10.0 WATER QUALITY & AQUATIC BIODIVERSITY

10.1 INTRODUCTION

The abundant supplies of surface and groundwater within Ireland dictate the importance of measures to protect the aquatic environment. This section outlines the aquatic environment currently present in the area and assesses the impact of the proposed development.

This section should be read in conjunction with the site layout plans for the proposed development and the project description sections of the EIAR. Risks to the aquatic environment were considered during the design of the proposed development and mitigation measures have been proposed where feasible.

10.2 LEGISLATIVE FRAMEWORK AND PLANNING POLICY

10.2.1 LEGISLATIVE CONTEXT

The main legislation pertaining to aquatic biodiversity and nature conservation in Ireland is briefly outlined below.

The Local Government (Water Pollution) Act, 1977, as Amended

This Act provides for the control of water pollution, by prohibiting the discharge of un-licenced polluting matter into waters.

European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I. 272 of 2009)

The regulations give statutory effect to Directive 2008/105/EC and provide legal status to quality objectives for all surface waters and environmental quality standards for pollutants. The regulations allow for the classification of surface waters by the Environmental Protection Agency (EPA) in accordance with the ecological objectives approach of the Water Framework Directive. The regulations also provide for the establishment of inventories of priority substances by the EPA and the preparation of pollution reduction plans.

The Fisheries (Consolidation) Act, 1959, as Amended

The Act prohibits the entry of polluting substances into waters which have the potential to adversely impact upon fish, prohibits the obstruction of passage of certain fish species and provides legal protection to the spawn/fry of eels, salmon and trout, in addition to their spawning or nursery grounds.

Fisheries (Amendment) Act, 1999

This Act outlines the responsibilities of the Regional Fisheries Board to ensure the protection and conservation of fish and their habitats within its area of jurisdiction.

European Communities (Quality of Salmonid Waters) Regulations, 1988 (S.I. 293 of 1988)

These regulations give statutory effect to Directive 78/659/EEC. The regulations designate salmonid waters, specify the quality standards for designated salmonid waters and outline the monitoring requirements.

Water Framework Directive (2000/60/EC)

The Water Framework Directive (WFD) aims to improve the water environment (including groundwater, rivers, lakes, estuaries and coastal waters) of E.U. Member States. The aim of the WFD is for Member States to achieve and maintain "good status" in all water bodies.

The Wildlife Act, 1976 and Wildlife (Amendment) Act, 2000

The Wildlife Act is the primary piece of Irish legislation providing for the protection and conservation of wildlife. Under the Amendment Act of 2000, the scope was broadened to include freshwater aquatic species, including the majority of fish. The Act provides for the control of specific activities which could adversely affect wildlife. Under the Wildlife Act, all bird species, 22 other fauna species and 86 flora species in Ireland are afforded protected status. The Wildlife Act, 1976 allows for the designation of specific areas of ecological value such as Statutory Nature Reserves and Refuges for Fauna. The Wildlife (Amendment) Act, 2000 provides for greater protection and conservation of wildlife and also provides for the designation and statutory protection of Natural Heritage Areas (NHA).

European Communities (Birds and Natural Habitats) Regulations, 2011 (S.I. 477 of 2011)

These regulations transpose the European Council Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and Flora (known as the "Habitats Directive") and the European Council Directive 2009/147/EC on the Conservation of Wild Birds (known as the "Birds Directive") into Irish Law. The regulations provide for the designation and protection of Natura 2000 sites comprising of Special Areas of Conservation (SAC) and Special Protection Areas (SPA). The regulations safeguard the SAC and SPA sites from developments with the potential to significantly impact upon them. Under the Habitats Directive, a number of Annex I habitats are aquatic habitats, while Annex II species include Atlantic salmon, white-clawed crayfish and the three species (Brook, River and Sea) lamprey.

The Flora (Protection) Order, 2015 (S.I. 356 of 2015)

This order provides statutory protection to flora listed in Section 21 of the Wildlife Act, 1976 and Wildlife (Amendment) Act, 2000. Under the Order, it is illegal to wilfully cut, uproot or damage the listed species or interfere in any way with their habitats. The Flora (Protection) Order includes aquatic species such Opposite-leaved Pondweed (*Groenlandia densa*) and Short-leaved Water-Starwort (*Callitriche truncata*).

Planning and Development Regulations, 2001 to 2018

These regulations transpose the requirements of Directive 2014/52/EU (and previous Directive 2011/52/EU) on the assessment of the effects of certain projects on the environment into planning law. Under these regulations, development plans must include mandatory objectives for the conservation of natural heritage and for the conservation of European sites.

10.2.2 PLANNING POLICIES

Regional Policies

The Regional Planning Guidelines (RPGs) for the Midland Region 2010-2022, which includes the counties of Laois, Offaly, Westmeath and Longford, outlines the long-term spatial planning strategy for the area. As part of the guidelines, a number of policies relating to aquatic biodiversity and relevant to the proposed development were outlined, as per Table 10.1 below.

Table 10.1: Regional Policies Relevant to Aquatic Biodiversity and the Proposed Development

STRATEGIC POLICY REFERENCE	POLICY
EP 5	Conserve and enhance the nature conservation resources of the waterways throughout the Midland Region, including the Shannon and Lough Ree.
EP 12	Promote the protection, conservation and enhancement of the region's biodiversity and natural and geological heritage. This includes wildlife (flora and fauna), Species protected under the Wildlife Acts and listed for strict protection on Annex IV of the Habitats Directive; and Wildlife corridors and stepping stones as envisaged under Article 10 of the Habitats Directive, habitats, sites with no statutory protection, proposed National Heritage Areas, landscapes and/or landscape features of importance to wildlife or which play a key role in the conservation and management of natural resources such as water.
EP 13	Facilitate the protection of sites designated in National and European legislation, and in other relevant International Conventions, Agreements and Processes. This includes sites designated or proposed to be designated as: Ramsar sites, Special Areas of Conservation, Special Protection Areas, National Heritage Areas, nature reserves, and refuges for flora or fauna.

Local Policies and Objectives

Local planning policies and objectives are detailed in the Offaly County Development Plan, 2014-2020. Policies and objectives relating to aquatic biodiversity and relevant to the proposed development are outlined in Table 10.2.

Table 10.2: Local Policies and Objectives Relevant to Aquatic Biodiversity and the Proposed Development

POLICY / OBJECTIVE REFERENCE	POLICY / OBJECTIVE
WSP-17	It is Council policy to limit and manage the permitted stormwater run-off from all new developments. The maximum permitted surface water outflow from any new development is to be restricted to that of a Greenfield site before any development took place unless otherwise agreed by the Environment & Water Services Section of Offaly County Council…

POLICY / OBJECTIVE REFERENCE	POLICY / OBJECTIVE
WSO-03	It is an objective of the Council to promote and comply with all environmental standards and objectives established for bodies of surface water, by the European Communities (Surface Waters) Regulations 2009 and to meet the requirements of the Water Framework Directive and River Basin District Management Plans' Programme of Measures.
EnvP-02	It is Council policy to comply with the provisions of the EU Water Framework Directive in order to fulfil obligations relating to water quality in the county and to implement the provisions of the River Basin Management Plans... To this end, the Council will continue to co-operate with other statutory authorities / agencies and stakeholders in the preparation and implementation of existing water quality monitoring and management plans and also implementation of River Basin District Management Plans. In the assessment of development proposals due regard shall be given to the requirements of the plans.
EnvP-24	It is policy of the Council that all planning applications whether for new development or redevelopment are required to make an assessment of the suitability of the proposed development for the incorporation of sustainable drainage systems and provide accordingly on site. All development sites will require the following: • The drainage system to be designed to accommodate all storm events up to and including the 1% AEP (1 in 100 year) event, with an appropriate allowance for climate change • A hierarchical approach should be applied to the SuDS used, in order of priority… • A hierarchical approach should be applied to the disposal of surface water from the site referencing in order of priority… • Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions… • Exceedance design measures to be applied to ensure that extreme events above the design standards of the system do not pose adverse impacts. A sequential approach should be applied to the site layout to specifically set aside appropriate location for SuDS. • SuDS should be designed for the lifetime of the development, with suitable provisions for likely future permitted and minor development.
EnvO-02	It is an objective of the Council to promote and comply with the Environmental standards and objectives established for: (i) Bodies of Surface water, by EC (Surface Water Regulations) 2009 and (ii) Groundwater, by the EC (Groundwater) Regulations 2010, of which standards and objectives are included in the River Basin Management Plans.
EnvO-03	It is an objective of the Council to Protect and preserve the quality of surface water, ground water and drinking water in the county through the relevant legislative provisions.
EnvO-07	It is an objective of the Council to protect the county's waters from pollution.
EnvO-08	It is an objective of the Council to issue and monitor, where appropriate, effluent licences for discharges to sewers and waterbodies.

