Chapter 7:

Water – Hydrology and Hydrogeology

7 WATER – HYDROLOGY & HYDROGEOLOGY

7.1 INTRODUCTION

This Chapter of the Environmental Impact Statement covers the potential impact of the proposed Lower Lee (Cork City) Drainage Scheme on the Water Environment. The chapter discusses the existing aquatic environment, the potential impacts of the scheme and remedial measures on both surface water and groundwater along with the hydrological and hydrogeological regimes of the Study Area. Impacts on Water: Hydrology and Hydrology are broken down into the following sections:

- Surface Water Quality;
- Hydrogeology;
- Flooding and Hydrology.

7.2 SURFACE WATER QUALITY

7.2.1 Surface Water Quality Legislative Review

7.2.1.1 Water Framework Directive

The EU Water Framework Directive (WFD) was adopted on the 23rd of October 2000 came into effect on the 22nd December 2000. It is the most significant piece of water legislation to be introduced by the European Commission in twenty years.

The Directive takes a broad approach to the protection, enhancement and restoration of all coastal waters, rivers, lakes, estuaries and groundwaters in Europe. It requires all countries to control, manage and protect their water resources from all impacts – physical, polluting or otherwise. Under the Directive, all waters within Europe must achieve at least 'Good' status by December 2015 unless otherwise agreed upon by the relevant authority and the European Commission and the status of any waters must not deteriorate.

7.2.1.2 The European Communities Environmental Objectives (Surface Water) Regulations, 2009 and Amendment Regulations 2012 and 2015

The European Communities Environmental Objectives (Surface Waters) Regulations, 2009 and Amendment Regulations 2012 and 2015 have a significant effect on the Water Framework Directive and the Dangerous Substances and Priority Substances Directives.

The Directive, similar to the requirements of the Water Framework Directive, requires that all waters must be maintained at or improved to at least 'Good Status' by 22 December 2021. No deterioration in quality is permitted.

'Status' is a descriptor term that incorporates ecological and hydrochemical data and facilitates catchment comparisons on an EU scale. The catchment scale is referred to as the 'macro-scale'. Its status cannot be used to assess the potential impacts at a micro-scale i.e. a point discharge on a river, without there first being validation by monitoring data at the source of the point discharge. The EPA is responsible for assigning Status.

The European Communities Environmental Objectives (Surface Waters) Regulation, 2009, specify the conditions and physico-chemical concentrations that should be considered in the assessment of Status.

The 2012 Regulations set standards for a range of pesticide, herbicide and heavy metals in surface waters. It clarifies the role of public authorities in the protection of surface waters, include standards and sets limits for priority hazardous substances. The 2015 Regulations amend the Biological quality requirements conditions and concentrations of priority substances.

Table 7.1 below shows the surface water quality standards applied across a range of relevant legislation.

Table 7.1 Mandatory levels for physiochemical parameters for specific legislation

Parameter	Units	European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989 (S.I. No. 294/1989)*	European Communities Environmental Objectives (Surface Water) Regulations (S.I. No. 272 of 2009)	European Communities Drinking Water Regulations S.I. 106 of 2007	Salmonid Water Regulations (Mandatory Level) (S.I. No. 293 of 1988)
BOD	mg/l	5 –A1 & A2 7 – A3	High status ≤1.3 (mean) or ≤2.2 (95%ile) Good status ≤1.5 (mean) or ≤2.6 (95%ile)	N/A	≤ 5
Suspended Solids	mg/l	50	N/A	N/A	≤ 25
pH	-	5.5-8.5 – A1 5.5-9.0 – A2 & A3	4.5-9.5 (Soft Water) 6.0-9.0 (Hard Water)	≥ 6.5 & ≤ 9.5	≥ 6 & ≤ 9
Conductivity	µS/cm	1,000	N/A	2,500	N/A
Phosphates	mg/l P_2O_5	0.5 – A1 & A2 0.7 A3	N/A	N/A	N/A
Molybdate Reactive Phosphorus (MRP)	mg/l P	N/A	High status ≤0.025 (mean) or ≤0.045 (95%ile) Good status ≤0.035 (mean) or ≤0.075 (95%ile)	N/A	N/A
Chloride	mg/l Cl	250	N/A	250	N/A
Ammonium	mg/l NH_4	0.2 – A1 1.5 – A2 4 – A3	N/A	N/A	≤ 1.0
Total Ammonia	mg/l N	N/A	High status ≤0.040 (mean) or ≤0.090 (95%ile) Good status ≤0.065 (mean) or ≤0.140 (95%ile)	N/A	N/A

Parameter	Units	European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989 (S.I. No. 294/1989)*	European Communities Environmental Objectives (Surface Water) Regulations (S.I. No. 272 of 2009)	European Communities Drinking Water Regulations S.I. 106 of 2007	Salmonid Water Regulations (Mandatory Level) (S.I. No. 293 of 1988)
Nitrate	mg/l NO_3	50	N/A	50	N/A
Nitrite	mg/l NO_2	N/A	N/A	0.5	≤ 0.05
Dissolved Oxygen	-	>60% - A1 >50% - A2 >30% - A3	Lower limit: 95%ile>80% saturation Upper limit: 95%ile<120 %saturation	N/A	50% ≥ 9 mg/l
Total Hardness	mg/l $CaCO_3$	N/A	N/A	N/A	N/A
Copper	mg/l Cu	0.05 –A1 0.1– A2 1.0 – A3	5 - water hardness ≤100mg/l $CaCO_3$ 30 – water hardness >100mg/l $CaCO_3$	2.0	≤ 0.005 [1, 6] ≤ 0.022 [2, 6] ≤ 0.04 [3, 6] ≤ 0.112 [4, 6]
Zinc	mg/l Zn	3–A1 5- A2 & A3	0.008 - water hardness ≤10mg/l $CaCO_3$ 0.05 - water hardness>10 ≤100mg/l $CaCO_3$ 0.1- water hardness >100mg/l $CaCO_3$	N/A	≤ 0.03 [1, 6] ≤ 0.2 [2, 6] ≤ 0.3 [3, 6] ≤ 0.5 [5, 6]
Total coliforms	no/100ml	5,000 – A1 25,000 – A2 100,000 – A3	N/A	N/A	N/A
Faecal coliforms	no/100ml	1,000 – A1 5,000 – A2 40,000 – A3	N/A	0	N/A

[1] At water hardness 10 mg/l CaCO3; [2] At water hardness 50 mg/l CaCO3.; [3] At water hardness 100 mg/l CaCO3 ; [4] At water hardness 300 mg/l CaCO3; [5] At water hardness 500 mg/l CaCO3; [6] To be conformed with by 95% of samples over a period of 12 months where sampling is carried out at least once a month; where sampling is less frequent, to be conformed with by all samples.

*S.I. No. 294/1989 is superseded by S.I. No. 272 of 2009. If a particular parameter is not found in SI 272 of 2009 then the 1989 value applies.

7.2.2 Methodology

7.2.2.1 Desk Study

A desk study of relevant hydrological data was conducted. The following documentation and sources were reviewed:

- Environmental Protection Area (EPA) water quality database and maps (http://gis.epa.ie/Envision)
- Cork County Council Surface Water Results for the River Lee
- South Western River Basin District Management Plan (2009 – 2015)
- The Water Framework Directive website www.WFD.ie

7.2.2.2 Field Assessment

Q Values were determined for the River Lee in order to determine the baseline biological water quality for the study area.

Q Values are biotic indices used to express biological water quality and are based on changes in the macro invertebrate communities of riffle areas brought about by organic pollution. Q1 indicates a seriously polluted water body and Q5 indicates unpolluted water of high quality. A value of Q3 indicates moderately polluted water. These Q value ratings are shown in Table 7.2. In addition, various chemical parameters are also tested by the EPA and are available for some of the monitoring points.

