intensity and hedonic tone-defined measurable parameters at odour source
- Frequency of odour-how frequently the odour is present at the receptor location
- Duration of odour-how long the odour persists at the receptor location
- Physiological-previous experiences encountered by receptor etc.

By assessing these combined interlinked factors, the ability for a facility to cause odour complaint can be determined.

When utilising dispersion models for impact assessment, specific impact criterion (odour concentrations) need to be established at receptors. For odour assessment in general terms, this is called an odour impact criterion, which defines the maximum allowable ground level concentration (GLC) of odour at a receptor location for a particular exposure period (i.e. $\leq$1.50 Ou_E m^{-3} at the 98th percentile of hourly averages).

By abating the sources of offensive odours within the WWTP and pumping station, the odour limit value becomes less conservative as the odour emitted from the odour abatement technology is considered less offensive and therefore has a markedly lower potential risk of causing complaint. Taking into account these factors for the WWTP's and pumping stations, it is proposed that:

- All sensitive locations and areas of amenity should be located outside the 1.50 Ou_E m^{-3} at the 98th percentile of hourly averages over a meteorological year
- All sensitive locations and areas of amenity should be located outside the 3.0 Ou_E m^{-3} at the 99.5th percentile of hourly averages over a meteorological year
- The hedonic tone should not be considered unpleasant (scale greater than –2) as assessed in accordance with VDI 3882:1997, part 2; ('Determination of Hedonic) for all emission points
- Recent studies demonstrate trends where both mean ranking of dislike ability and hedonic scoring provide subjective ranking of odours and their respective ability to cause offensive/complaint. It would appear that when the hedonic tone of the odour reached a specific level, the odour hedonic tone decreases rapidly to small increases in odour threshold concentration (i.e. small increases in odour threshold concentrations will cause a large change in the perceived odour offensiveness). Such trends have been observed by OMI in a laboratory-based environment. It has been suggested that when an odour reached an odour intensity level of 3 (distinct) and a mean hedonic score of –2 (unpleasant), an odour will become offensive and cause odour complaint.
- These proposed odour impact criterion is considered by OMI as sufficiently conservative to provide protection to the community at large taking into account latest suggested odour impact criterion by environmental agencies in Ireland, UK and Netherlands.

(iii) Climate

The methodology for the description of the current climate in the region of the proposed development includes a desk study and literature review of published data available for Ireland and the Cork Harbour area, carried out by OMI. Possible implications of climate change are assessed for consideration in the design of the proposed development. A full description of this assessment is included in *Volume III, Appendix 5A and 5C*.

3.6.3 Existing Environment

(i) Air Quality

Benzene, Toluene, Ethyl Benzene and Ortho and Para Xylene (BTEX)

BTEX and other aromatic/alkanes are most likely derived from petrol driven vehicle exhausts. Heavier semi-volatile organic compounds are frequently derived from diesel-powered engines. Benzene is a known carcinogen, poisonous by inhalation and a severe eye and moderate skin irritant. At each of the five monitoring locations (A1 to A5; Table 3.6.1), the air quality was monitored for BTEX, over a 29-day period, using BTEX diffusion tubes.

Table 3.6.2: Baseline Air Quality - Average BTEX concentrations at each location as measured by passive diffusion tubes.

Location	Benzene ($\mu g/m^3$)	Toluene ($\mu g/m^3$)	Ethyl Benzene ($\mu g/m^3$)	P-Xylene ($\mu g/m^3$)	O-Xylene ($\mu g/m^3$)
A1	0.695	0.256	0.183	0.256	0.121
A2	0.143	0.361	0.428	0.312	0.224
A3	0.270	0.233	0.418	0.249	0.186
A4	-	-	-	-	-
A5	0.329	0.282	0.471	0.576	0.248
Old Station Rd. hourly median (EPA)[Note]	0.20	-	-	-	-
Limit Value	**5**	**4700**	**10,875**	**5525**	**5525**

Note - Old Station Road is located on the south side of the River Lee near City Hall, about 500m from Cork City centre.

The results illustrated in Table 3.6.2 for BTEX at A1 to A5 are all in compliance with Irish and EU limit values (i.e. SI 271 of 2002 and EU Directive 2000/69/EC) for Benzene. Average Benzene concentrations were up to 93% lower than the Irish and EU directive limit values. The rule of thumb for guidelines for ambient air quality of volatile organic compounds without legislative limit values is using 1/40th of the 8-hour Occupational Exposure Limit as stated in the National Authority for Occupational Safety and Health 2002 "Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations". Toluene, ethyl benzene and xylene isomers are well within their respective fractional exposure limit values.

Nitrogen Dioxides (NO_2)

When industrial metabolism releases nitrogen to the environment it is considered a "pollutant" because of its chemical form: NO, NO_2, and N_2O. These oxides of nitrogen can be toxic to humans, to biota, and they also perturb the chemistry of the global atmosphere. In the transportation sector, the NO_x emissions result from internal combustion engines.

At each of the five monitoring locations (A1 to A5; Table 3.6.1), levels of NO_2 were measured using diffusion tubes, which were left on site for a 29-day period. The results are presented in Table 3.6.3.

Table 3.6.3: Average NO_2 concentrations at each location as measured by passive diffusion tubes

Location	Sampling Period	Average No_2 Concentration ($\mu g/m^3$)
A1	July to Aug 2007	6.00
A2	July to Aug 2007	4.82
A3	July to Aug 2007	4.86
A4	July to Aug 2007	6.06
A5	July to Aug 2007	6.76
EPA value - Old Station Rd hourly max value	2006	111
EPA value - Old Station Rd Annual mean value	2006	26
Limit value - Annual average	**-**	**40**
Limit value - 1 hour average	**-**	**200**

The dominant source of NO_2 in the area appears to be from motor vehicle exhausts and the burners/boiler of space heating of local light industry and business units. The measured concentrations of NO_2 at all monitoring locations are within the Irish and EU Ambient Air Standards. Monitoring locations A1 to A5 are an average 83% lower than currently established Irish and European ambient air regulatory levels for annual averages.

Sulphur Dioxide (SO_2)

Sulphur dioxide is a colourless gas, about 2.5 times as heavy as air, with a suffocating faint sweet odour. At each of the five monitoring locations (A1 to A5; Table 3.6.1), levels of SO_2 were measured using diffusion tubes, which were left on site for a 29-day period. The results are presented in Table 3.6.4.