POLICY / OBJECTIVE REFERENCE	POLICY / OBJECTIVE
NHP-01	It is Council policy to prohibit any development that would be harmful to or that would result in a significant deterioration of habitats and/or disturbance of species in a Special Protection Area (SPA), Special Area of Conservation (SAC) and candidate Special Area of Conservation (cSAC), Natural Heritage Area (NHA) and Proposed Natural Heritage Area (pNHA)…
NHP-02	It is the policy of the Council to ensure an Appropriate Assessment in accordance with Article 6(3) and Article 6(4) of the Habitats Directive, and in accordance with the Department of Environment, Heritage and Local Government Appropriate Assessment of Plans and Projects in Ireland – Guidance for Planning Authorities, 2009 and relevant EPA and European Commission guidance documents, is carried out in respect of any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect on a European site(s), either individually or in combination with other plans or projects, in view of the site's conservation objectives.
NHP-04	It is Council policy to ensure that development proposals are screened to determine whether they are likely to have a significant direct, indirect or cumulative effect on the integrity or conservation objectives of any European Site and, where significant effects are likely or uncertain, there will be a requirement for consultation with the relevant environmental authorities as part of any Habitats Directive Assessment that may be required.
NHP-08	It is Council policy to protect, conserve and enhance the county's biodiversity and natural heritage including wildlife (flora and fauna), habitats, landscapes and/or landscape features of importance to wildlife or which play a key role in the conservation and management of natural resources such as water.
NHP-11	It is Council policy to conserve, protect and enhance where possible wildlife habitats such as rivers, streams, canals, lakes, and associated wetlands including reed-beds and swamps, ponds, springs, bogs, fens, trees, woodlands and scrub, hedgerows and other boundary types such as stone walls and ditches which occur outside of designated areas providing a network of habitats and corridors essential for wildlife to flourish.
NHP-13	It is Council policy to protect riparian corridors by reserving land along their banks for ecological corridors and maintain them free from inappropriate development, where appropriate clear span structures will be promoted where fisheries exist, and culverting and/or realignment of streams will be discouraged…
NHP-24	It is Council policy to protect, conserve and enhance the county's biodiversity and natural heritage including wildlife (flora and fauna), habitats, landscapes and / or landscape features of importance to wildlife or which play a key role in the conservation and management of natural resources such as water.
NHO-01	It is an objective of the Council to ensure that any development proposal in the vicinity of, or affecting a designated site, complies with the provisions relating Appropriate Assessment and SEA requirements and the Council will consult with the appropriate statutory environmental authority in this regard.
NHO-02	It is an objective of the Council to conserve and protect the natural heritage of the county and to conserve and protect European and National designated sites within the county including Special Protection Areas (SPAs), Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSACs), Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs), Ramsar Sites, Statutory Nature Reserves, Biogenetic Reserves and Wildfowl Sanctuaries.
NHO-03	It is an objective of the Council to protect, conserve and enhance the county's biodiversity and natural heritage and the principle of enhancement will be taken into account in the Development Management process. It is a particular objective to protect plants, animal species and habitats which have been identified by the Habitats Directive, Birds Directive, Wildlife Act and the Flora Protection Order.

10.3 METHODOLOGY

This chapter has been prepared in accordance with the following guidelines from the Environmental Protection Agency (EPA):

- Environmental Protection Agency (EPA). Guidelines on Information to be contained in Environmental Impact Statements (EPA, 2002).
- EPA (2017). Guidelines on the Information to be contained in Environmental Impact Assessment Reports, Draft 2017.

This section has been prepared following a desktop review, the undertaking of an assimilative capacity study, a field assessment by Mr. Martin O'Looney on the 24th September 2018 and a review of the Natura Impact Statement Report prepared for the proposed development following the outline of the NPWS Guidance document (DoEHLG, 2009) (Document Ref. PES_NIS_19_9201).

The objectives of the ecological assessment were as follows:

- To undertake a comprehensive desktop review of the aquatic habitats and species, in particular the Feeghroe Stream, within the vicinity of the proposed development;
- To assess the current water quality status of the Feeghroe Stream;
- To undertake a field assessment of the proposed development site and surroundings in the context of aquatic ecology;
- To assess the impact from the proposed discharge of treated effluent to the Feeghroe Stream;
- To determine and assess the potential impacts of the proposed development on aquatic habitats, flora and fauna;
- To propose mitigation measures for both the construction and operational phases of the development to reduce potential impacts upon aquatic flora and fauna.

10.3.1 DESKTOP REVIEW

The desktop review comprised gathering information pertaining to the Shannon and Rapemills watercourses and catchments, reviewing mapping sites and determining if notable aquatic species, including protected, rare or invasive, had previously been recorded for the watercourses in the vicinity of the proposed development. The desktop review also served to provide supporting documentation for the assimilative capacity assessment.

10.3.2 ASSIMILATIVE CAPACITY

An assimilative capacity assessment was conducted on the Feeghroe Stream to determine the risk of negative impacts from a potential future discharge of treated effluent from the Banagher facility.

For the purposes of this assessment, a candidate discharge location to the west of the facility (E203696, N213595) was used as this is the closest point of the Feeghroe Stream to the site.

Other tributaries in the vicinity of the Rapemills River, and the Rapemills River, itself were considered as part of scoping for this assessment, the Feeghroe Stream was chosen due to practicality.

The assimilative capacity assessment was used to predict the Feeghroe Stream's ability to accommodate a treated effluent discharge of BOD_5, COD, Orthophosphate, Nitrogen, Total Ammonia and Suspended Solids. The assessment concluded that proposed discharge would not, in and of itself, cause to Feeghroe Stream to fail to achieve good status. The assimilative capacity assessment is included as part of the planning application for this development (Document Ref. PES_AC_19_9201).

10.3.3 FIELD ASSESSMENT

A field assessment was undertaken on the 24th September 2018 by Mr. Martin O'Looney, BSc. of Panther Environmental Solutions Limited to examine the ecological context of the proposed development. This comprised a walkover of the proposed development at the Banagher Chilling Ltd site and the surrounding area, including the Feeghroe Stream and Rapemills River.

This included an assessment of the watercourses in the vicinity of the site and any associated aquatic flora and fauna.

10.4 CHARACTERISTICS OF THE EXISTING & PROPOSED DEVELOPMENT

The existing facility at Meenwaun was originally developed as an abattoir by the Lynch family in the 1990s and was acquired by Banagher Chilling Limited in 2018. The remainder of the site comprising of agricultural land, is located in the townland of Boheradurrow. The site is approximately 19.6 hectares in size and includes buildings, hardstanding areas, car parking areas, and seven agricultural fields.

The existing abattoir development is comprised of the following:

- Main building housing the slaughter hall, boning hall, cold room, loading area and amenities (including offices, locker rooms, kitchen and toilets);
- Lairage and holding pen areas;
- Offal skip shed;
- Septic tank and percolation area servicing staff facilities;
- Surface water tank;
- Wastewater treatment system, comprising of inlet sump and storage sump;
- Lorry-wash.

The proposed development would comprise of the refurbishment and extension of the existing abattoir on the site, to allow a maximum cattle slaughter rate of 140 per day. To achieve this, the existing slaughter line would be modified and lengthened within the existing abattoir building. The existing abattoir building would be extended to provide for additional cattle chills, processing rooms, waste-out rooms, offices and staff facilities, in addition to the

construction of a meat cutting, packing, blast freezing and cold storage facility with an output of approximately 40 tonnes per day.

Other facilities to be constructed would include the associated plant rooms, packaging storage, electrical sub-station, water treatment system and wastewater treatment plant (WWTP). The existing lairage would also be extended, and the livestock yard increased in size.