Table 7.2 Q value classification

Quality Ratings	Quality Class	Pollution Status	Condition (re beneficial uses)
Q5, Q4-5, Q4	Class A	Unpolluted	Satisfactory
Q3-4	Class B	Slightly Polluted	Unsatisfactory
Q3, Q2-3	Class C	Moderately Polluted	Unsatisfactory
Q2, Q1-2, Q1	Class D	Seriously Polluted	Unsatisfactory

Kick samples of aquatic macro-invertebrates were collected on the River Lee and tributaries Curragheen, Glasheen, Glenamought and Bride (North) between the 2nd and 5th May 2015. Where possible the macro-invertebrate sampling stations were situated in the vicinity upstream or downstream of the works areas, given the selection of the sampling sites also depended on the presence of riffle/ glide habitat from which samples could be collected. No samples were collected in the tidal reaches of the river, i.e. north channel of the River Lee (full extent of channel) or downstream of the Gillabey Rock on the south channel as these areas are tidal and are outside the scope of the EPA Q-Value system. Kick sampling was carried out at 11 locations in the River lee and its tributaries.

Table 7.3 Location of macro-invertebrate sampling locations on the River Lee

Site No	River Name	Location	GPS Co-ordinates
Site 1	River Lee	Inniscarra Graveyard	W 56461 70943
Site 2	River Lee	Grotto	W 62992 71957
Site 3	River Lee	Downstream County Hall	W 65373 71319
Site 4	Curragheen River	Concrete Works	W 63035 71218
Site 5	Curragheen river,	GAA Pitches	W 64179 71289
Site 6	Glasheen River	R608	W 65358 70859
Site 7	Glasheen River	Orchard Road	W 65182 71117
Site 8	Glenamought River	Viaduct	W 66461 75061
Site 9	Glenamought River	Industrial Park	W 66250 74765
Site 10	River Bride (North), Commons Inn	Commons Inn	W 66499 74563
Site 11	River Bride (North)	Orchard Court	W 67371 73426

Kick sampling was performed for 2.5 minutes in the faster flowing areas (riffles) of the river. The kick sample was taken moving across the riffle zone and also involved washing large rocks from the riffle zone to ensure a full representation of the species composition from this micro-habitat type. Collected samples were elutriated, refrigerated and identified live within 24 hours of each site visit. The samples were identified using a Nikon SMZ 1000 stereo microscope and numerous Freshwater Biological Association invertebrate keys. Invertebrate taxa were identified to species level where possible. The relative proportions of taxonomic groups were recorded based on the EPA categories (i.e. 8 categories ranging from present to excessive) (Appendix I of Toner et al., 2005). Biological water quality data as prescribed by the Environmental Protection Agency (EPA; Toner et al. 2005), group invertebrates into classes whereby very pollution intolerant species are denoted class A, and species with greater pollution tolerance fall into successive classes (B through E respectively). As such the presence or absence of these groups and their relative abundances facilitates an assessment of biological river health. Using Appendix 1 of the Environmental Protection Agency publication Water Quality in Ireland, Q values were determined for all sites sampled, based on the faunal assemblage found at each sampling location.

7.2.3 Description of the Study Area

The River Lee flows into the Study Area from the west. It rises in the Shehy Mountains on the western border of County Cork and flows eastwards through Cork, where it splits in two for a short distance, creating an island on which Cork's city centre is built. The River Lee is joined by a number of large tributaries within the study area. These include:

- The River Sullane
- The Laney River.
- The Dripsey River
- The Bride (West and North) Rivers
- The Shournagh River

A number of smaller tributaries join the River Lee in Cork City including the Curragheen, Glasheen and Kiln Rivers. The catchment also includes a number of smaller rivers and their estuaries that drain directly into Cork Harbour. These include the Glashaboy, Owennacurra, Tramore and Owenboy Rivers.

The Study Area consists of the of the River Lee (Cork City) Drainage Scheme which will alleviate flooding.