Table 3.6.4: Average SO_2 concentrations at each location as measured by passive diffusion tubes

Location	Sampling Period	Average So_2 Concentration ($\mu g/m^3$)
A1	July to Aug 2007	1.64
A2	July to Aug 2007	1.75
A3	July to Aug 2007	1.32
A4	July to Aug 2007	1.60
A5	July to Aug 2007	1.18
EPA value-Old Station Rd hourly max value	2006	58
EPA value-Old Station Rd daily max value	2006	24
EPA value-Old Station Rd annual mean value	2006	4
Limit value - Annual average	**-**	**20**
Limit value - Daily average	**-**	**125**
Limit value - Hourly average	**-**	**350**

The dominant source of SO_2 in the area appears to be from motor vehicle exhausts and the burners/boiler/solid fuel heating local single residences and industrial units. The measured concentrations of SO_2 at all monitoring locations are within the Irish and EU Ambient Air Standards. Monitoring locations A1 to A5 are an average 91% lower than currently established Irish and European ambient air regulatory annual levels.

Carbon Monoxide (CO)

Carbon monoxide is produced as a result of incomplete burning of carbon-containing fuels. It can be emitted by combustion sources such as un-vented kerosene and gas heaters, furnaces, woodstoves, gas stoves, fireplaces and water heaters, automobile exhaust from attached garages, and tobacco smoke. Due to power and equipment safety issues existing baseline monitoring data from EPA monitoring sites (*Air Quality Monitoring Report, 2006* - Old Station Rd.) was used for assessment of baseline Carbon monoxide air quality. The EPA monitoring location and results are presented in Table 3.6.5.

Table 3.6.5: Average ambient baseline CO concentrations for the proposed site development.

Location	Sampling Period	Ambient Co Concentration (mg/m^3)
EPA - Annual mean - Old Station Rd	2006	0.50
EPA - 8 hour median value - Old Station Rd	2006	0.40
EPA - Maximum 8 hourly value - Old Station Rd	2006	2.80
Limit value-8 hour average	-	**10**

CO monitoring is also very limited in Ireland. Data sets developed by the EPA indicate 8 hour running average CO levels of between 0.10 and 0.80mg m^{-3} for 8 hour rolling averages, respectively for urban areas in Ireland. The dominant source of CO in this area would appear to be vehicle emissions, boilers (i.e. home heating and industrial heating), industrial processes and construction activities. The CO emissions measured in Old Station Rd would be considered worst case in comparison to the proposed site location. CO emissions are on average 78% lower than Irish and EU ambient air limit values, which would be considered worst case in terms of exposure for the area

Particulate Matter (PM_{10})

PM_{10} (Particulate Matter 10) refers to particulate matter with an aerodynamically diameter of 10 µm. Generally, such particulate matter remains in the air due to low deposition rates. It is the main particulate matter of concern in Europe and has existing air quality limits. In order to obtain a baseline PM_{10} for the proposed work area, a PM_{10} analyser was used to monitor the PM_{10} ambient concentration levels at one location (A1) within the vicinity of the proposed works. Continuous monitoring was performed over a 2-day period. Results are presented in Table 3.6.6.

Table 3.6.6: Average ambient PM_{10} concentrations in the vicinity of the proposed development

Location	Sampling Period	Ambient m_{10} Concentration ($\mu g/m^3$)
A1-24 hour average	July 2007	22
A1-24 hour average	July 2007	31
EPA measured conc. – Old Station Rd, annual mean value	2006	16
Limit Value at 98.07th percentile	-	**50**
Limit Value - annual mean Stage 1	-	**40**
Limit value - annual mean Stage 2	-	**20**

PM_{10} monitoring in Ireland is limited to continuous monitoring stations operated by the Local Authorities and the Irish EPA, mainly in large urban centres. Average 24-hour ambient air concentrations monitored at Old Station Rd, Cork would be considered worst case in this area. The EPA measured an annual mean of 16 $\mu g\ m^{-3}$ at this monitoring station. The dominant source of PM_{10} in the area appears to be vehicle emissions, boilers (i.e. home heating and industrial heating), industrial processes and construction activities. The average ambient PM_{10} concentrations are higher than those monitored by the EPA (highlighting elevated levels in the existing environment). Maximum-recorded ambient PM_{10} concentrations were on average 38% lower than the Irish and EU 24-hour ambient air quality limit value (SI 271 of 2002 and 1999/30/EC).

Total Depositional Dust

Total dust deposition was measured at the site using Bergerhoff gauges specified in the German Engineering Institute VDI 2119 entitled "Measurement of Dustfall Using the Bergerhoff Instrument (Standard Method)." Samples were collected at five locations (i.e. A1 to A5) over a 30-day period. The purpose of these monitors is to assess the baseline total depositional dust impact in the vicinity of the current site. The results are presented in Table 3.6.7.

Table 3.6.7: Total depositional dust levels at each monitoring location

Sample Reference	Sampling Period	Total Dust Deposition (Summer Sampling Period) ($mg/m^2/day$)
A1	July to Aug 2007	66
A2	July to Aug 2007	78
A3	July to Aug 2007	94
A4	July to Aug 2007	62
A5	July to Aug 2007	87
EPA recommended Limit value	-	**350**

Currently in Ireland there are no statutory limits for dust deposition, however, EPA guidance suggest, "a soiling of $10mg/m^2$/hour is generally considered to pose a soiling nuisance" (TA Luft, 2002). This equates to $240mg/m^2$/day of Total Depositional Dust. The EPA recommend a maximum level of $350mg/m^2$day of dust deposition when measured according to TA Luft standard, which includes both soluble and insoluble matter (i.e. EPA compliance monitoring is based on the TA Luft Method). This value was not exceeded at any of the sample locations with all measured values at least 73% lower than the maximum recommended limit value.

Hydrogen Sulphide (H_2S)

H_2S is commonly associated with waste water handling operations. It is used as an indicator gas for the assessment of significant odour nuisance in the vicinity of waste water facilities. An ambient H_2S profile monitoring exercise was carried out in the vicinity of the proposed WWTP site and five pumping stations using a pre-calibrated H_2S analyser (Jerome metre). Samples were taken approximately 1.2 metres above ground level. The analyser is a real time analyser with a range of detection from 3 ppb to 50 ppm. Samples were collected at twelve locations (i.e. A1, to A12). In order to maintain clarity within the document all 5 individual monitoring locations in the vicinity of the pumping stations are presented as one value as the ambient H_2S concentration were below instrumental limits of detection. The purpose of this monitoring is to assess the baseline H_2S in the vicinity of the sites. The results are presented in Table 3.6.8.