A detailed description of the development is provided in Section 2.0 of this EIAR report.

Run-off from "dirty" yard areas, process waters and sewage from staff welfare facilities would be directed to the site's new WWTP.

A discharge to surface water is included in the proposed development for this application for planning consent. A wastewater treatment plant would be constructed, comprising of primary, biological and tertiary treatment stages. The proposed effluent plant would discharge to an integrated constructed wetland (ICW) system, which would discharge to a manhole and the Feeghroe Stream.

Stormwater from clean-yard areas and car parking areas would pass through a silt trap and Class 1 By-Pass Separator before being directed to a modular underground attenuation system. From here, the stormwater would be pumped to the final manhole prior to discharge to the Feeghroe Stream.

The proposed effluent treatment process has been designed with the potential for a future discharge to surface water in mind. It should be noted that any such discharge in the future would be subject to an application for a Section 4 (discharge to waters) licence to Offaly County Council.

The proposed final treated effluent quality parameters are included in Table 10.3 below.

Table 10.3: Proposed Final Effluent Quality discharging to the Feeghroe Stream

PARAMETER	UNITS	PROPOSED DISCHARGE
Volume Flow	M^3/Day	250
pH	pH Units	6 - 9
BOD_5	mg/l O_2	5
COD	mg/l O_2	50
Orthophosphate	mg/l PO_4-P	0.2
Nitrogen	mg/l N	5
Total Ammonia	mg/l N	0.4
Suspended Solids	mg/l SS	20

An Assimilative Capacity Assessment (Reference: PES_AC_19_9201) has been prepared as part of the design of the proposed wastewater treatment process for the site, and is submitted as part of this planning application.

The following table summarises the existing background quality of the watercourse, the legislated limits and surface-water objectives downstream of the proposed discharge location, the proposed final effluent quality from the facility and the resultant concentration within the Feeghroe Stream at 95%ile (low flow) conditions due to a proposed discharge at 250 M^3/day.

Table 10.4: Assimilative Capacity of proposed discharge to the Feeghroe Stream

Parameter	Units	Background Quality	Legislated Quality	Proposed Discharge Quality	Predicted Levels Post Discharge (mg/l)	% Headroom Utilised
BOD_5	mg/l O_2	2.3	2.6	5.0	3.0	243.3%
Orthophosphate	mg/l PO_4-P	0.010	0.075	0.2	0.056	71.1%
Total Ammonia	mg/l N	0.43	0.14	0.4	0.43	N/A
Un-ionised Ammonia	*mg/l NH_3-N*	*0.0067*	*0.0164*	*0.0063*	*0.0066*	*-1.1%*

**Unionised ammonia concentration calculated at average monitored pH 7.7 and 15°C.*

10.5 DESCRIPTION OF EXISTING ENVIRONMENT

The proposed abattoir extension is located in the townland of Meenwaun, approximately 2.4km south-east of Banagher and 8.0km north-west of Birr, Co. Offaly. The remainder of the site comprising of agricultural land, is located in the townland of Boheradurrow. The approximate Irish National Grid (ING) reference for the site is 204143E, 213196N.

Figure 10.1: Proposed Site Location

The site is located in a rural, farming area predominantly comprised of pastureland, hedgerows and peatland. Arable fields and wooded areas can also be found scattered around

the landscape. Residential development in the area is predominantly linearly aligned along the existing road network. A number of large farmsteads, as well as some commercial developments, are located within the area.

The nearest national road to the site is the N62, which connects Athlone to Thurles. The site is accessed via the L3010, a local road linking to the R438 road. The R438 road connects to the N65 National Primary Road some 21.5km to the south-west and N62 National Primary Road some 7.0km to the north-east.

The topography surrounding the site is gently undulating between low points of around 48m AOD and a number of local highpoints of over 53m AOD. The existing facility is located between 48-50m AOD. Levels fall to under 33m AOD along the course of the local Rapemills and Shannon Rivers.

The Feeghroe Stream travels along the site's western boundary, which connects to the River Shannon via the Rapemills River. The River Shannon flows in a south-westerly direction and is located, at its closest, 4.4 km north-west of the site. Throughout the site, there are several culverts to allow livestock/farm machinery pass over the drainage ditches to access each field. The current onsite drainage network is outlined in Figure 10.2 below.

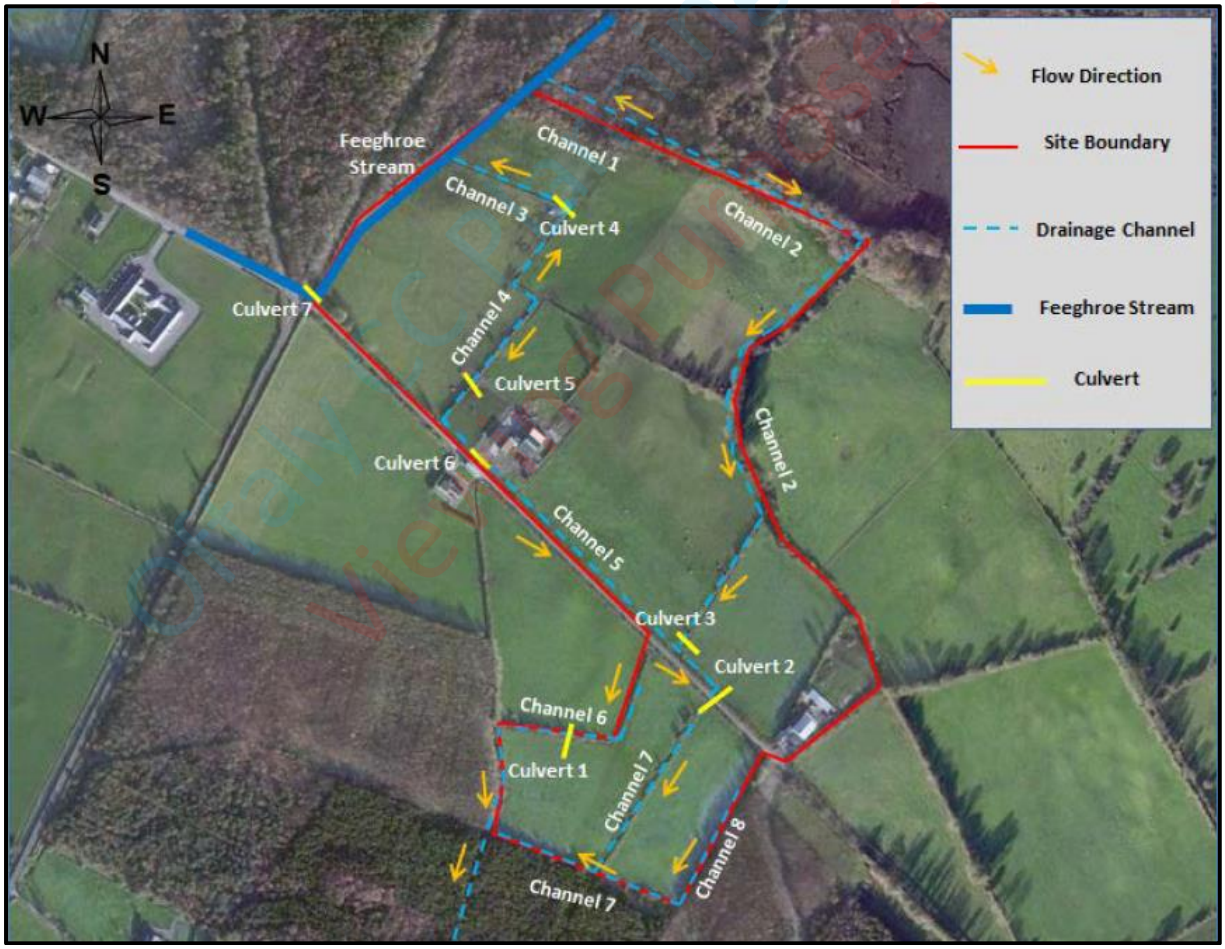

Figure 10.2: Existing site drainage network

10.5.1 WATER QUALITY

Feeghroe Stream (25F41)

The proposed development would involve works in the vicinity the Feeghroe River (EPA Code 25F41). This area is located within the Lower Shannon River catchment (25B_1) (EPA Code 25S01), in the Rapemills River sub-catchment (Sub-catchment Shannon[Lower]_SC_040 or RAPEMILLS_020) (EPA Code 25R01).