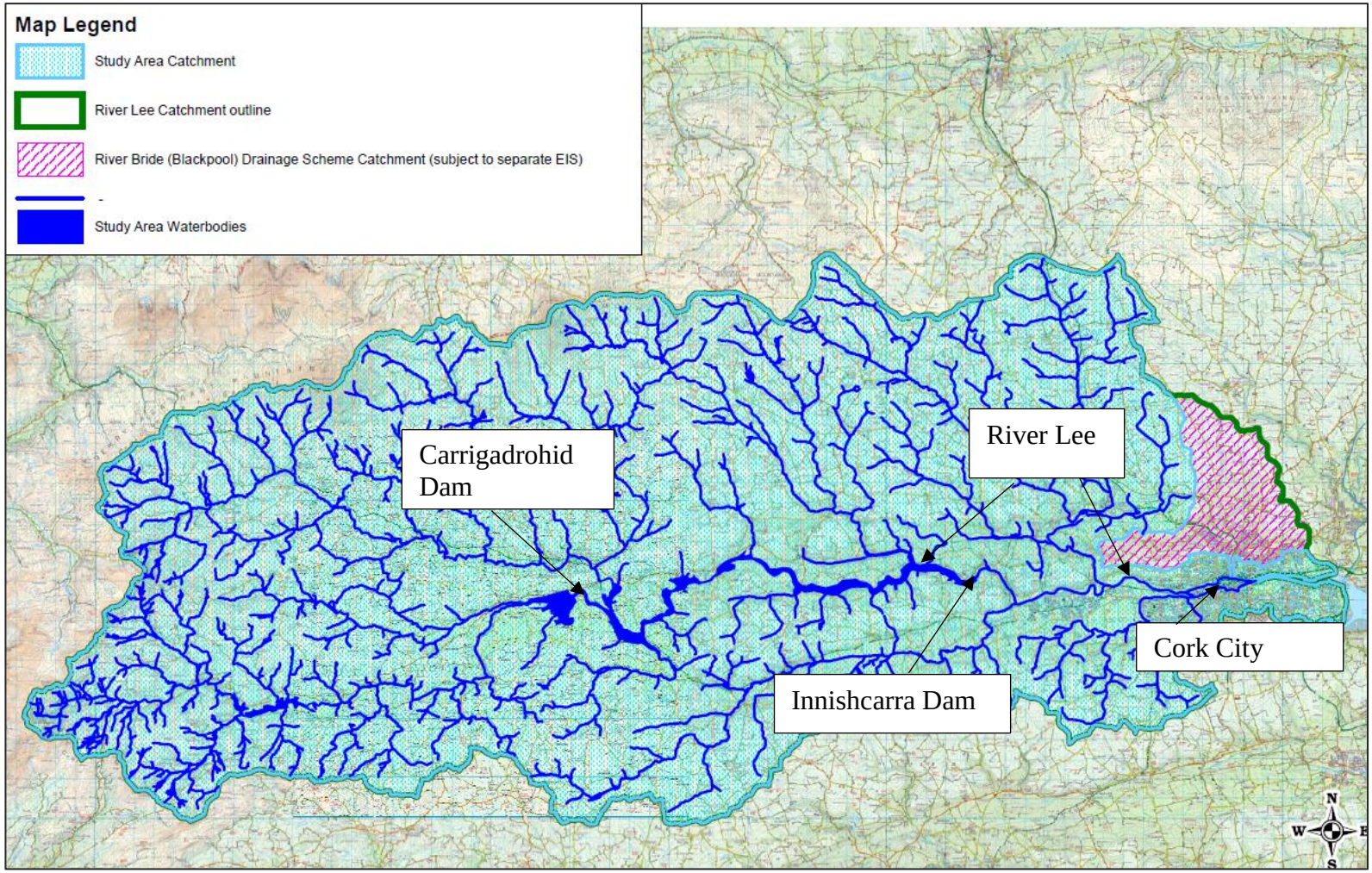

Figure 7.1 River Lee Catchment

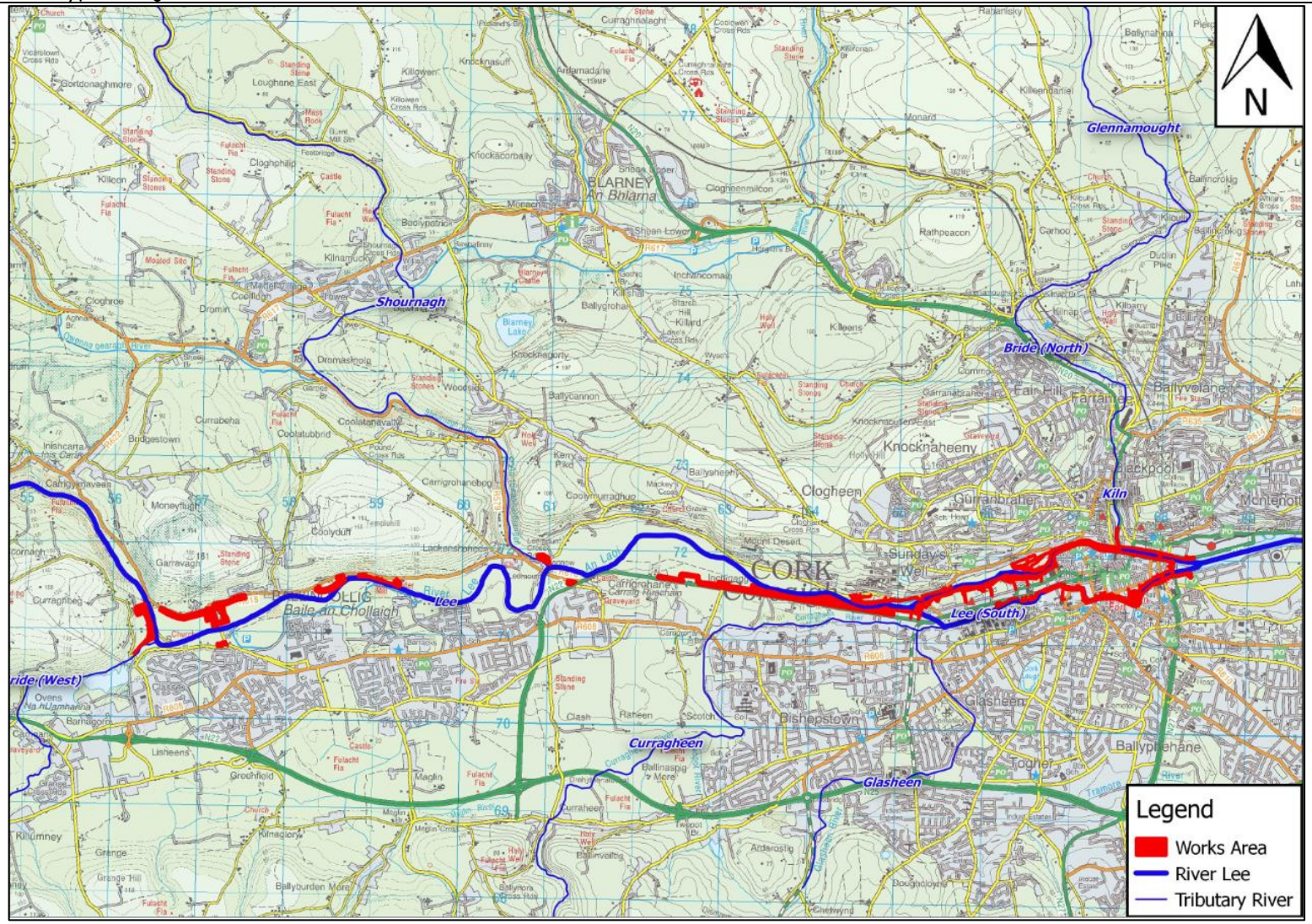

Figure 7.2 River Lee and its tributaries

7.2.3.1 EPA Water Quality Data

The EPA website, http://gis.epa.ie/Envision, contains information regarding water quality in selected Irish rivers based on surveys carried out by the EPA. Information was obtained from EPA monitoring stations on the River Lee within the Study Area.

Information obtained for the River Lee from the EPA monitoring points within or close to the Study Area indicate that the current water quality (2014) ranges from moderately polluted to unpolluted (Q3-4 to Q4-5) as shown in Table 7.4.

The EPA water quality assessment highlighted the River Lee Assessment as:

River Lee – Water quality "continuing mostly satisfactory, with High and Good ecological quality, and with a slight improvement from Poor to Moderate quality, at Inniscarra".

Table 7.4 Biological water quality in the River Lee based on EPA data

Biological Quality Ratings (Q Values)									
	Station Nos.	1994	1997	1999	2002	2005	2008	2011	2014
River Lee									
Leemount Br	19L030700	4	4	4	4	3-4	4	4	4
Inniscarra Br	19L030600	3	3	3	3	3	3	3	3-4
Bannow Br	19S010500	4-5	4-5	4	4	4	4	4-5	4-5
Br U/S of Lee R. conf	19B041600	4	4-5	4	4	4	4	4	4-5

Table 7.5 EPA Physico-chemical data from EPA sampling points in the River Lee

Chemical Data				
River Lee				
Parameter	**Unit**	**Station No. 0700 Leemount Br**		
		Minimum	**Mean**	**Maximum**
Alkalinity-total	(mg/l CaCO3)	28.0	46.7	60.0
Chloride	mg/l Cl	11.2	15.2	17.7
Conductivity @20°C	µS/cm	173.0	176.3	178.0
Conductivity @25°C	µS/cm	116.0	170.4	203.0
pH		7.0	7.7	8.0
Sulphate mg/l	mg/l	3.8	6.1	8.6
Temperature °C	°C	7.0	9.5	18.2
Total Hardness	(mg/l CaCO3)	35.0	56.4	72.0
Total Organic Carbon	mg/l	3.5800	6.2313	9.5900
True Colour	(Hazen)	12.0	23.6	45.0
Nitrate	(mg/l NO3)	4.450	9.136	16.800
Nitrite	(mg/l N)	0.006	0.008	0.012
ortho-Phosphate	(µg/l P)	0.003	9.185	47.000
Total Nitrogen	(mg/l N)	1.400	1.871	2.800
Total Oxidised Nitrogen	(mg/l N)	1.100	1.500	2.000

Total Phosphorus	(mg/l P)	0.014	0.040	0.14
Ammonia-Total	(mg/l N)	0.01	0.032	0.056
BOD - 5 days (Total)	(mg/l O2)	0.5	0.8	1.2
BOD(2d <5°C+5d incub. 20°C)	(mg/l O2)	0.5	1.4	3.4
Dissolved Oxygen	(% Saturation)	93.0	84.7	109.0
Dissolved Oxygen	(mg/l)	8.80	9.29	12.30
Suspended Solids	(mg/l)	2.0	3.4	7.0

7.2.3.2 Water Framework Directive

The Study Area is located within the Water Framework Directive (WFD) South Western River Basin District (SWRBD) and the management plan for this area was consulted. The main objectives of this management plan were to prevent deterioration, restore good status, reduce chemical pollution in surface waters and to achieve protected areas objectives. The programme of measures designed to achieve these objectives include the following:

- Control of urban waste water discharges;
- Control of unsewered waste water discharges;
- Control of agricultural sources of pollution;
- Water pricing policy;
- Sub-basin management plans and programmes of measures for the purpose of achieving environmental water quality objectives for Natura 2000 sites designated for the protection of Freshwater Pearl Mussel populations;
- Pollution reduction programmes for the purpose of achieving water quality standards for designated shellfish waters; and
- Control of environmental impacts from forestry.

Information on status, objectives and measures in the SWRBD has been compiled for smaller, more manageable geographical areas than river basin districts, termed water management unit action plans. There are twenty-eight water management units (WMUs) in the SWRBD. These units represent smaller river and lake basins where management of the pressures, investigations and measures will be focussed and refined during implementation of this plan. In addition, action plans focusing on groundwater and a transitional and coastal water management have been prepared for the SWRBD. WMU action plans are a key background document to the plan.