Monitoring Location	Sampling Period	Ambient Air Concentration ($\mu g/m^3$)
A1-WWTP	July 2007	<4.50
A2-WWTP	July 2007	6.0
A3-WWTP	July 2007	6.0
A4-WWTP	July 2007	7.50
A5-WWTP	July 2007	<4.50
A6-WWTP	July 2007	<4.50
A7-WWTP	July 2007	<4.50
A8-Raffeen Pumping Station	July 2007	<4.50
A9-West Beach Pumping Station	July 2007	<4.50
A10-Monkstown Pumping Station	July 2007	<4.50
A11-Carrigaloe Pumping Station	July 2007	<4.50
A12-Church Rd Pumping Station (existing)	July 2007	<4.50
Recommended limit	-	**7.50**

Table 3.6.8: Hydrogen sulphide levels at each monitoring location

Currently in Ireland, there are no statutory limits for hydrogen sulphide concentrations in ambient air, however, guidance from the California Air Resources Board suggest an ambient air concentration level of less than 7.50 $\mu g/m^3$ to limit odour nuisance. This value was not exceeded at any of the sample locations. Elevated ambient concentrations above the lower limits of detection of the instrument method were detected at location A2, A3 and A4. There were no scheduled point emissions of Hydrogen sulphide in the vicinity of the site although; concentrations could be attributed to traffic movement on the nearby main road. Hydrogen sulphide is generated from side product reactions of exhaust emissions with the catalytic converter on diesel engines.

Speciated Volatile Organic Compounds (VOC's)

Speciated VOC's to include alkanes, mercaptans, organic acids, aromatics and nitrogen containing organics in ambient air at elevated concentrations can lead to the formation of odours. In order to ascertain the baseline levels of speciated VOC's in the vicinity of the proposed site location, ambient pumped sampling of VOC's was performed in order to ascertain the baseline profile of such compounds in order to generate a baseline profile during no operation of the WWTP. Samples were collected at two locations across the proposed WWTP site (i.e. A6 and A7), and at one location in the vicinity of each of the five pumping stations (i.e. A8 to A12). The results of the main VOC constituents are presented in Tables 3.6.9 to 3.6.15.

Table 3.6.9: Speciated VOC profile and concentrations in the vicinity of the proposed site location at monitoring location A6-WWTP

Compound Identity	Ambient Air Concentration ($\mu g/m^3$)
3-Butyn-1-ol	1.75
Benzaldehyde	0.58
Acetophenone	0.63
Nonanal	0.38
Decanal	0.40
Cyclododecane	0.56
Hexadecanal	0.99
Cyclohexadecane	13.20
Total VOC's	**26.02**

Table 3.6.10: Speciated VOC profile and concentrations in the vicinity of the proposed site location at monitoring location A7-WWTP

Compound Identity	Ambient Air Concentration ($\mu g/m^3$)
Benzaldehyde	0.65
Acetophenone	0.65
Nonanal	0.84
Decanal	0.66
Tetradecane	0.65
1-Hexadecene	0.57
Oxirane, tetradecyl-	1.49
Cyclohexadecane	4.09
Total VOC's	**25.64**

Table 3.6.11: Speciated VOC profile and concentrations in the vicinity of the proposed site location at monitoring location A8-Raffeen Pumping Station

Compound Identity	Ambient Air Concentration ($\mu g/m^3$)
2,5-Furandione, dihydro-3-methylene-	7.43
3(2H)-Thiophenone, dihydro-2-methyl-	1.02
2,2-Dichlorocyclopropanecarboxamide	6.05
Cyclohexan-1,4,5-triol-3-one-1-carboxylic acid	1.61
2,4-Diethyl-6-methyl-1,3,5-trioxane	12.20
1-Tetradecene	2.03
Cyclohexadecane	5.54
Oxirane, heptadecyl-	1.45
1-Nonadecene	16.90
Total VOC's	**74.03**

Table 3.6.12: Speciated VOC profile and concentrations in the vicinity of the proposed site location at monitoring location A9-West Beach Pumping Station

COMPOUND IDENTITY	AMBIENT AIR CONCENTRATION ($\mu g/m^3$)
2,5-Furandione, dihydro-3-methylene-	5.62
Formamide, N,N-dimethyl-	2.54
Ethanol, 2-butoxy-	2.19
Benzaldehyde	1.26
Acetophenone	0.82
Cyclotetradecane	1.03
1-Decanol, 2-hexyl-	19.44
1-Hexacosene	1.11
1-Heptadecanol	4.93
Total VOC's	**64.95**

Table 3.6.13: Speciated VOC profile and concentrations in the vicinity of the proposed site location at monitoring location A10-Monkstown Pumping Station

Compound Identity	Ambient Air Concentration ($\mu g/m^3$)
2,5-Furandione, dihydro-3-methylene-	4.23
Nonanal	3.32
Ethanol, 2-butoxy-	1.19
2-Propanol, 1-[2-(2-methoxy-1-methylethoxy)-1-methylethoxy]-	1.16
Acetophenone	1.25
Cyclotetradecane	1.20
1-Decanol, 2-hexyl-	6.89
2,4-Diethyl-6-methyl-1,3,5-trioxane	5.42
1-Heptadecanol	2.23
Total VOC's	**54.23**

Table 3.6.14: Speciated VOC profile and concentrations in the vicinity of the proposed site location at monitoring location A11-Carrigaloe Pumping Station

Compound Identity	Ambient Air Concentration ($\mu g/m^3$)
2,5-Furandione, dihydro-3-methylene-	5.42
2-Octanamine	0.66
Benzaldehyde	1.42
Acetophenone	1.22
2-Propanol, 1-[2-(2-methoxy-1-Methylethoxy)-1-methylethoxy]-	1.17
2,4-Diethyl-6-methyl-1,3,5-trioxane	2.43
Cyclohexadecane	5.05
1-Hexadecanol	2.38
Total VOC's	**36.78**

Table 3.15: Speciated VOC profile and concentrations in the vicinity of the proposed site location at monitoring location A12-Church Road Pumping Station (existing)

Compound Identity	Ambient Air Concentration ($\mu g/m^3$)
Propane, 1-(ethenylthio)-	0.72
Benzaldehyde	1.03
Acetophenone	0.84
Nonanal	1.11
Decanal	1.18
Cyclohexadecane	6.20
Hexadecanal	3.39
Cyclohexadecane	6.45
Eicosane	0.52
Total VOC's	**49.37**

Currently in Ireland, there are no statutory limits for total volatile organic compound concentrations in ambient air, however, research data gathered by Odour Monitoring Ireland suggest an ambient air concentration level of less than 250 $\mu g/m^3$ to limit odour impact. The compounds detected in ambient air would be typical of emissions detected close to busy roadways and in agricultural locations. No background concentrations of mercaptans or sulphur containing organics were detected and the absence of such compounds suggests in general that odour air quality is good in the vicinity of the site. The profiles can be compared with any additional profiles measured when the facilities are operational in order to ascertain any increases in ambient air concentrations of speciated VOC's. The overall background level of speciated VOC's as total VOC's is generally low in the vicinity of all site locations.