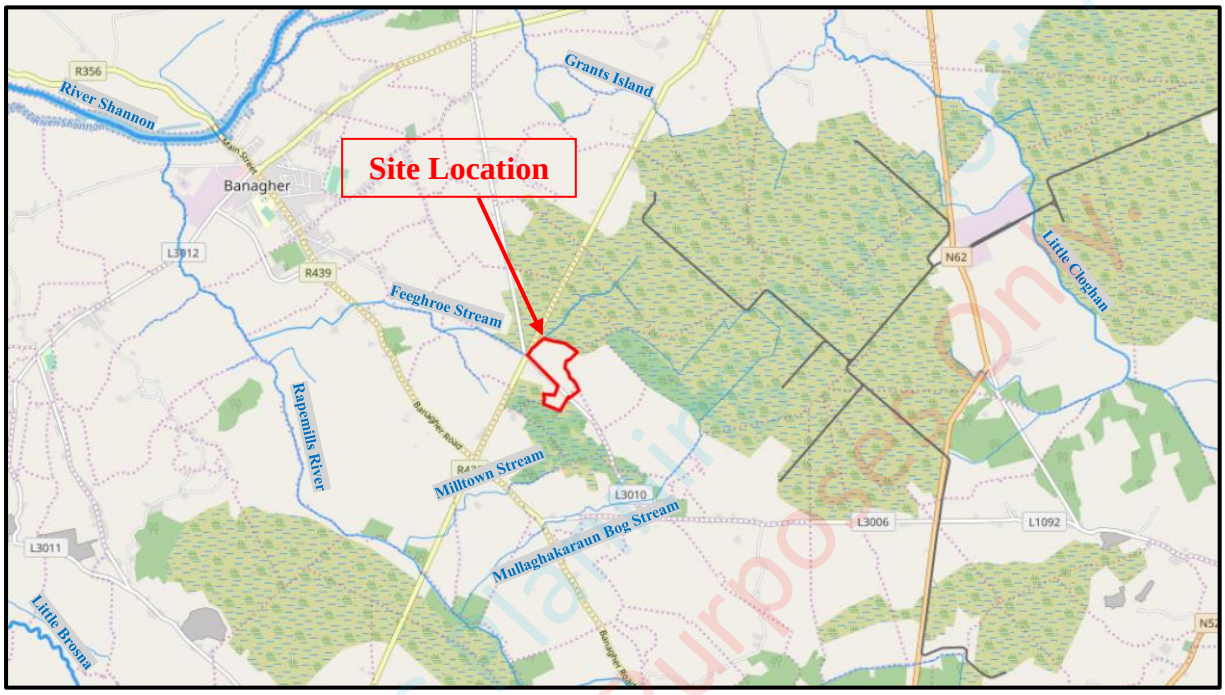

Figure 10.3: Watercourses within the vicinity of the site

The Feeghroe Stream rises just north of the site in Mullaghakaraun Bog, approximately 1.5km upstream of the proposed discharge point. The stream flows approximately west to north-west for approximately 3.25km to its confluence with the Rapemills River. The confluence with the Rapemills occurs approximately 2.5km upstream of the River Shannon.

There are no currently licenced discharges to the Feeghroe Stream.

Physico Chemical Status – Feeghroe Stream

There are no EPA monitoring stations located on the Feeghroe Stream.

As part of the assimilative capacity assessment, three water samples were taken on the 24th of September 2018, the 22nd of October 2018 and the 30th of October 2018 at the proposed discharge point on the Feeghroe Stream. The average results of monitoring on the Feeghroe Stream have been used to represent the typical water quality of the watercourse and are included in Table 10.5 below.

Table 10.5: Background Water Quality Values for the Feeghroe Stream

PARAMETER	UNIT	AVERAGE RESULTS 24/09/2018 – 30/10/2018	SURFACE WATERS OBJECTIVES REGULATIONS (SI 272 OF 2009)
BOD_5	mg/l O_2	2.3	2.6
COD	mg/l O_2	85.0	-
Orthophosphate	mg/l PO_4-P	0.010	0.075
Total Nitrogen	mg/l N	3.67	-
Total Ammonia	mg/l N	**0.43**	0.14
Unionised Ammonia	*mg/l NH_3-N*	*0.007**	-
Suspended Solids	mg/l SS	4.5	-

**Unionised ammonia concentration calculated at average monitored pH 7.7 and 15°C.*

Given the current Total Ammonia concentration of 0.43 mg/l N, the Feeghroe Stream would be classified as being of "*moderate status*".

The Feeghroe Stream is currently not achieving "good status" due to the high levels of Total Ammonia present. As the majority of the receiving waters for this stream derive from Mullaghakaraun Bog, it is considered likely that concentrations of Nitrogen and Total Ammonia may be naturally elevated above water quality limits.

The Water Framework Directive risk status of the Feeghroe Stream, as part of the Lower Rapemills River, is currently under review (accessed at https://www.catchments.ie/maps/ on 24/04/2019). However, the Upper Rapemills Stream and stretches of the River Shannon downstream of the Rapemills River are classified as "not at risk".

Macroinvertebrate Status – Feeghroe Stream

The Feeghroe Stream, which flows along the north-western site boundary of the site, would be classified as depositing / lowland rivers (FW2) habitat as per Fossitt's "*A Guide to Habitats in Ireland*", (Fossitt, 2000). Substrate was comprised of mud and particularly leaf detritus. There was little to no aquatic vegetation within the stream itself.

Kick samples of macroinvertebrates were collected from Feeghroe Stream in the vicinity of the proposed discharge location. The macroinvertebrate community within the Feeghroe were found to be composed of pollution tolerant species, typical of slow flowing waters in first order streams and arterial drainage.

The *Gammarus duebeni* and *Asellus aquaticus* were numerous within the community, and were the most represented species. The caseless caddisfly *Polycentropus sp*. and the beetles Elminthidae and Dytiscidae were present in fair numbers. Segmented worms, Tubificidae and Hydracarina were also present in small numbers.

The macroinvertebrate status of the Feeghroe Stream was rated as Q2 (*bad status*), due to the absence of Group A and Group B pollution intolerant species. The Small Streams Risk Score (SSRS) determined that the site would be considered "*at risk of not achieving good status*".

Rapemills River (25R01)

The Rapemills River rises in bogland north-east of the townland of Ballymaddock, Co. Offaly, approximately 5 kilometres north of Kinnitty. The river flows for approximately 22.5 km to the confluence with the Feeghroe Stream, and continues for approximately 2.5 km to the confluence with the River Shannon.

Table 10.6: EPA Monitoring Points on the Rapemills River

STATION NO.	STATION LOCATION	NATIONAL X	NATIONAL Y	APPROX. LOCATION RELATIVE TO CONFLUENCE
0500	RAPEMILLS – Lusmagh Br	200175	214603	c. 1.25 km d/s
0400	RAPEMILLS – Br SW of Taylors X Rds	202696	211284	c. 3.4 km u/s
0300	Br at Rapemills	204818	210194	c. 6.25 km u/s
0200	RAPEMILLS – Boolinarig Br	207614	209296	c. 9.5 km u/s
0100	RAPEMILLS – Br nr Eglish Castle	210068	209618	c. 12.4 km u/s