The Study Area is within the Lower Lee Owenboy Water Management Unit (WMU). There are 43 river water bodies in the Lower Lee Owenboy WMU –9 High, 9 Good, 11 Moderate and 14 Poor Status. The status of the various water bodies in this area is calculated using the EPA data, physicio chemical data and fish status data.

The status of the Lee in is described in the Lower Lee Owenboy WMU Action Plan (2010) as follows:

- 2001: Satisfactory apart from Innishcarra Bridge (0600) where again highly eutrophic. The protected pearl mussel has apparently become scarce in the river in the past two decades.
- 2005- Major disruption to fauna at first location, upstream of Gouganebarra Lake (0010), where salmonid parr and other age classes had been killed. The pH of the water was 10.66 on the day, outside the limit of tolerance for these fish, which resulted from concreting work on a small bridge

upstream of the sampling site. Further downstream the water quality status was the same as that of the previous survey with highly eutrophic conditions again recorded at Innishcarra Bridge (0600).

- 2008- Satisfactory apart from at Innishcarra Bridge where again poor ecological quality was recorded. 2009: Poor status dictated by Q score

The identified pressures/risks in this WMU Action Plan include the following:

- Nutrient Sources: Main source of TP is from unsewered industry (64%) and agriculture (26%). P
- Point Pressures: There are 24 Waste-water Treatment Plants (WwTP), 2 Water Treatment Plants (WTP), 21 Section 4 licenced facilities, 26 Integrated Pollution Prevention and Control (IPPC) licenced facilities and 1 contaminated site within the WMU.
- Quarries: There are14 quarries and 5 landfills within the WMU. 3 WB are at risk from quarries
- Agriculture: 39 water bodies have been determined to be at risk from agriculture within the WMU.
- On-site Water Treatment Systems (OSWTS): There are 15275 septic tanks in this WMU. 963 of these are located in areas of very high or extreme risk.
- Forestry: Significant area of SW_19_1910 is under forestry
- Morphology: There are 3 water bodies that have been determined to be at risk from morphology within the WMU. Water Regulation and Impoundments - Inniscarra Reservoir is a HMWB. (the local authority also note some drainage & channelisation of WB 19-1584 in the past particularly between Ballinhassig & Halfway when road was realigned, also some drainage upstream of Halfway in 2006)
- Abstractions: One water body has been determined to be at risk from abstractions within the WMU: SW_19_1663
- Other: Local authority note possible impact of Bride confluence with Lee upstream of Inniscarra Bridge due to different chemistry of river waters (19-1663)

The Gearagh, which is within the zone of influence of the proposed works, is within the Upper Lee WMU.

7.2.3.3 Water Framework Directive Operational Monitoring Data

Water quality monitoring, as required under the terms of the Water Framework Directive (WFD), is one of the functions of the Environment Section of Cork County Council and the water services department of Cork City Council. The most recent physico-chemical data from monitoring points within and close to the Study Area taken by Cork County Council from the River Lee are presented in Tables 7.6.

Table 7.6 Cork County Council Physico-chemical Monitoring Data for the River Lee

River Lee Surface Water Operational Monitoring Data, 2016					
Parameter	**Unit**	**River: Lee. Station name and reference: Innishcarra Br. RS19L030600**			
		13/05/2016	**08/07/2016**	**22/08/2016**	**07/10/2016**
Temperature	°C	9.5	18.7	16.4	17.4
Dissolved Oxygen	% Sat.	110	101	99	94
pH	pH units	7.6	8.1	8	8
Conductivity @20°C	µS/cm	162	182	184	178
True Colour	Hazen	28	15	15	13
Biochemical Oxygen	mg/l O_2	0.5	0.5	1.3	1.3
Total Hardness	mg/l $CaCO_3$	40	64	64	60
Alkalinity- total	mg/l $CaCO_3$		52	52	52
Ammonium	mg/l NH_4-N	0.028	0.035	0.027	0.02
Molybdate Reactive	mg/l P	0.005	0.005	0.005	0.005
Nitrate	mg/l NO3-N	2.1	1.5	1.3	1.3
Nitrite	mg/l N	0.005	0.01	0.012	0.011
Parameter	**Unit**	**River: Lee. Station name and reference: Leemount Br 19L030700**			
		13/05/2016	**08/07/2016**	**22/08/2016**	**07/10/2016**
Temperature	°C	9.4	18.2	15.6	-
Dissolved Oxygen	% Sat.	109	96	93	-
pH	pH units	7.7	8	7.8	8
Conductivity @25°C	µS/cm	154	192	201	188
True Colour	mg/litre Pt	27	12	14	12
Biochemical Oxygen	mg/l O_2	0.5	1	1	0.5
Total Hardness	mg/l $CaCO_3$	40	68	72	65
Alkalinity- total	mg/l $CaCO_3$	36	56	60	57
Ammonium	mg/l NH_4-N	0.028	0.04	0.022	0.01
Molybdate Reactive	mg/l P	0.005	0.005	0.005	0.005
Nitrate	mg/l NO3-N	1.4	1.4	1.5	1.1
Nitrite	mg/l N	0.006	0.012	0.009	0.009
Parameter	**Unit**	**River: Lee. Station name and reference: Bannow Br RS19S010500**			
		15/02/2016	**13/05/2016**	**13/05/2016**	**7/10/2016**
Temperature	°C	6.4	8.6		14.1
Dissolved Oxygen	% Sat.	99	98		100
pH	pH units	7.9	7.8		7.6
Conductivity @25°C	µS/cm	242	245		255
True Colour	mg/litre Pt	21	13		32
Biochemical Oxygen	mg/l O_2	0.5	0.5		0.5
Total Hardness	mg/l $CaCO_3$	104	90		90
Alkalinity- total	mg/l $CaCO_3$	58	59		54
Ammonium	mg/l NH_4-N	0.072	0.01		0.01
Molybdate Reactive	mg/l P	0.042	0.032		0.095
Nitrate	mg/l NO3-N	5.1	4.9		3.7
Nitrite	mg/l N	0.027	0.013		0.004

7.2.3.4 Results of Water Sampling

The invertebrate communities that were recorded at Site 1-3 were located on the main River Lee channel.

Site 1 and 3 were pollution tolerant and indicated slightly polluted (Q3-Q4) and moderately polluted (Q3) water. The invertebrate sample collected at Site 2 on the River Lee was diverse and contained a number of very clean water mayfly and stonefly species in indicated unpolluted water (Q4) at this site.

One of the sites sampled on the Curragheen River (Site 4) had a high invertebrate species diversity including good numbers of pollution intolerant mayfly and stonefly status and indicated water quality of good status (Q4). The second site sampled further downstream on the Curraheen (Site 5) was considered to be of moderate water quality status (Q3-Q4) as a result of the presence of pollution tolerant invertebrate species and low diversity and abundance of pollution intolerant invertebrate species.

No clean water invertebrate species were recorded at the two sites sampled on the Glasheen River (Site 6 and 7) and both samples were dominated by pollution tolerant species. Water quality was therefore considered to be of poor status (Q2-Q3) in the Glasheen.

The Glenamought was sampled at Site 8 and 9 and showed a god diversity of clean water species and had a rating of Q4. Further downstream on the River Bride (North) Sites 10 and 11 were on a more modified section of the river with signs of pollution and had Q values of Q3-Q4.

Currently the overall water quality on the River Lee main channel is achieving target Q4 good status as required under the Water Framework Directive at only one of the three sites surveyed on the River Lee (i.e. site 2). The remaining 2 sites surveyed (i.e. sites 1 and 3) are achieving slightly polluted (Q3-4) and moderately polluted (Q3) water respectively. As such both sites have moderate status and are not achieving the target Q4 good status water quality required under the Water Framework Directive. It is likely that diffuse agricultural enrichment in addition to waste water point sources are contributing to the localised declines in water quality of the River Lee. Future improvement in water quality may push longer longitudinal reaches of the river channel into the good status (Q4) category.