(ii) Odour

In terms of odour, the existing background will be dominated by the influence of the rural environment and to a lesser degree the coastal location. Currently the air quality is average to good with levels of criteria and baseline odour pollutants for traffic, industrial and residential derived pollution below the relevant Irish and European Union limits. No background concentrations of mercaptans or sulphur containing organics were detected and the absence of such compounds suggests in general that odour air quality is good in the vicinity of the site (detailed in *Volume III, Appendix 5A*).

As odour is not measurable in ambient air due to issues in sampling techniques, limit of detections for olfactometers and the inability to monitor continuously; therefore the existing odour is effectively omitted in the olfactometry assessment. Dispersion models become useful tools in odour impact assessments and odour risk analysis (as described in *Volume III, Appendix 5B* and the odour impact assessment in Section 3.6.4.2).

(iii) Climate

Climate is constantly changing. The signal that indicates that the changes are occurring can be evaluated over a range of temporal and spatial scales. We can consider climate to be an integration of complex weather conditions averaged over a significant area of the earth (typically in the region of 100 km^2 or more), expressed in terms of both the *mean* of weather expressed by properties such as temperature, radiation, atmospheric pressure, wind, humidity, rainfall and cloudiness (amongst others) and the *distribution*, or range of variation, of these properties, usually calculated over a period of 30 years. As the frequency and magnitude of seemingly unremarkable events change, such as rainstorms, the mean and distribution that characterise a particular climate will start to change. Thus climate, as we define it, is influenced by events occurring over periods of hours, through to global processes taking centuries.

Over the millennia natural processes have driven changes in climate, and these mechanisms continue to cause change. "Climate change" as a term in common usage over much of the world is now taken to mean *anthropogenically* driven change in climate.

Evidence for an anthropogenic influence on climate change is now stronger than ever before, with the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report assertion that 'It is very likely that anthropogenic greenhouse gas increases caused most of the observed increase in globally averaged temperatures since the mid-20th Century' (IPCC, 2007). Global average temperature has increased by 0.74°C over the past 100 years with the rate of warming almost doubling over the last 50 years. Precipitation patterns have also changed with an increase in the number of heavy precipitation events being observed globally.

Sweeney *et al* (2003) summed up the evidence of our changing climate with the following key points:

- Global average temperature has increased by 0.6°C ±0.2°C since 1860 with accelerated warming apparent in the latter decades of the 20th Century. A further increase of 1.5-6.0°C from 1990 to 2100 is projected, depending on how emissions of greenhouse gases increase over the period
- The last century was the warmest of the last millennium in the Northern Hemisphere, with the 1990s being the warmest decade and 1998 being the warmest year. Warming has been more pronounced at night than during the day
- Reductions in the extent of snow cover of 10% have occurred in the past 40 years concurrent with a widespread retreat of mountain glaciers outside the Polar Regions. Sea-ice thickness in the Arctic has declined by about 40% during late summer/early autumn, though no comparable reduction has taken place in winter. These trends are considered likely to continue. In the Antarctic, no similar trends have been observed. One of the most serious impacts on global sea level could occur from a catastrophic failure of grounded ice in West Antarctica. This is, however, considered unlikely over the coming century
- Global sea level has risen by 0.1-0.2m over the past century, an order of magnitude larger than the average rate over the past three millennia. A rise of approximately 0.5m is considered likely during the period 1990-2100
- Precipitation has increased over the landmasses of the temperate regions by 0.5-1.0% per decade. Frequencies of more intense rainfall events appear to be increasing also in the Northern Hemisphere. In contrast, decreases in rainfall over the tropics have been observed, though this trend has weakened in recent years. More frequent warm phase El Niño events are occurring in the Pacific Basin. Precipitation increases are projected, particularly for winter, for northern middle and high latitudes and for Antarctica

- No significant trends in the tropical cyclone climatology have been detected

As a mid latitude country, these global trends have implications for the future course of Irish climate, and for a range of impacts which it is judicious to anticipate (Sweeney et al 2003).

A recent report published by the EPA (McElwain and Sweeney, 2007) summarised the indicators of climate change in Ireland and summarised the changes in climate over recent years:

- Ireland's mean annual temperature has increased by 0.7°C between 1890 and 2004
- The average rate of increase is 0.06°C per decade. However, as Ireland experiences considerable climate variability, the trend is not linear. The highest decadal rate of increase has occurred since 1980, with a warming rate of 0.42°C per decade
- The warmest year on record was 1945, although 6 of the 10 warmest years have occurred since 1990
- An alteration of the temperature distribution has occurred, with a differential warming rate between maximum and minimum temperatures. Minimum temperatures are increasing more than maximum temperatures in spring, summer and autumn, while maximum temperatures are increasing more than minimum temperatures in winter
- There has been a reduction in the number of frost days and a shortening of the frost season length
- The annual precipitation has increased on the north and west coasts, with decreases or small increases in the south and east
- The wetter conditions on the west and north coastal regions appear due to increases in rainfall intensity and persistence
- There is an increase in precipitation events over 10 mm on the west coast with decreases on the east coast, there is an increase in the amount of rain per rain day on the west coast, and a greater increase in number of events greater than the 90th percentile also on the west coast

The increases in intensity and frequency of extreme precipitation events provide a cause for concern as they may have a greater impact upon the environment, society and the economy. The precipitation series however require further analysis as there is large spatial and temporal variability associated with extreme precipitation events.