Source: http://www.epa.ie/qvalue/webusers/PDFS/HA25.pdf?Submit=Get+Results

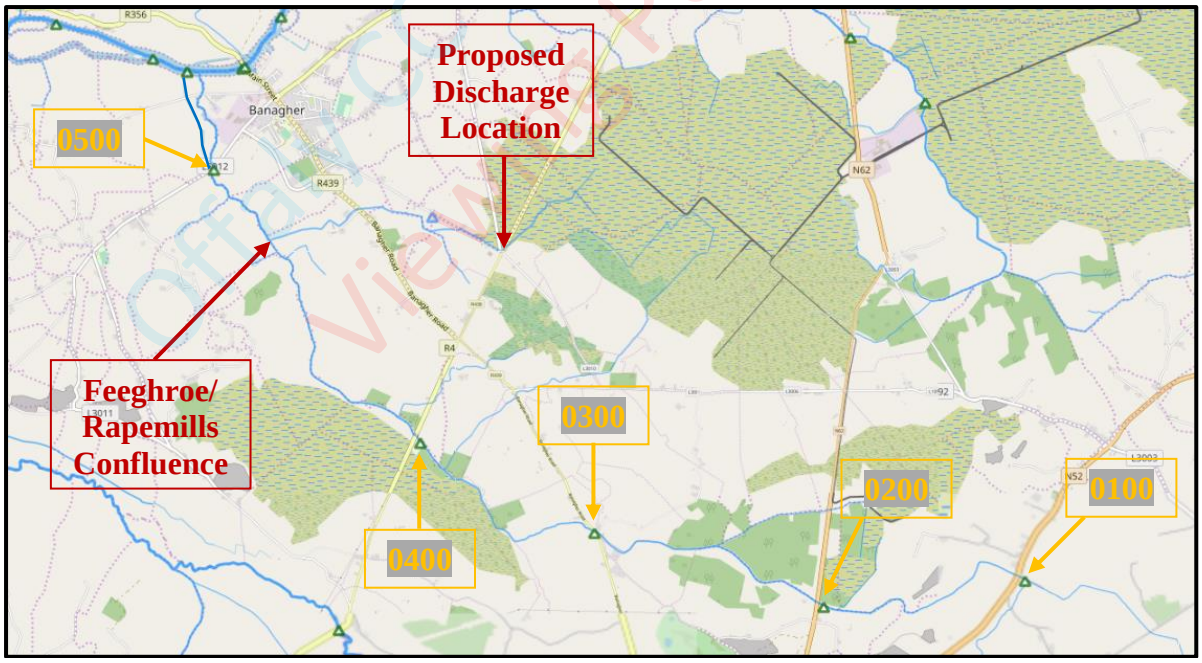

Figure 10.4: Rapemills River EPA monitoring locations

It should be noted that path of the Rapemills River was redirected downstream of Lusmagh Br, and the discharge to the River Shannon as redirected to approximately 200m downstream of the pre-existing location, as shown in Figure 10.4 above.

There is a historic Section 4 discharge licence to the Rapemills River at the confluence with the Feeghroe Stream [E 200850, N 213730]. Midlands Malting Company Ltd / Minch Malting Ltd (Greencore Ltd) closed at this site in 2005.

Banagher Precast Concrete Ltd hold a Section 4 discharge licence (Discharge Licence: WP/W9/10) with Offaly County Council [E 200200, N 215115]. This discharge is to the old Rapemills River route, which discharges to the River Shannon upstream of the current confluence.

Table 10.7: EPA Ecological Monitoring of the Rapemills River (1984 – 2017)

REF.	BIOLOGICAL QUALITY RATING (Q VALUES)					
0100	4	4	-	-	-	-
0200	4	4	-	-	-	-
0300	4-5	4-5	3-4	4	4	3-4
0400	4	4-5	-	-	-	-
0500	4-5	3-4	-	-	-	-
Year	**1984**	**1987**	**2008**	**2011**	**2014**	**2017**

As can be seen in the above table, the quality of the Rapemills River upstream of the confluence with the Feeghroe Stream has varied from a "*moderate status*" to "*good status*" since 2008.

Reporting by the EPA on river quality assessments of the Rapemills River (accessed at http://www.epa.ie/QValue/webusers/ on 24/04/2019) stated "*The macroinvertebrate fauna indicated an unwelcome decline to moderate ecological conditions on the Rapemills stream (0300) when surveyed in 2017. Enhanced filamentous algal growth observed was indicative of some enrichment.*"

The Water Framework Directive risk status of the Lower Rapemills River, is currently under review (accessed at https://www.catchments.ie/maps/ on 24/04/2019). The Upper Rapemills Stream and stretches of the River Shannon downstream of the Rapemills River are classified as "not at risk".

Shannon River (River Code: 25S01)

The River Shannon is the longest river in Ireland at approximately 360.5km. It drains the Shannon River Basin, which has an area of 16,865km2, which equates to one-fifth of the area of Ireland.

The river flows generally southwards from the Shannon Pot in County Cavan before turning west and emptying into the Atlantic Ocean via the 102.1 km long Shannon Estuary.

Further Q-Value information is available for the six EPA monitoring points located along the section of the Lower Shannon River within the vicinity of the tributary point with the Rapemills River. The stations and locations relative to the tributary point are included in Table 10.8 below, with the Q-Value results summarised in Table 10.9.

Table 10.8: EPA Monitoring Points on the River Shannon Lower

STATION NO.	STATION LOCATION	NATIONAL X	NATIONAL Y	APPROX. LOCATION RELATIVE TO TRIBUTARY POINT
2010	Shannon (Lower) – 0.8km d/s Banagher Br(LHS)	199853	215797	c. 60m u/s
2030	Shannon (Lower) – 2.5km d/s Banagher Br (RHS)	198254	216377	c. 1.6 km d/s
2050	Shannon (Lower) – 4km d/s Banagher Br	197010	215895	c. 3.3Km d/s
2060	Incherky Quay (d/s Banagher)	195270	214307	c. 5.8Km d/s
2110	Shannon (Lower) – Meelick- d/s L Brosna R confl	193367	212289	c. 9.1Km d/s
2300	Shannon (Lower) – Killaloe Br (RHS)	187343	204881	c. 19.6Km d/s

Source: http://www.epa.ie/qvalue/webusers/PDFS/HA25.pdf?Submit=Get+Results

The main environmental pressures within the catchment were identified as agriculture and urban waste water according to the WFD Cycle 2 – Lower Shannon – Sub Catchment Shannon [Lower]-SC-40 Assessment Report (EPA, 2018).

The Banagher Agglomeration Wastewater Treatment Plant (Discharge Licence: D0141-01) [E 200200, N 215350]. The agglomeration is served by a wastewater treatment plant with a Plant Capacity PE of 2,500. The treatment process includes preliminary treatment (screening and grit removal) and secondary treatment (oxidation ditch with settlement chamber). Banagher UWWTP discharges to the River Shannon [E 200015, N 215725], approximately 225 metres upstream of the Rapemills-Shannon confluence and just upstream of the old Rapemills-Shannon confluence.

Figure 10.5: Lower River Shannon EPA monitoring locations

Table 10.9: EPA Ecological Monitoring of the Lower River Shannon (1972 – 2017)

REF.	BIOLOGICAL QUALITY RATING (Q VALUES)														
1960	-	-	4.5	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	-	4.5	-	-	-	-	-	-	-	-	-	-	-	-
2030	-	4.5	4	-	-	-	-	-	-	-	-	-	-	-	-
2050	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
2060	-	-	-	-	-	-	-	-	-	3.5	4	-	4	-	3.5
2110	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
2300	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Year	**72**	**76**	**84**	**87**	**90**	**93**	**96**	**99**	**02**	**08**	**11**	**12**	**14**	**15**	**17**

As can be seen in the above table, the quality of the River Shannon downstream of the confluence with the Rapemills River has varied from a "*moderate status*" to "*good status*" since 2008.

The Lower River Shannon was classified as being of "*moderate status*" in the last round of monitoring in 2017.

The Lower River Shannon has been classified as being "*not at risk of failing to achieve good status*" downstream of Banagher. However, the risk status of the watercourse between station 2060 and Lough Derg is currently under review (accessed at https://www.catchments.ie/maps/ on 24/04/2019).

10.5.2 DRINKING WATER ABSTRACTION POINTS

A Drinking Water Risk Assessment has been prepared as part of the planning application documentation (Reference: PES_DWRA_19_9201)

The Banagher Water Treatment Works river water abstraction (2500PUB1001) [E 200864, N 216181] is located upstream of the Rapemills-Shannon confluence, and also is supplied by a groundwater abstraction [E 202850, N214030] located <0.5km from the boundary of the proposed site.

The Portumna Water Treatment Works (1200PUB1042) is located downstream of the Rapemills-Shannon confluence in Lough Derg [E 185210, N 203730]. The abstraction point is located approximately 30km downstream of the proposed discharge location.