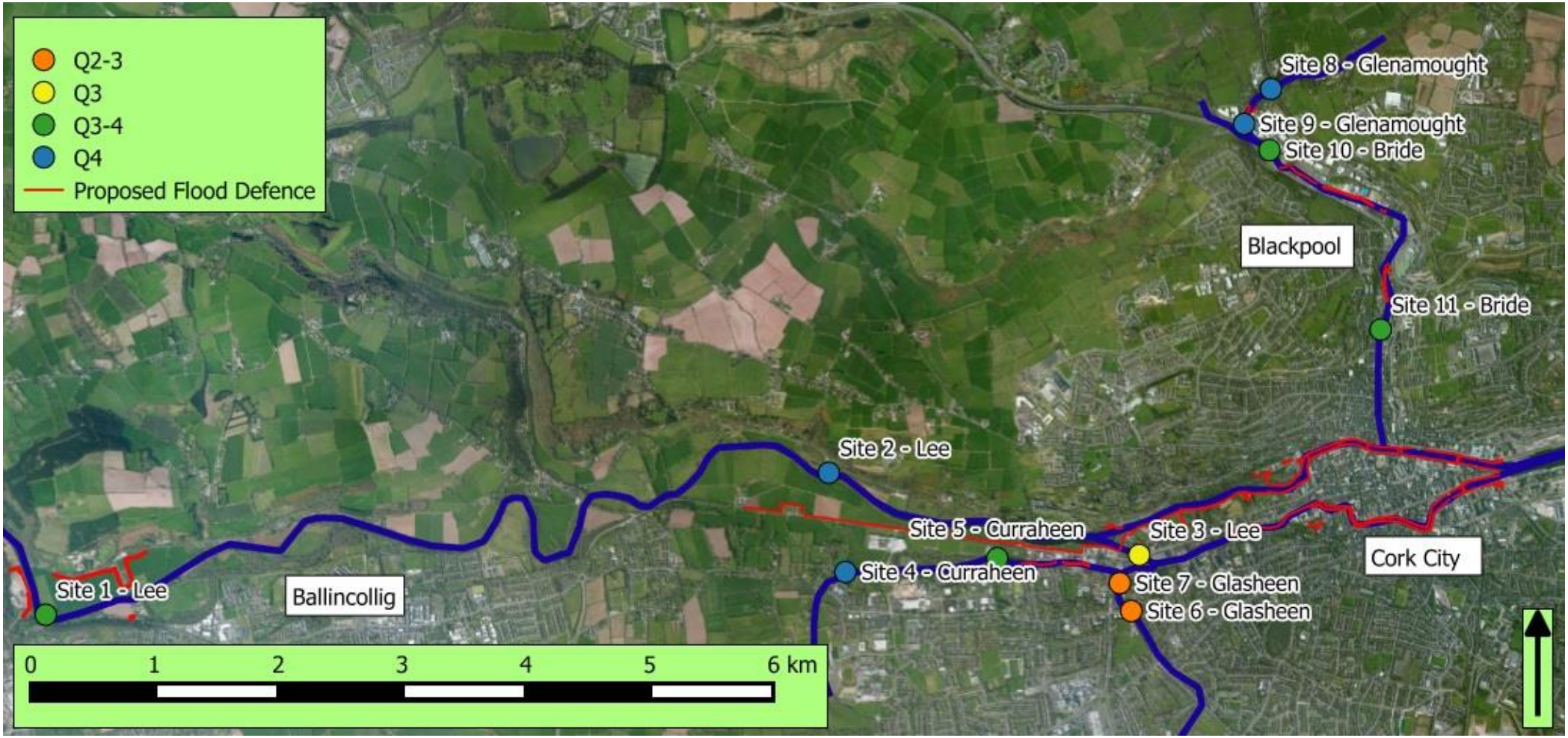

Figure 7.3 Q-Values determined for the River Lee and its Tributaries

7.2.3.5 Surface Water Abstraction

The Lee Road Water Treatment Plant is the main source of drinking water for Cork City (70%) with the remaining supplied for the Cork Harbour and City Scheme (30%). Surface water is abstracted from the River Lee for the Lee Road Plant and at Inniscarra Lake for the Cork Harbour and City Supply Scheme. There are no works proposed at Inniscarra Lake, the proposed management of the dam will not have an impact on the water supply. Work in proximity to Lee Road Water Treatment Plant consists of embankment and flood defence wall. None of these works will have an impact on the operation or the quality of water abstracted from the Lee at this location.

7.2.4 Impacts on Water Quality and Mitigation

As identified in Section 7.2.4.1 the Study area is located within the WDF South Western River Basin District. The main objectives of this management plan are to prevent deterioration, restore good status, reduce chemical pollution in surface waters and to achieve protected areas objectives. It. The following impact assessment and mitigation measures will ensure that the objectives of the Waters Framework Directive are not delayed or obstructed. Chapter 5 Flora and Fauna further details the ecological impact and mitigation for the scheme on the River Lee.

7.2.4.1 Generation of Silt-Laden Run-off & Increase in Suspended Solids

Short-term Moderate Negative Impact

The preparation phase, site clearance and preparatory groundworks including site compound set-up etc. will lead to exposure of bare ground and the potential for the generation of silt-laden run-off in works areas along the river bank. The potential for the generation of silt-laden surface run-off on the adjacent banks and along access and egress routes is likely to continue through the construction phase of the works and until the ground has consolidated. Stockpiled excavated material also poses an increased threat of increased siltation in the watercourse.

Excessive suspended sediment in the water column can clog and cause abrasions to fish gills, interfere with fish navigation and feeding, affect egg and fry development, while also affecting populations of aquatic invertebrates, on which the fishes' diet is based. Once deposited, excessive amounts of silt may damage fish habitat by clogging interstices between gravels in spawning grounds, resulting in diminished flow of oxygenated water to eggs and rendering these gravels unsuitable for egg incubation. Deposited sediment may also impact on the habitat of bottom dwelling aquatic invertebrates and damage nursery habitat for young fish (See also Chapter 5, Flora and Fauna).

Mitigation Measures

- Measures to minimise the suspension and transfer of sediment downstream will be implemented. These measures will include the use of silt barriers downstream of the works areas and removal of any accumulated silt, construction of silt sumps downstream of the works areas, cofferdamming and dewatering of works areas where concrete and other building works are proposed. Any stockpiling will also be further than 10 metres from the river bank.
- All works undertaken on the banks will be fully consolidated to prevent scour and run off of silt. Consolidation may include use of protective and biodegradable matting (coirmesh) on the banks and also the sowing of grass seed on bare soil.

- In river works will only be undertaken during normal working hours (8:00 – 6:00) thus allowing the river to run clean for 14 hours per day (with the exclusion of emergency works that may be required).
- An Environmental Management Plan (EMP) will be prepared prior to the commencement of any works in order to ensure all works are carried out in a manner designed to avoid and minimise any adverse impacts on the receiving environment.

Residual Impact - Temporary Slight Negative Impact

It is likely that, with mitigation measures in place this impact will constitute a **Temporary Slight Negative** Impact.

7.2.4.2 Use of Potential Water Contaminants

Potential Temporary Moderate to Significant Negative Impact

Numerous substances used on construction sites have the potential to pollute both ground and surface water if not properly managed and treated. Such substances include fuels, lubricants, cement, mortar, silt, soil and other substances which arise during construction. The washing of construction vehicles and equipment also poses a pollution risk to watercourses. The spillage or leaking of fuel or oil from fuel tanks or construction vehicles has the potential to contaminate soils, groundwater and surface water. Such substances entering the River Lee could damage the habitat of local populations of fish and aquatic invertebrates and also cause direct harm to aquatic fauna.