3.6.4 Impact Assessment

(i) Air

Construction Phase Impacts

There is the potential for a number of emissions to atmosphere during the construction of the development with wind blown dust being most significant. Wind blown dust emissions may arise during the construction phase of the proposed development, which may impact upon the surrounding environment. The deposition of dust and mud on the local roads is both unsightly and dangerous. Dust may be a particular problem during periods of dry windy weather.

Potential sources of dust from construction and operation include the following:

- Vehicles carrying dust on their wheels,
- Un-vegetated stockpiles of construction materials,
- The handling of construction materials for the construction phase of the development,
- The generation of dust from the recycling activities to be carried out indoors within the facility.

The construction and operation vehicles, generators, etc., will also give rise to petrol and diesel exhausts emissions, although this is of minor significance compared to dust.

Operational Phase Impacts

Regarding operations at the proposed development, the activities to be located in the development are waste water treatment activities. All equipment generating dust emissions will contain localised dust abatement equipment where necessary in order to prevent the release of dust to atmosphere.

'Do Nothing' Impact

The baseline survey results suggest that air quality in the vicinity of the proposed development is average/good and shows typical levels for a rural and suburban area with all pollutants within the relevant Irish and EU limits. The air quality may improve slightly in future years due to improvements in engine technology and greater controls on petrol, diesel, coal and gas composition and purity. If the proposed development were not to take place, the current air pollutant concentrations will remain unchanged followed by potential decreases in future years for the reasons outlined above. In relation to dust, non-development of the site would result in no movement of soils/sands and no construction activity and therefore no dust creation as a result of construction works. Other factors which may alter background dust concentrations is beyond the scope of this assessment.

'Worst Case Scenario' Impact

For traffic-derived pollutants, the "worst-case" scenario consists of gridlock conditions with large volumes of traffic on the road, simultaneously. This has been accounted for within the model whereby it is predicted that traffic movements will occur simultaneously on the road network. In addition gridlock is also assessed.

The DMRB predictive model employed (refer to *Volume III, Appendix 5A*) is a screening model that is used to generate worst-case scenario predictions for air quality. If this model indicates that pollutant levels will not breach the Irish and EU limits, then it can be assumed with some confidence that a project will not produce air pollution problems if none are identified by this method. There are no predicted breaches of Irish and EU legislation for DMRB design year and 2023. As a result of these model predictions it may be concluded that the worst-case impact of the traffic alterations associated with the proposed development are predicted to be a slight negative.

(ii) Odour

Construction Phase Impacts

During the construction phase, odour impacts are not predicted due to the nature of the activities.

Operational Phase Impacts

The contractor will be required to meet the following impact criteria for both the WWTP and pumping stations:

- All sensitive locations and areas of amenity should be located outside the 1.50 Ou_E m^{-3} at the 98th percentile of hourly averages over a meteorological year
- All sensitive locations and areas of amenity should be located outside the 3.0 Ou_E m^{-3} at the 99.5th percentile of hourly averages over a meteorological year
- The hedonic tone should not be considered unpleasant (scale greater than –2) as assessed in accordance with VDI 3882:1997, part 2; ('Determination of Hedonic) for all emission points

An odour modelling assessment has been carried out for the WWTP and pumping stations based on the specimen design (Indicative Design Nr. 1, refer to Section 2.5.5). A worst-case odour-modelling scenario was chosen to estimate worst-case odour impact from the proposed Cork Harbour Main Drainage Scheme WWTP and five pumping stations following the incorporation of odour management systems (i.e. five years of met data, predicted odour emission rate, etc.).

This will allow for the predictive analysis of any potential impact on the neighbouring sensitive locations while the WWTP and pumping stations are in operation. It will also allow the operators of the WWTP and pumping station site to assess the effectiveness of their suggested odour abatement/minimisation strategies. The intensity of the odour from two or more sources of the WWTP operation will depend on the strength of the initial odour threshold concentration from the sources and the distance downwind at which the prediction and/or measurement is being made. Where the odour emission plumes from a number of sources combine downwind, then the predicted odour concentrations may be higher than that resulting from an individual emission source. It is important to note that various odour sources have different odour characters. This is important when assessing those odour sources to minimise and/or abate. Although an odour source may have a high odour emission rate, the corresponding odour intensity (strength) may be low and therefore it is easily diluted. Those sources that express the same odour character, as an odour impact should be investigated first for abatement/minimisation before other sources are examined as these sources are the driving force behind the character of the perceived odour.

Dispersion Model: AERMOD Prime was used to determine the overall odour impact of the proposed Cork Harbour Main Drainage Scheme WWTP and pumping stations operation. The output data was analysed to calculate:

Scenario 1 - WWTP

- Predicted odour emission contribution of overall proposed WWTP operation to surrounding population, to odour plume dispersal at the 98th percentile for an odour concentration of less than or equal to 1.50 Ou_E m^{-3}

- Predicted odour emission contribution of overall proposed WWTP operation to surrounding population, to odour plume dispersal at the 99.5th percentile for an odour concentration of less than or equal to 3.0 $Ou_E\ m^{-3}$
- Predicted odour emissions contribution of individual grouped Odour Control Units to surrounding population, to odour plume dispersal at the 98th percentile for an odour concentration of less than or equal to 0.30 Ou_E/m^3
- Predicted odour emissions contribution of individual grouped Aeration, Secondary settlement and Storm water tankage sources to surrounding population, to odour plume dispersal at the 98th percentile for an odour concentration of less than or equal to 1.50 Ou_E/m^3

These odour impact criterions were chosen for the WWTP in order to ascertain the level of proposed impact to the surrounding residential and industrial population in the vicinity of the proposed WWTP.

The plotted odour concentrations of ≤ 1.50 $Ou_E\ m^{-3}$ for the 98th percentile and ≤ 3.0 $Ou_E\ m^{-3}$ for the 99.5th percentile for the proposed Cork Harbour Main Drainage Scheme WWTP specimen design operation are illustrated in *Figure 3.6.7 and Figure 3.6.8*, respectively. As can be observed for the 98th percentile contour, it is predicted that odour plume spread is small with a radial spread of 80 metres from the boundary of the facility in a northerly direction. In accordance with odour impact criterion and in keeping with currently recommended odour impact criterion in this country, no long-term odour impacts will be generated by receptors in the vicinity of the future proposed WWTP.

In terms of the 99.5th percentile of hourly averages over five years of meteorological data, the overall odour plume spread is similar with a radial spread of 75 metres in a northerly and easterly direction. In accordance with odour impact criterion and in keeping with currently recommended odour impact criterion in this country, no short-term odour impacts will be generated by receptors in the vicinity of the future proposed WWTP.