This abstraction point serves the Portumna agglomeration, providing in the region of 1,100 M^3/day of drinking water. The following map details the locations of the proposed discharge point in relation to the Portumna Water Abstraction Point.

Figure 10.6: Drinking Water Supply Abstraction Locations

10.5.3 ECOLOGICAL VALUE

The Feeghroe Stream and majority of the Rapemills River are not designated for the protection of habitats or species.

A Natura Impact Statement (Reference: PES_NIS_19_9201) has been prepared in support of the planning application for the proposed development, and considered the potential impacts upon protected sites within 2km and 15 km radius of the proposed site. The SAC and SPA sites considered to be within the potential zone of influence of the proposed development were;

- All Saints Bog and Esker SAC (Site Code: 000566);
- River Shannon Callows SAC (Site Code: 000216);
- Redwood Bog SAC (Site Code: 002353);
- All Saints Bog SPA (Site Code: 004103);
- Middle Shannon Callows SPA (Site Code: 004096);
- River Little Brosna Callows SPA (Site Code: 004086);
- Dovegrove Callows SPA (Site Code: 004137) and
- River Suck Callows SPA (Site Code: 004097)

due to hydrological connectivity / potential hydrological connectivity, distances from the proposed development site and / or the potential for ex-situ impacts of the development upon wintering wildfowl.

The closest of these, and most likely to be at risk of potential impacts, are;

- All Saints Bog and Esker SAC (Site Code: 000566),
- All Saints Bog SPA (Site Code: 004103),
- River Shannon Callows SAC (Site Code: 000216), and
- Middle Shannon Callows SPA (Site Code: 004096),

The All Saints Bog and Esker Special Area of Conservation (SAC code: 000556) is located approximately 2.3km south of the proposed site, and is bordered to the north by the Rapemills River. This site is also designated as a Special Protection Area (SPA code: 004103). This site is located upstream of proposed discharges from Banagher Chilling Ltd.

The Shannon River Callows Special Area of Conservation (SAC code: 000216) is located approximately 3.2km west of the proposed site, and includes the lower c.1.75km of the Rapemills River prior to entering the River Shannon. The SAC includes the protected Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae) [91E0] habitat and *Lutra lutra* (Otter) [1355] species.

This Middle Shannon Callows site is also designated as a Special Protection Area (SPA code: 004096). The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Whooper Swan, Wigeon, Corncrake, Golden Plover, Lapwing, Black-tailed Godwit and Black-Headed Gull. It is also of special conservation interest for holding an assemblage of over 20,000 wintering waterbirds. The site also supports a nationally important breeding population of Corncrake.

The Shannon River is not designated as a salmonid water under the European Commission (Quality of Salmonid Waters) Regulations, 1988.

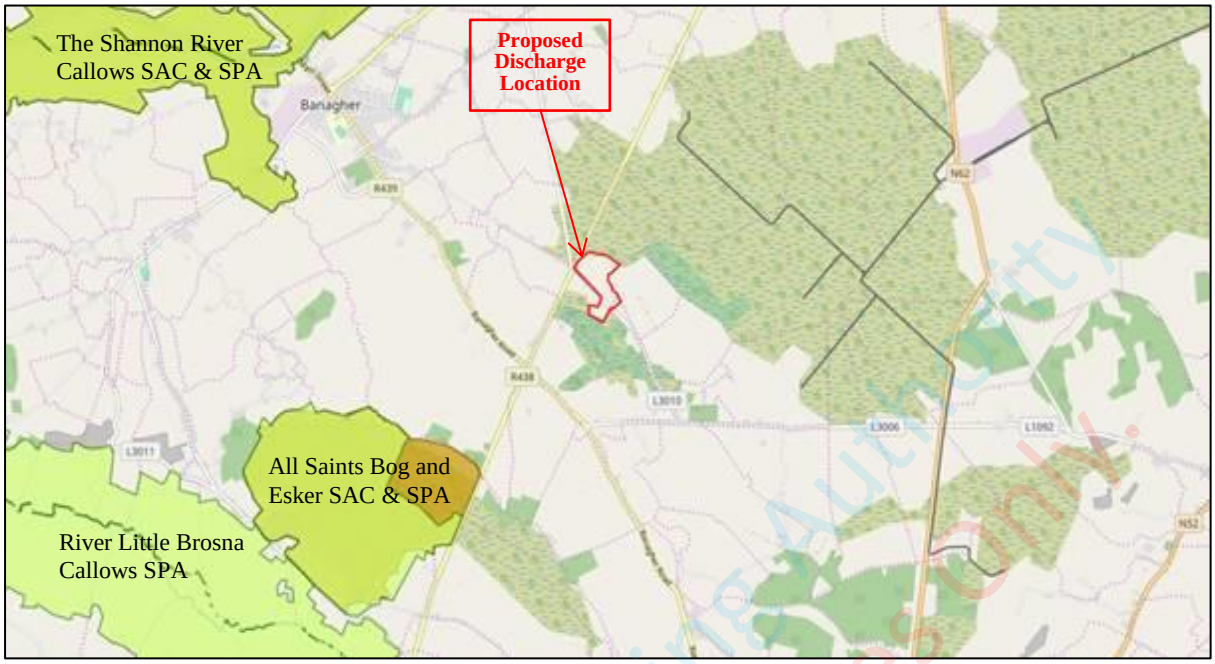

Figure 10.7: Designated Habitat and Species Protection Sites Map

The ecological value of the aquatic habitat types and species potentially at the proposed development site have been assessed following the criteria outlined in the National Roads Authority (NRA) guidelines (2009). Tables 10.10 and 10.11 below detail the habitats recorded and potential species, and their associated ecological value.

Table 10.10: Ecological Value of Aquatic Habitats of the Proposed Development

AQUATIC HABITAT	HABITAT RATING	KEY ECOLOGICAL RECEPTOR?
Depositing / lowland rivers (FW2)	Local importance, higher value	Yes. Joins with the River Shannon Callows SAC and Middle Shannon Callows SPA approximately 4km downstream of the site.
Drainage ditches (FW4)	Local importance, lower value	No. Mainly small in extent with limited volume. Low ecological value.

Table 10.11: Ecological Value of Species of the Proposed Development

SPECIES	SPECIES RATING	KEY ECOLOGICAL RECEPTOR?
Atlantic Salmon (1106)	Local importance, low value	No. Not recorded within the vicinity of the proposed site. Little Brosna River has a population of introduced salmon from the ESB Parteen Salmon hatchery. Ardnacurisha and the Parteen weir present a significant barrier to wild populations.
Freshwater pearl mussel (1029)	Local importance, lower value	No. Proposed development and local catchment is outside of the recorded range and distribution for this species.
White Clawed crayfish (1092)	Local importance, lower value	Yes. There are no records of crayfish within the tributaries of the Rapemills and the tributary habitats are unfavourable. However, the Rapemills main channel would be within the recorded range and distribution of the species.
Brook lamprey (1096)	Local importance, lower value	Yes. There are no records of brook lamprey within the tributaries of the Rapemills and the tributary habitats are unfavourable. However, the Rapemills main channel would be within the recorded range and distribution of the species. Adults may be present in silt deposits in the main Rapemills channel, however, gravel substrate for spawning sites in local tributaries appears to be rare.
River lamprey (1099)	Local importance, low value	No. There are no records of river lamprey within the tributaries of the Rapemills and the tributary habitats are unfavourable. However, the Rapemills main channel would be within the recorded range and distribution of the species. Ardnacurisha and the Parteen weir present a significant barrier to migration, and the species is unlikely to be present.
Sea lamprey (1095)	Local importance, low value	No. Proposed development and local catchment is outside of the recorded range and distribution for this species. The species migration is also impacted by barriers on the Shannon.

10.5.4 FISHERY VALUE

The river Shannon is predominantly a Brown Trout and coarse fishery upstream of the Ardnacrusha Power Station and the Parteen Weir. Limited numbers of Atlantic salmon pass these barriers, supplemented by an ESB scheme for the restocking of the River Shannon with juvenile salmon produced at the Parteen Salmon hatchery. Salmon fishing is generally found in tributaries of the lower reaches of the Shannon catchment.