Mitigation Measures

- All concrete works will be carried out in dry conditions with no in-stream pouring of concrete.
- There will be no refuelling of machinery within the river channel. Refuelling will take place at designated locations at distances of greater than 30 metres from the watercourse.
- No vehicles will be left unattended when refuelling and a spill kit including an oil containment boom and absorbent pads will be on site at all times.
- Any fuel that is stored on the site will be in a double skinned, bunded container that will be located within a designated works compound at a location that is removed from the river. All other construction materials and plant will be stored in this compound. The compound will also house the site offices and portaloo toilets. This compound will either be located on ground that is not prone to flooding or will be surrounded by a protective earth bund to prevent inundation.
- All vehicles will be regularly maintained and checked for fuel and oil leaks.

Residual Impact – Neutral Impact

It is likely that with proper implementation of the above mitigation this impact will constitute a slight negative short term impact and a Neutral long-term Impact.

7.3 HYDROGEOLOGY

This section describes the existing hydrogeological environment within the Study Area and assesses the potential impacts of the Lower Lee (Cork city) Drainage Scheme.

7.3.1 Methodology

A desktop study was carried out in order to ascertain a comprehensive baseline for the Study Area and give a description of the existing environment. This information was then used in assessing the potential impact the proposed works will have on the hydrogeology within the Study Area.

The following documents were consulted during the preparation of this section:

- The Geology of South Cork (1994)
- The Geological Survey of Ireland (GSI) online database

7.3.2 Hydrogeology in the Existing Environment

The Geological Survey of Ireland (GSI) online database shows the Study Area as being underlain by Devonian Old red sandstone to the north of the River Lee with dinantian mudstone and sandstone and dinantian pure unbedded limestone to the south of the river. The site is locally important aquifer with bedrock which is moderately productive only in Local Zones. Groundwater flows though fractures, fissures or joints in the bedrock. The groundwater body is generally covered by till derived from its sandstone parent material. An extract from the GSI Online Database is provided.

The direction of groundwater flow is likely to be influenced by the topography of the surrounding area. Groundwater within the Study Area is more than likely hydraulically connected to the River Lee and its tributaries.

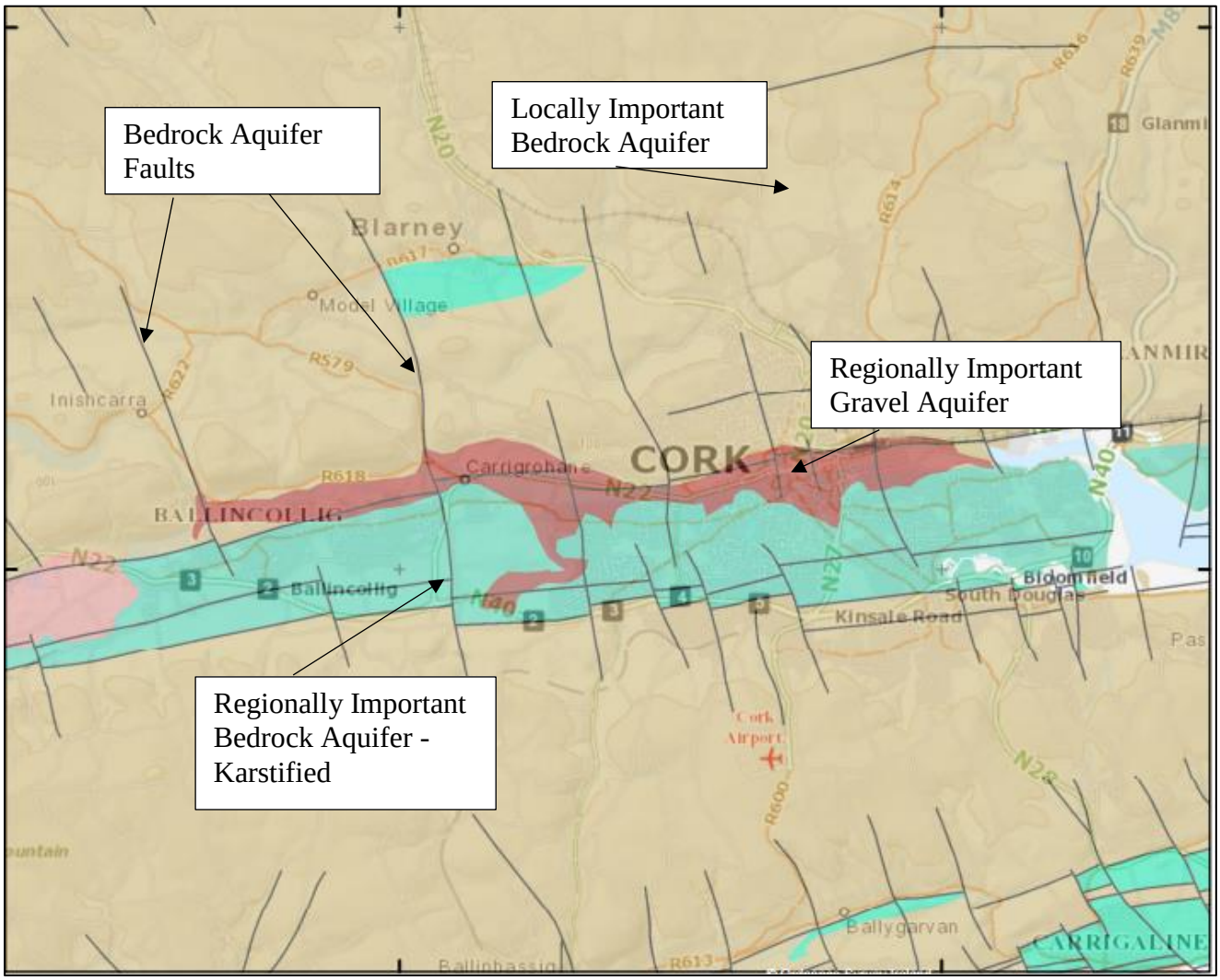

Figure 7.4 GSI Groundwater Resources (Aquafers) (www.gsi.ie)

7.3.2.1 Ground Water Vulnerability

Groundwater vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The Geological Survey of Ireland (GSI) online database was referenced regarding the vulnerability of the local aquifers to contamination from ground waters. The vulnerability mapping indicates that the local aquifers range from Moderate to high or extreme in places with pockets of Rock at or near the surface or Karst. An extract from the GSI Online Database is included below.