Figures 3.6.9 and 3.6.10 illustrates the odour plume spread for individual grouped odour sources to include odour control units (OCU 1 to 5) and tankage odour sources – aeration tankage, secondary settlement and storm water tankage. As can be observed, the main contributor of odour to the actual plume spread is the aeration, secondary settlement and storm water tankage. All other offensive odour sources will be covered, sealed and negatively ventilated and odorous air directed to odour control units (two stages of odour control if biological treatment is chosen as first stage). The maximum predicted ground level concentration for OCU 1 to 5 will be less than 0.41 Ou_E/m^3 at the 98th percentile of hourly averages over 5 years of meteorological data (odour threshold concentration of less than 300 Ou_E/m^3 for OCUs 1, 2, 4, and 5 and less than 500 Ou_E/m^3 for OCU 3; refer to Table 3.6.16). The overall stack heights of each OCU are 12 m high from ground level with an efflux velocity greater than 15 m/s.

It should be noted that in terms of the number of odour treatment units, the contractor will be required to ensure that odour emission rates do not exceed 2,314 $Ou_E\ s^{-1}$ whether 3, 4 or 5 OCUs are utilised within the design (i.e. must achieve the total odour emission of 6,611 Ou_E/s from the WWTP and also at minimum the total treatment volume 6.20 m^3/s and a total odour emission rate of less than or equal to 2,314 $Ou_E\ s^{-1}$ from the odour control units, refer to Table 3.6.16).

Scenario 2 - Pumping Stations

Based on the proposed design (Indicative Design Nr.1) plotted odour concentrations for the 98th of hourly averages were generated for the five major pumping stations (four proposed and one existing). Maximum ground level concentrations ranged from 0.15 to 0.34 Ou_E/m^3 for the 98th percentile. This is up to 77 - 90% lower than the odour impact criterion presented in Section 3.6.2. In accordance with odour impact criterion, no long-term odour impacts will be perceived in the vicinity of the pumping stations (refer to *Volume III, Appendix 5B*).

Minor pumping stations were not assessed as it was anticipated that impacts predicted for the major pumping stations would be greater than that for minor pumping stations.

The implementation of odour management systems at each pumping station will minimise the uncontrolled release of fugitive odour emissions. An odour management system (e.g. good design in terms of odour management, tight fitting covers, etc.) will be required to minimise the uncontrolled release of fugitive odour emissions and prevent complaints from the public at large.

The dispersion model incorporated odour emission rates identified in Table 3.6.17. Since the overall predicted odour emission rate from the five major pumping stations is low (due to the small nature and characteristics of the odour source). Taking this low impact into account, there is no requirement to perform risk analysis using the 99.5th percentile assessment criterion, as the predicted odour impact criterion will always be below this level.

Table 3.6.16: Predicted overall odour emission rate from proposed Cork Harbour Main Drainage Scheme WWTP specimen design with the incorporation of odour mitigation protocols

Source Identity	Area (M^2)	Odour Emission Flux ($ou_e/m^2/s$)	Volumetric Airflow Rate (m^3/s)	Odour Threshold Concentration (ou_e/m^3)	Odour Emission Rate (ou/s)	% Contribution
Inlet works - Primary treatment building	0	See OCU emission rate		-	0	0
Primary settlement tank 1	0	See OCU emission rate	-	-	0	0
Primary settlement tank 2	0	See OCU emission rate	-	-	0	0
Primary settlement tank 3	0	See OCU emission rate	-	-	0	0
Storm water tank 1	952.47	0.50		-	476	7.20
Storm water tank 2	952.47	0.50		-	476	7.20
Aeration tank	1200	1.20		-	1440	21.78
Secondary settlement tank 1	952.47	0.50		-	476	7.20
Secondary settlement tank 2	952.47	0.50		-	476	7.20
Secondary settlement tank 3	952.47	0.50		-	476	7.20
Secondary settlement tank 4	952.47	0.50		-	476	7.20
OCU 1 - Inlet works building OCU	-	-	1.0	300	300	4.54
OCU 2 - Primary settlement tanks/Flow splitting chambers OCU	-	-	0.93	300	279	4.22
OCU 3 - Sludge holding tanks/Digesters/Sludge drier OCU	-	-	2.27	500	1135	17.17
OCU 4 - Primary sludge storage OCU	-	-	1	300	300	4.54
OCU 5 - Secondary sludge treatment OCU	-	-	1	300	300	4.54
Total odour emission rate	**-**	**-**	**-**	**-**	**6,611**	**100**

Table 3.6.17: Predicted overall odour emission rate from the five major pumping stations with the incorporation of good design and odour management systems (i.e. tight fitting covers, etc.)

Source Identity	Odour Emission Rate (ou_e/s)
Raffeen PS OCU	90
West beach PS OCU	360
Monkstown PS OCU	120
Church Rd PS OCU	81
Carrigaloe PS OCU	51

'Do Nothing' Impact

If the development does not proceed, the odour environment of the area would continue to be subject to existing prevailing influences.

'Worst Case Scenario' Impact

It is considered that the "Worst-Case Scenario" Impact for the odour would arise from ineffective management of the plant and consequently the plant causing a significant odour impact.

(iii) Climate

Construction and Operational Phase Impacts

There is a potential for impacts to climate as a result of any development that requires fuel and energy. These impacts are the generation of greenhouse gas emissions (principally carbon dioxide and oxides of nitrogen) from traffic and electrical supply.

The potential effects of climate change on a global scale have been investigated by the Intergovernmental Panel on Climate Change (IPCC). The resulting impacts in Ireland are outlined in the National Climate Change Strategy and recently by the EPA and include the following:

- Significant increases in winter rainfall, of the order of 10% in the southeast, with a corresponding increase in the water levels in rivers, lakes and soils. Serious flooding more frequent than at present
- Lower summer rainfall, of the order of 10% in the southern half of the country. Less recharge of reservoirs in the summer leading to more regular and prolonged water shortages than at present. Loss of bog land due to regular water deficits
- Increased agricultural production, with new crops becoming more viable and potentially reduced agricultural costs. Grass growth could enjoy beneficial effects with an increase in 20% possible with higher temperatures and changes in rainfall patterns
- The development will be designed to take account of changes in rainfall intensity and mean sea level rise

These figures for climate change refer to year 2100. The specimen design is for up to the year 2030.