ESB fisheries studies for West Offaly Power Station (WOP) in 2016 and 2017, found perch, roach, bream, roach-bream hybrids, eel, pike, gudgeon and trout in the sampled sites along the River Shannon near WOP, Shannonbridge (approximately 11 km upstream of the

Rapemills – Shannon confluence). No juvenile or adult salmon were recorded at any sampling site (ESBI & Aquatic Services Unit, 2018).

This is consistent with the findings of IFI as part of the WFD fish assessments carried out in 2010 and also in 2016. The overwhelming numerical dominance of cyprinid fish, as well as the greater diversity of this group at WOP, indicates that the main channel of the Shannon at this location can be classified as a cyprinid water (ESBI & Aquatic Services Unit, 2018).

As part of its restocking campaign on the River Shannon, the ESB carry out electrofishing and genetic surveys to monitor the performance of hatchery reared planted stock, and to assess naturally spawned juvenile salmon in the Shannon catchment.

Monitoring was conducted at three locations on the Rapemills River during the 2013 round of monitoring.

Table 10.12: ESB electrical fishing surveys of the Rapemills sub-catchment (ESB, 2013)

	m2	Min-1			
Site Name	**Area fished**	**Time fished**	**No. Trout**	**No. Salmon**	**Other Species**
Boolinarig Bridge	37.02	8	9	0	none
Rapemills Bridge	162.03	19	68	0	none
Lusmagh Bridge	137.28	9	9	0	Eel, stoneloach, minnow, stickleback, gudgeon
Average	112.1m2	12 min-1	Total = 86	Total = 0	

The report summarised the Rapemills catchment as follows; *"The Rapemills River: No salmon were found at any sites but the habitat was very poor being almost exclusively a deep drained canal-like channel. The exception to this was the Rapemills bridge site which was undrained for a short distance."* (ESB, 2013)

As part of baseline assessments undertaken by Fehily Timoney and Company in completion of an EIAR for the Meenwaun Wind Farm, electrofishing surveys were undertaken on tributaries of the Rapemills River.

Electrofishing was carried out on the Milltown and Mullaghakaraun Streams, located east of the Feeghroe Stream. The assessment found no fish present in either of the streams, and it was noted that this indicated the low value of these habitats for fish. The tributaries in the survey area were noted to be unsuitable with regard to salmon spawning considering the lack of gravel substrates, poor aeration, sluggish flows and degree of siltation.

As noted in section 10.5.1 above, the substrates within the Feeghroe stream were found to be composed predominantly of mud and detritus. It is considered that the Feeghroe Stream would also be of low habitat value for salmon. It is also noted that high ammonia levels would indicate a poor habitat.

The Feeghroe Stream may be of Local Importance (low value) with respect to fish, due to the poor habitat and water quality for salmonids. The Rapemills River has been rated as being of Local Importance (higher value) with respect to salmonids as it is likely to support populations of brown trout.

10.6 POTENTIAL IMPACTS OF THE PROPOSED DEVELOPMENT

The following sections detail the potential impact from the proposed development upon the water quality, habitats and species within the aquatic environment. Mitigation measures recommended to alleviate potential impacts are presented in Section 10.7.

10.6.1 WATER QUALITY IMPACTS

10.6.1.1 – Water Quality – Construction Impacts

The proposed site includes several surface water drains surrounding the site, which connect within the Feeghroe and Rapemills catchments. Proposed works include alterations to existing structures onsite and development works on green field areas to include building extensions, outbuildings, internal roadways any yards, the wastewater treatment compound, integrated constructed wetland (ICW), as well as provision of services.

During the construction phase, a deterioration in water quality could arise through the release of suspended solids during soil disturbance works and storage / landscaping, the release of uncured concrete and the accidental release of hydrocarbons (fuels and oils). Suspended solids could become entrained in surface water run-off and could affect aquatic habitats through reduction in water quality and deposition.

Surface waters in the vicinity of the site are also known to be gaining, with receiving water being composed of groundwater additions to varying degrees. Therefore, potential contamination of groundwaters also has the potential to impact upon the quality of nearby surface-waters.

An increase in sediments has the potential to impact upon fish, including Brown Trout and Brook Lamprey, by damaging gravel beds required for spawning, smothering fish eggs and in extreme cases, by interfering with the gills of fish. There is considered the be a low risk of such impacts occurring at this site as no such potential spawning habitats were noted during onsite surveys.

An increase in suspended solids has the potential to reduce water clarity, which can impact the light penetration of water and may also affect certain behaviours of aquatic fauna such as foraging success. Aquatic flora and fauna could also be impacted upon by an increase in nutrients which are bound to suspended solids. A significant increase in nutrients can result in eutrophication, leading to an increased risk of deoxygenation of waters and subsequent asphyxia of aquatic species.

In the event of uncured concrete entering a waterbody, the pH would be altered locally, potentially leading to the death of aquatic flora, fish and macroinvertebrates and alteration to the river substrate.

There is also a potential for releases of hydrocarbons from the operation of heavy construction plant and associated equipment. Hydrocarbons can affect water quality, potentially resulting in toxic and / or de-oxygenating conditions for aquatic flora and fauna.

During the construction phase, there would be a risk of a significant, negative and short term impact upon the water quality of nearby surface waters.

10.6.1.2 Water Quality –Operational Impacts

The primary potential impact upon the River Shannon catchment from the proposed development would be a deterioration in water quality arising from a discharge of treated effluent.

There would be no anticipated impacts upon the water quality of the Feeghroe Stream or the Rapemills and Shannon catchments due to stormwater discharges from the site. Stormwater from the proposed development would comprise of clean rainwater run-off from clean-yard areas and car parking areas, and would be directed to a silt trap and Class 1 By-Pass Separator before being directed to a modular underground attenuation system.

The BREF (2005) document for Slaughterhouses and Animals By-Products Industries note that the most significant environmental impact arising from slaughterhouses is the emissions to water. Generated wastewaters typically have a high organic strength owing to the high BOD (biochemical oxygen demand) and COD (chemical oxygen demand) properties of blood and animal by-products. Additionally, wastewaters from slaughtering facilities and meat processing facilities generally have a high suspended solids and nutrient content (phosphorous and nitrogen).

Organic pollution to rivers can occur when high organic wastewaters are insufficiently treated and discharged to waterbodies. When a high organic load enters a waterbody, the growth of bacteria and other micro-organisms increase significantly in response to the available food supply. The rapid break down of organic compounds by bacteria and micro-organisms results in the deoxygenation of the water. Where significant organic pollution takes place, the river can become uninhabitable for aquatic flora and fauna due to the lack of required oxygen.

Bacteria also break down the protein content of the wastewater into various nitrogen compounds including nitrate, nitrite, ammonia and ammonium. Depending on the concentration, these compounds can have further impacts upon water quality and aquatic flora and fauna. For example, the compound ammonia (NH_3) is considered toxic to freshwater fish at low concentrations (EPA, 2001).

Oils and fats from wastewaters can cause deoxygenation of waters due to the consumption of oxygen during bacterial breakdown and, in the instance of an oil film, by disrupting oxygen diffusion from the atmosphere to water.

An increase in suspended solids can affect aquatic habitats by reducing water clarity, affecting the light availability to flora and visibility required by fauna for feeding and other behaviour. Furthermore, an increase in suspended solids can have significant impacts upon fish by damaging spawning beds, smothering eggs and, in extreme cases, interfering with gills.

Aquatic flora and fauna could also be impacted upon by an increase in the nutrients nitrogen and phosphorous. A significant increase in nutrients (particularly phosphorous for freshwater bodies), could result in excessive eutrophication, whereby an increase in nutrients results in the significant growth of aquatic plants, particularly algae (EPA, 2015). As plant growth increases, oxygen depletion occurs due to increased photosynthesis and through the decomposition of plant organic material. The increase in plant growth can also limit the availability of sunlight.

The principal legislation governing the control of the ambient quality of surface waters under the Water Framework Directive is the European Communities Environmental Objectives (Surface Waters) Regulations [S.I. No. 272 of 2009] as amended. This legislation sets out legal limits for parameters of water quality in the form of thresholds for quality status; pristine, good, moderate, and poor. All waters are required to achieve at least "good status" within timeframes set under the regulations. Under the Surface Water Regulations classification system, a waterbody is classified based upon the lowest score attained for any of the determining parameters (River Waterbody: Q-rating, BOD, orthophosphate, ammonia, temperature, pH, heavy metals and priority substances).