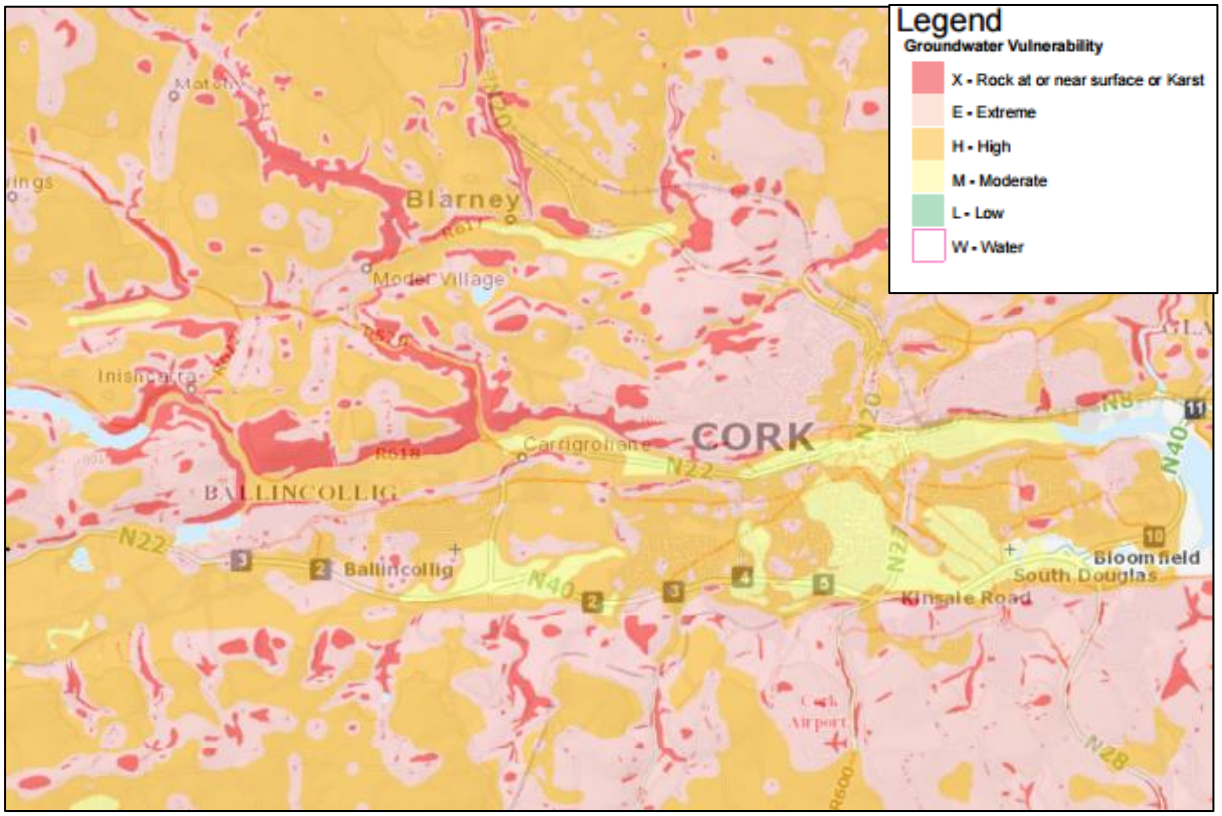

Figure 7.5 GSI Aquafer Vulnerability (www.gsi.ie)

7.3.2.2 Ground Water Abstractions and Wells

The well card data by the Geological Survey of Ireland (GSI) indicates that a number of wells along the route of the River Lee and the proposed works. The wells are located in or near a moderately productive gravel aquifer.

A list of abstractions for is provided in Table 7.7.

Table 7.7 GSI Well Card Data (Boreholes)

Townland	Depth (m)	Depth to Rock (m)	Source Use	Yield Class	Yield (m^3/day)
Cork	18.0	-	Unknown	-	-
Holy Trinity	42.7	10.4	-	-	-
Inchigaggin	-	-	Industrial use	Moderate	-
Carrigrohane	42.7	-	Agri use only	Good	109.0
Carrigrohane	8.8	0.9	Unknown	-	-
Carrigrohane	36.6	3.0	Unknown	Poor	16.4
Coolymurraghue	10.1	0.5	Other	Poor	32.7
Carrigrohane	6.0	-	Other	-	-
Carrigrohane	6.0	-	Other	-	-
Curraghbeg	25.9	3.7	Unknown	Poor	21.8
Curraghbeg	36.0	9.1	Unknown	Poor	21.8
Curraghbeg	2.7	2.7	Unknown	Poor	38.2
Garravagh	2.7	2.1	Unknown	Poor	21.8
Ballincollig	67.0	3.0	Domestic use only	Poor	7.6
Ballincollig	56.4	-	Domestic use only	Poor	32.7

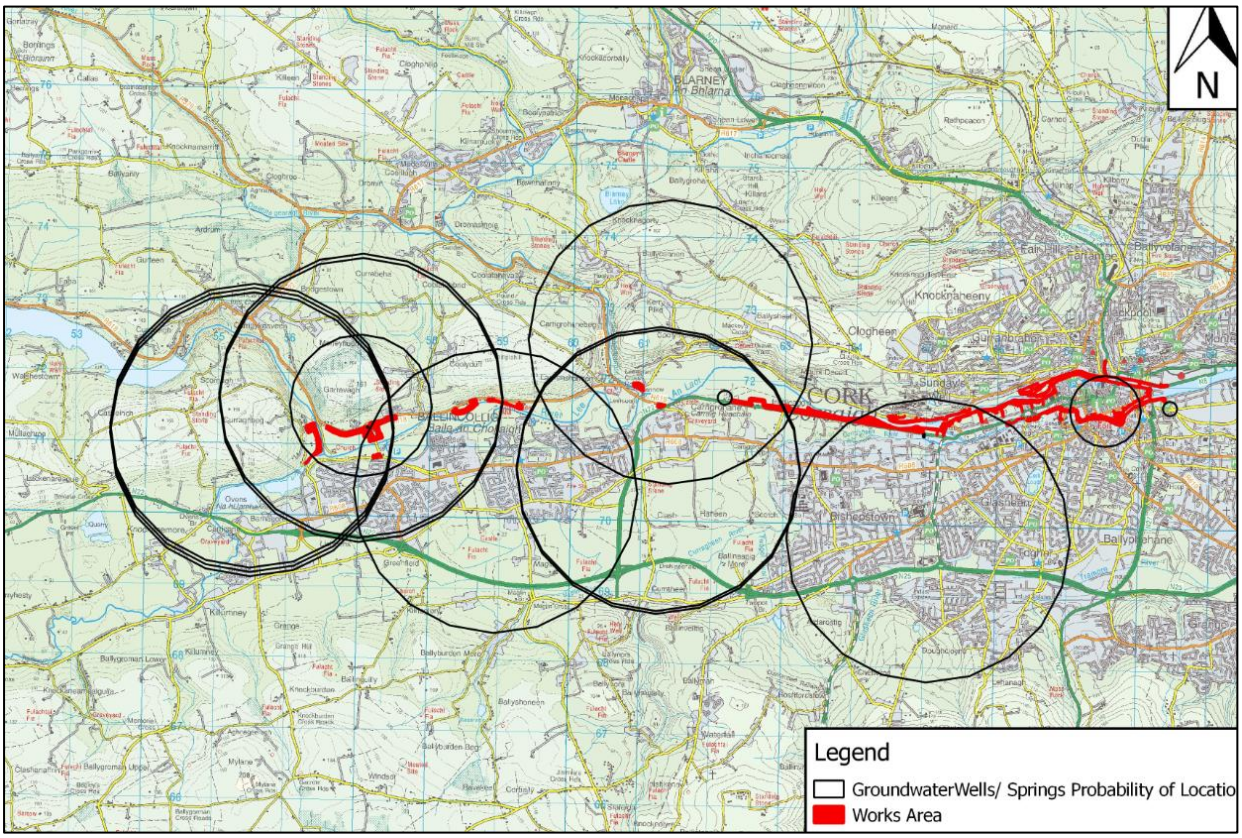

Figure 7.6 Well Locations

7.3.3 Potential Impacts on Hydrogeology

Potential Slight Negative Impact

There are numerous substances that will be used during the construction phase such as fuel, oil, lubricants, cement, silt, soil and other hydrocarbons which have the potential to pollute ground water. Washing of construction vehicles and machinery also poses a risk of polluting ground water. The impacts to hydrogeology as a result of the Lower Lee (Cork City) Drainage Scheme are temporary and significant. Any impacts associated with the scheme will occur during the construction or maintenance phase.

As set out in Section 7.3.2 above, the aquifers in the study area are classified as moderate to extremely vulnerable (and karstic) to infiltration. Should any of the above-mentioned substances contaminate the ground water in the study area then there is a risk to groundwater quality. However, the poor yields from wells and urban nature of the scheme suggests the importance of groundwater as a drinking source is limited. Never the less best practice construction measures will be put in place to ensure that the risk to ground water quality is limited and ground water quality will be maintained.

Mitigation Measures

A bunded area will be constructed within the site compound in order to avoid any polluting substances infiltrating the ground water during the construction and operation phase of the Scheme. All plant refuelling, maintenance and washing will be carried out within the bunded area. Spill kits will be available at the bunded area in order to ensure the quick and effective cleaning of any substances.