It is recognised that Ireland cannot, on its own, prevent or ameliorate the impacts of climate change. However, the National Climate Change Strategy states that Ireland must meet its responsibilities with regard to reducing CO_2 emissions in partnership with the EU and the global community. In terms of this specimen design, the generation of biogas and utilisation of generated biogas in a gas utilisation engine/boiler will offset CO_2 eq. emissions generated by the WWTP.

Road traffic and power usage would be expected to be the dominant sources of greenhouse gas emissions as a result of the proposed development. Vehicles and power used to operate the plant will give rise to CO_2 and NO_2 emissions as a result of the proposed development. For the purposes of this assessment, it is estimated that the number of vehicles accessing the site on a weekly basis (when operational) will be 12 vehicles for truck movements and approximately 60 vehicle movements per week for small vehicles such as passenger cars. This will lead to the emission of 139 tonnes of CO_2 per annum, which is equivalent to 0.00000175% of the National Emissions in Ireland in 2008 to 2012 (assuming a driving radius of 30km from the facility and a payload of 13 tonnes).

With reference to relevant evaluation criteria such as the Kyoto Protocol, which has set objectives to be achieved by 2008 – 2012, GHG emissions as a result of this proposal will be imperceptible.

'Do Nothing' Impact

If the development does not proceed, the general climate of the area would continue to be subject to existing prevailing influences.

'Worst Case Scenario' Impact

Due to the nature and scale of the development, it is considered that there are no impacts arising which could affect the general climate of the area, either regionally or locally.

3.6.5 Mitigation Measures

(i) Air

Construction Phase

Construction activities are likely to generate some dust emissions. The potential for dust to be emitted depends on the type of construction activity being carried out in conjunction with environmental factors including levels of rainfall, wind speed and wind direction. In order to ensure that no dust nuisance occurs, a series of measures will be implemented and incorporated into the Construction Environmental Plan (CEMP). Site roads shall be regularly cleaned and maintained as appropriate. Hard surface roads shall be swept to remove mud and aggregate materials from their surface as a result of the development. Any un-surfaced roads shall be restricted to essential site traffic only. Furthermore, any road in the vicinity of the development that has the potential to give rise to dust may be regularly watered, as appropriate, during extended dry and/or windy conditions.

A full traffic management plan and dust management plan will be implemented into the CEMP in order to minimise such emission as a result of the construction phase of the development. This will be generated specifically for the development when detailed design is completed.

Vehicles using site roads shall have their speed restricted, and this speed restriction must be enforced rigidly. On any un-surfaced site road and on hard surfaced roads that site management dictates speed shall be restricted to 20 km per hour.

Material handling systems and site stockpiling of materials shall be designed and laid out to minimise exposure to wind. Water misting or sprays shall be used as required if particularly dusty activities are necessary during dry or windy periods.

In relation to the completion of the proposed development, the hard standing surface, and all roads will be tarmacadamed/concreted. In periods of dry weather when dust emission would be greatest, a road sweeper, which would also dampen the road, may be employed in order to prevent the generation of dust.

It is envisaged that the proposed development will not have a significant impact on the surrounding air quality. However, as discussed previously a number of dust mitigation measures have been suggested. Moreover, dust monitoring could be carried out during the construction phase of the development if deemed necessary by the planning authority. If the level of dust is found to exceed 350mg/m^{2}day in the vicinity of the site (using Bergerhoff gauges), further mitigation measures will be incorporated into the construction of the proposed site.

Operational Phase

It is not anticipated that dust will be a significant problem during the operation of the development. All sources generating dust will operate dust management equipment as required.

Depositional dust monitoring will be carried out during the operation phase of the development if deemed necessary by the regulatory authority. If the level of dust is found to exceed 350mg/m^{2}day in the vicinity of the site, further mitigation measures will be incorporated into the operation of the proposed site.

Emissions of pollutants from road traffic can be controlled by either controlling the number of road users or by controlling the flow of traffic. For the majority of vehicle-generated pollutants, emissions rise as speed drops. Emissions are also higher under stop-start conditions when compared with steady speed driving. Since the development will generate only small volumes of traffic, emissions from such activities were predicted to be minimal.

It is envisaged that the proposed development will not have a significant impact on the surrounding air quality.

(ii) Odour

Construction Phase

Since the impact of the scheme during the construction phase in terms of odour is not significant, measures to mitigate odour impacts are not required.

Operational Phase

The following recommendations were developed during the study:

- Odour management, minimisation and mitigation procedures will be implemented at the proposed Cork Harbour Main Drainage Scheme WWTP and each pumping station in order to prevent any odour impact in the surrounding vicinity
- The maximum allowable odour emission rate from the overall proposed WWTP should not be greater than 6,611Ou_E s^{-1} (*refer to Table 3.6.16*) inclusive of the odour emission contribution from the abatement systems installed on the primary treatment, pumping and sludge handling processes. The maximum overall odour emission rate from the odour control units shall be no greater than 2,314 Ou_E s^{-1} (with an exhaust stack concentration of less than 300 Ou_E/m^3 for OCU 1, 2, 4 and 5 and less than 500 Ou_E/m^3 for OCU 3, respectively). The specimen design suggests the use of three OCUs. As long as the total odour emission rate for the WWTP (i.e. 6,611Ou_E s^{-1}) is achieved along with the total minimum odour treatment volume (i.e. 6.20 m^3/s) and a total odour emission rate from the OCUs of less than or equal to 2,314 Ou_E s^{-1} is similar, then the number of OCUs utilised onsite is not important. The hedonic tone of this odour should not be considered unpleasant (Scale greater than –2) as assessed in accordance with VDI 3882:1997, part 2; ('Determination of Hedonic) for all emission points
- The odour management systems to be installed upon Raffeen, Carrigaloe, West Beach, Monkstown and Church Road should be sufficient to prevent any uncontrolled fugitive odours escaping from the system. In addition any odour management system incorporated into the design and upgrade of the pumping stations (both minor and major) should be capable of achieving less than 1.5 Ou_E/m^3 at the 98th percentile and less than 3.0 Ou_E/m^3 at the 99.5th percentile of hourly averages
- Maintain good housekeeping practices (i.e. keep yard area clean, etc.), closed-door management strategy (i.e. to eliminate puff odour emissions from sludge dewatering building), maintain sludge storage within sealed airtight containers and to implement an odour management plan for the operators of the WWTP and all pumping station. All odorous processes such as inlet works, primary treatment, and thickening will be carried out indoors/enclosed tankage
- Avoid accumulation of floating debris and persistent sediments in channels and holding tanks by design (i.e. flow splitters and secondary sedimentation tanks, etc.). Techniques to eliminate such circumstances shall be employed
- Enclose and seal all primary treatment, wet wells and sludge handling processes
- Operate the proposed WWTP within specifications to eliminate overloading and under loading, which may increase septic conditions within the processes
- Odour scrubbing technologies employing will be implemented within the proposed Cork Harbour Main Drainage Scheme WWTP. An odour management system will be implemented upon each pumping station (both minor and major)
- When operational, it is recommended that the contractor should provide evidence through the use of dispersion modelling (AERMOD Prime) and olfactometry measurement (in accordance with EN13725:2003), that the as built WWTP and pumping stations are achieving the overall mass emission rate of odour and emission limit values for the installed odour management systems