Site compounds will not be located in an area classified as 'highly' vulnerable to infiltration of ground water to further reduce the risk of pollution to the groundwater.

Residual Impact - Potential Negligible Impact

Taking into account the abovementioned mitigation measures, it is considered that the impact will constitute a Potential Negligible Impact.

7.4 FLOODING

This section describes the existing hydrological environment within the Study Area and potential impacts of the proposed works on flooding. Mitigation measures are also provided for any potentially significant impacts identified.

7.4.1 Methodology

A desktop study was carried out in order to obtain a baseline for the Study Area and provide a description of the existing environment. The information was then used to assess the potential impact the Scheme will have on the hydrology of the Study Area.

The following documents were consulted during the preparation of this section:

- Ryan Hanley, McCarthy Keville and O'Sullivan (2014) Lower Lee Flood Relief Scheme – Constraints Study;
- JBA Consulting Feasibility Study, Modelling Report
- The Office of Public Works (2010) Lower Lee Draft Catchment Flood Risk Management Plan.

7.4.2 Hydrology and Flooding in the Existing Environment

The dominant feature of the hydrology of the Study Area is the River Lee and its tributaries. The Lee catchment covers an area approximately 2,000km². The River rises in the mountains to the west of Cork and flows into Cork Harbour at Cork City. The Lower Lee catchment covers an area approximately 420km², extending downstream of Innishcarra Dam to Cork Harbour. The River Lee has developed wide flat floodplains lower down its courses. A large proportion of the catchment is made up of agricultural land, mainly used for pasture. Arable land use is prominent. Urban area covers approximately 6% of the land in the catchment with Cork City extending for approximately 8km.

7.4.2.1 Lower Lee Downstream of the Waterworks weir

The engineered Lower Lee forms a heavily modified bifurcated channel through Cork splitting at the Salmon weir, just downstream of the Waterworks Weir, and flowing as the North and South channels down to the Tivoli Docks Area. The character of the watercourses through Cork City is one of a stable, coarse gravel bed strongly indurated with fines filling the spaces between larger clasts with a low sediment supply. Ponding of river flows occurs frequently due to low weirs (functional at low tide) and tidal influences.

The Waterworks Weir and the Salmon Weir are strong influences on the watercourse, acting to split the flow along the North and South channels and impounding the watercourse for several hundred metres upstream.

7.4.2.2 Upstream of the Waterworks weir

Upstream of the Waterworks Weir, the channel is strongly ponded. Pool-riffle sequences develop further upstream, outside of the impounding influence, extending through Ballincollig where the main channel is joined from the north by the Shournagh River. The stretches of functioning pool-riffle-point bar morphology are interspersed between impacted reaches where impoundments have created extended ponded pool and glide biotopes.

There is a lack of fluvial sediment, linked to the trapping of sediment by the Carrigadrohid and Inniscarra Dam complex upstream. These structures have moderated the flow regime downstream releasing a controlled, relatively constant, base flow. There is little evidence of large scale lateral movement of the channel from the historic record and only limited bank erosion has occurred.

A geomorphological audit of the site has shown that the Lower Lee through Cork is presently an unreactive channel displaying revetted channel margins and a stable armoured bed. Fine sediment being delivered from upstream is generally at a low level and this material appears to be moving through the North and South channels rather than accumulating as bar deposits. Tidal fine sediment inputs are similarly very low. Presently there is little risk of increased sedimentation unless the fine and medium sediment supply from the Lower Lee upstream of the Shournagh River confluence increases significantly beyond the present transport capacity of the watercourse downstream. Alterations to the flow regulation regime at the Carrigadrohid and Innishcarra Dam complex upstream, particularly an increased frequency of flood releases, could change the sediment balance that exists at present.

There is a long history of flooding in Cork City and the River Lee valley. A number of severe floods have affected the city in the past. Since construction of the two dams at Inniscarra and Carrigadrohid in the 1950's, fluvial flooding in Cork has generally been less severe although there has been frequent flooding of land, roads and small numbers of properties. The event of November 2009 was an exception, with major damage caused to commercial and residential buildings in Cork City.

Tidal flooding in the east of Cork City centre is more frequent, with some flooding of the lowest lying parts occurring at least every other year with more significant tidal flooding occurring on average every ten years. Notable recent tidal floods occurred in 1994, 2004 and 2014.

7.4.2.3 Proposed Scheme in Terms of Flooding

The Lower Lee (Cork City) Drainage Scheme provides for the construction of flood defence walls and embankments, raising of bridge parapets and drainage works in Cork city. The flood defence works will increase the bank level at critical areas to reduce the risk of flooding.

The Flood Forecasting and Early Warning System has been put in place for fluvial flooding which will provide advance warning of rainfall event which have the potential to cause significant flooding and this allow for pre-emptive lower of levels in Carrigadrohid and Inniscarra Reservoirs to maximise available storage ahead of and during major flood events. A tidal flood forecasting system is already in place for Cork city.

The flood forecasting system will provide advance warning of rainfall/storm events and allow lowering of levels in Carrigadrohid and Inniscarra Reservoirs to maximise available storage ahead of and during major flood events. For the vast majority of time, outside of flood events, the ESB will continue to operate the dams at Carrigadrohid and Inniscarra as at present, primarily as a hydroelectric enterprise.

When a potentially significant event is detected by the forecasting system, the 'flood protocol' will be triggered and the reservoir levels can be safely drawn down to create storage in advance of the event. The greater discharge will result in flooding of washlands designated by the scheme.

7.4.3 Potential Impacts on Flooding

7.4.3.1 Impact on Flooding

Potential Permanent Significant Positive Impact

The Lower Lee (Cork City) Drainage Scheme raises the bank levels along the River Lee within Cork City. This reduces the risk of water levels overtopping the bank and flooding the surrounding area. Providing flood defence walls and embankments will reduce the risk of flooding to roads, businesses and private properties in Cork.

When a potentially significant event is detected by the forecasting system, the 'flood protocol' will be triggered.

This would advise the implementation of optimised procedures developed as part of the flood scheme that would suggest that reservoir levels be safely drawn down to create storage in advance of the event. This greater discharge will not result in the flooding of properties other than in washlands which are designated by the scheme, due to creation of downstream defences.

In creating washlands by pre-emptive advance spilling of water from the reservoirs at higher rates, 'artificial' or 'early' flooding of existing floodplains will occur. This will predominantly affect agricultural land to the west of the city. These lands will benefit from the scheme in terms of a reduction in the peak flows and thus magnitude of flooding from extreme events. However, as a result of the pre-emptive spilling of higher flows from the dams, these lands will be subject to a greater frequency of lower or medium flooding events. In

addition, the proposed scheme will result in peak flows extending for a longer duration during a given flood event.

Overall the proposed project is considered significantly positive in terms of flooding.

7.4.3.2 Impact on Water Levels Upstream and Downstream of Proposed Works

Potential Negligible Impact

The construction of flood defence walls and embankments etc. will not significantly affect the water levels upstream and downstream of the proposed works during normal flow conditions.

At Inniscarra and Carrigadrohid the normal range of operating levels in the dams are not amended (i.e. outside of 'flood protocol' times, ESB will continue to operate as normal). Minimum and maximum reservoir levels and/or seasonal variations in same, have not be amended so as to avoid impacting existing environmental receptors/constraints such as levels in the Gearagh, water supply requirements, fish life etc. Dam safety rules are not impacted, i.e. once levels in the reservoirs exceed ESB's safety thresholds, dam safety takes precedence and greater discharges will occur. In this scenario, emergency procedures will be put in place and warnings will be issued to advise of flooding as a result of a design exceedance event. The maximum draw down rate limit at Carrigadrohid remains for road embankment safety reasons.

The impact of any dam operations as detailed above will have a negligible impact on water levels upstream and downstream of the proposed works.

7.4.3.3 Residual Impacts

Overall, there will be a positive impact on Flooding as a result of the scheme.