(iii) Climate

All space heating and energy requirements for the proposed development should be designed in accordance with best practice. The Building Regulations 2002 "Technical Guidance Document Part L – Conservation of Fuel an Energy Dwellings" should be used as a reference for best practice in order to reduce the impact of the proposed development on greenhouse gas emissions.

Since it is envisaged that the proposed facility will have no impacts on the regional and local climate, no specific mitigation measures are deemed necessary.

3.6.6 Residual Impacts

(i) Air

Construction Phase

The effect of construction of the facility on air quality will not be significant following the implementation of the proposed mitigation measures. The main environmental nuisance associated with construction activities is dust. However, it is proposed to adhere to good working practices and dust mitigation measures to ensure that the levels of dust generated will be minimal and are unlikely to cause an environmental nuisance. A series of such good working practices and mitigation measures are outlined earlier in Section 3.6.5.

Operational Phase

The predicted increases in traffic volumes as a result of the development along the existing road network are expected to be very low. The information on traffic provided in the traffic section of the Statement has been used to identify whether any significant impact on sensitive receptors will occur. The traffic information has been input into the Design Manual for Roads and Bridges (DMRB), Volume 11 (February 2003) model. This model was prepared by the United Kingdom Department of Transport, the Scottish Office of Industrial Development, the Welsh Office and the Department of Environment for Northern Ireland as a screening tool to assess worst-case air quality impact associated with roads developments. The screening model uses a worst-case scenario in calculating emissions. The emission factors used for each pollutant are intentionally biased to overestimate the actual emission rate. It is assumed that a total of 4 AADT movements per day for HGVs and a maximum 12 AADT movements per day for LGV/cars (i.e. to and from the site).

The DMRB only assesses the potential impacts from traffic up to and including the year 2023. Even though the development design period goes beyond this date, this is not considered significant since impacts are expected to be even lower beyond this date due to improvements in engine technology etc. The impacts associated with the proposed development are well within the ground level impact concentrations in year 2023 (as predicted by the model). Using the model, concentrations of Carbon Monoxide, Benzene, Oxides of Nitrogen and PM_{10} (particulate matter with an average 10 µm aerodynamic diameter), have been determined for a receptor point road along the road L2490 (Fernhill Rd).

The computer model predictions indicate the following findings:

- Ambient concentrations will, in general, decrease due to legislation driven improvements in engine technology and fuel content. Any increases will be slight.
- There will be negligible increases in NO_2 and PM_{10} concentrations as the development phase is implemented.
- The net impact of the proposed development will be a slight negative for NO_2 and PM_{10} but will remain well within the Irish and EU legislative limit values.

(ii) Odour

A worst-case odour emission scenario was modelled using the atmospheric dispersion model AERMOD Prime with meteorology data representative of the study area. A worst-case odour emission data set was used to predict any potential odour impact in the vicinity of the proposed Cork Harbour Main Drainage Scheme WWTP and five pumping stations. Odour impact potential was discussed for proposed operations with the implementation of mitigation protocols. It was concluded that for Cork Harbour Main Drainage Scheme WWTP:

- In accordance with odour impact criterion, and in keeping with current recommended odour impact criterion in this country, no odour impact will be perceived by sensitive receptors in the vicinity of the proposed Cork Harbour Main Drainage Scheme WWTP following the installation of proposed odour management, minimisation and mitigation protocols assuming specimen design. As can be observed, the overall odour emission rate from the new proposed Cork Harbour Main Drainage Scheme WWTP will be no greater than 6,611 Ou_E/s based on the specimen design.
- All residents/industrial neighbours in the vicinity of the proposed Cork Harbour Main Drainage Scheme WWTP will perceive an odour concentration at or less than 1.50 Ou_E m^{-3} for the 98th percentile and less than 3.0 Ou_E/m^3 for the 99.5th percentile for five years of meteorological data (refer to Figures 3.6.7 and 3.6.8). Those odour sources considered most offensive (inlet works, primary treatment and holding tanks, centrate, filtrate, sludge, RAS/WAS pump sumps, flow splitting chambers and all sludge handling processes including tankage will be effectively contained and ventilated to an odour control system and therefore the overall risk of any resident/industrial neighbours detecting odour will be negligible since the major odour sources contributing to the remaining odour plume are considered low risk in term of odour. These sources include the aeration tankage, secondary settlement tankage and storm water tankage (refer to Figures 3.6.9 and 3.6.10).

It was concluded that for Pumping Stations:

- In accordance with odour impact criterion, and in keeping with current recommended odour impact criterion in this country, no odour impact will be perceived by sensitive receptors in the vicinity of the major pumping stations Raffeen, West Beach, Monkstown, Church Road and Carrigaloe pumping stations following the implementation of good design in terms of odour management (e.g. tight fitting covers, etc.).
- All residents/industrial neighbours in the vicinity of the proposed pumping stations will perceive an odour concentration at or less than 1.50 Ou_E m^{-3} for the 98th percentile and less than 3.0 Ou_E/m^3 for the 99.5th percentile for five years of meteorological data (refer to *Volume III, Appendix 5B*). All pumping station (both minor and major) will incorporate the use of an odour management system (e.g. good design in terms of odour minimisation, tight fitting covers etc.) to ensure no fugitive release of odours from each pumping station. In addition, each pumping station will be regularly visited so as to ensure efficient operation of the odour management system.

- It is acknowledged that many of the pumping stations are located in populous areas. For this reason the design of the collection system will include best practice and adequate odour management systems to prevent odour complaint and impact.

(iii) Climate

No significant residual impacts are envisaged.