The Feeghroe Stream is currently not achieving "good status" due to the high levels of Total Ammonia present. As the majority of the receiving waters for this stream derive from Mullaghakaraun Bog, it is considered likely that concentrations of Nitrogen and Total Ammonia may be naturally elevated above water quality limits.

The macroinvertebrate status of the Feeghroe Stream was rated as Q2 (bad status). The Small Streams Risk Score (SSRS) determined that the site would be considered "*at risk of not achieving good status*".

Following an assimilative capacity assessment of the Feeghroe Stream during 95%ile (low flow) conditions, as summarised in Table 10.4 above, it was concluded that the proposed discharge from the effluent treatment plant and ICW system would not, in and of itself, result in the Feeghroe Stream failing to achieve "good status". However, it is noted that existing monitored concentrations of BOD would be expected to moderately exceed "good status" post discharge.

As the existing monitored quality of the Feeghroe Stream appears to be naturally of physico-chemically "moderate status" or poorer, with a macroinvertebrate "bad status", it is considered that the proposed discharge would have a permanent and slight, negative impact upon the quality of the Feeghroe Stream.

The Feeghroe Stream discharges to the Rapemills River. The following table provides an estimation of the potential impact of the combined effluent discharge and Feeghroe Stream upon the Rapemills River water quality at 95%ile flow rates, following the methodology used in the Assimilative Capacity Report (Reference: PES_AC_19_9201). The background quality provided for the Rapemills River assumes identical water quality as the Feeghroe.

As can be seen in the following table, there would not be anticipated to cause a significant deviation in the existing water quality of the Rapemills River should the proposed development go ahead.

It is anticipated that the proposed discharge to the Feeghroe Stream would have a permanent and slight, negative impact upon the quality of the Rapemills River and catchment.

Table 10.13: Assimilative Capacity of the Rapemills River

Parameter	Units	Assumed Background Quality (based on Feeghroe)	Legislated Quality	Quality of Feeghroe + Proposed Discharge	Rise in Levels due to Discharge (mg/l)	Predicted Levels Post Discharge (mg/l)
BOD_5	mg/l O_2	2.3	2.6	3.0	0.03	2.4
Orthophosphate	mg/l PO_4-P	0.010	0.075	0.056	0.002	0.012
Total Ammonia	mg/l N	0.433	0.14	0.425	-0.0004	0.43
Un-ionised Ammonia	*mg/l NH_3-N*	*0.0067*	*0.0164*	*0.0066*	*-0.000007*	*0.0067*

**Unionised ammonia concentration calculated at average monitored pH 7.7 and 15°C.*

It is considered that operational risks to water quality would be mitigated through the proposed design of the effluent treatment process in view of the existing water quality of the Feeghroe Stream. Any trade discharge from the Banagher Chilling Limited facility would be required to be in compliance with a Local Authority Section 4 (Trade Effluent) Discharge Licence in agreement Offaly County Council.

There would also be a potential risk to surface water quality due to accidents and potential spills and leaks from chemicals and materials stored onsite during operation. The proposed development would be typical of abattoirs in Ireland, and aside from animal by-products, particularly animal slurry, the volumes of stored chemicals would be relatively low. However, shock loads would have the potential to significantly impact upon water quality.

There would be a risk of a major, negative and short term impact upon water quality within the Feeghroe and Rapemills watercourses as a result of potential accidents onsite.

10.6.1.3 Water Quality – Impacts to Drinking Water Abstractions

A deterioration in water quality may have the potential to adversely impact upon the quality of drinking water, particularly with regards microbial loading.

Discharges from slaughtering facilities have the potential to cause a microbial impact upon receiving waters due to the presence of total coliform, faecal coliform (including *Escherichia coli*) and streptococci groups of bacteria, in addition to parasites such as *Cryptosporidium parvum*. It has been estimated that densities of total and faecal coliforms and streptococci are in the order of several million colony forming units (cfu) per 100ml of wastewaters generated at slaughtering facilities (USEPA, 2004).

Sources of micro-organisms present within wastewaters at the Banagher Chilling facility include sanitary facilities for staff, blood and cleaning waters from the slaughter hall and dirty yard areas.

Total coliform, faecal coliform and streptococci groups of bacteria present in slaughtering facility wastewaters are primarily enteric in origin, coming from the intestinal tract of warm-blooded animals. The treatment of human waste arising from staff welfare facilities at the Banagher Chilling facility would also contribute to populations of enteric bacteria.

While these groups of bacteria are not generally considered as pathogenic, they can be used to indicate the possible presence of pathogenic enteric organisms, such as *Salmonella* ssp., *Campylobacter jejuni* and *Listeria monocytogenes*, gastrointestinal parasites including *Ascaris* sp., *Giardia lamblia*, and *Cryptosporidium parvum*, and enteric viruses (Mittal, 2004).

As enteric micro-organisms leave their optimal environmental conditions (intestinal tract of animals), their survivability would be impacted upon during the wastewater treatment process and discharge to surface water. For instance, studies undertaken on E. Coli have indicated that their survival in freshwater is adversely affected by the cooler temperatures, visible light and predation by endemic micro-organisms such as flagellates and ciliates (Wcislo and Chróst, 2000). While viruses can survive adverse conditions, they can only multiply within their hosts and are therefore limited in population once they enter the wastewater process.

A Drinking Water Risk Assessment has been prepared as part of this planning application (Reference: PES_DWRA_19_9201). The Drinking Water Risk Assessment has been based upon the methodology described in guidance documents published by the EPA, including the "*Drinking Water Regulations Guidance Booklet No.4*", and the "*Handbook on the Implementation of the Regulations for Water Service Authorities for Public Water Supplies*".

The Banagher Water Treatment Works river water abstraction (2500PUB1001) [E 200864, N 216181] is located upstream of the Rapemills-Shannon confluence, and would not be affected by the proposed discharge. Due to the nature of the area hydrology, streams are generally gaining and there is a low risk of impact from the proposed discharge to the Banagher WTW groundwater abstraction, located <0.5km from the boundary of the proposed site.

The Portumna Water Treatment Works (1200PUB1042) is located downstream of the Rapemills-Shannon confluence in Lough Derg [E 185210, N 203730]. The abstraction point is located approximately 30km downstream of the proposed discharge location.

As part of the proposed development, clarified effluent would be directed to a sand filtration system. While the sand filter serves to reduce the suspended solids in the final effluent, this would also reduce the microbial content of the wastewaters by filtering and retaining micro-organisms from the treated effluent. Sand filtration is estimated to remove enteric bacteria by over 90% with the World Health Organisation estimating that 99% of larger parasites and between 50-90% of enteric viruses are removed.

The effluent would then be passed through an integrated constructed wetland system, which removes solids due to filtration and sedimentation, and reduces pathogens through predation and natural die-off.

The Drinking Water Risk Assessment report concluded that the overall risk from the proposed discharge to the Banagher and Portumna water abstraction plants would be considered low. This conclusion was based upon the nature of generated wastewaters, proposed discharge limits, the wastewater treatment process, the level of dilution, nature of

the area hydrology, the quality of receiving water and the anticipated impact of discharges during normal and abnormal operations.

There would remain a risk of potential impacts due to accidental release and spills from the proposed site. However, as discussed in the drinking water risk assessment report, design and operation measures would substantially reduce this potential risk.

It is anticipated that there would be no significant impact upon the quality of drinking water at the Banagher and Portumna supply schemes as a result of the proposed development.

10.6.2 PROTECTED SITES (SAC & SPA) – AQUATIC ENVIRONMENT

Of the eight designated SAC and SPA sites considered to be within the potential zone of influence of the proposed development, three sites are located upstream of drainage from the site and are therefore not considered to be hydrologically connected: River Little Brosna Callows SPA, Dovegrove Callows SPA and River Suck Callows SPA.

It is not considered that the proposed development would have the potential to impact upon Redwood Bog SAC, given that this site is located a considerable distance (13.25km) downstream of the development site and given the considerable dilution of the site's drainage within the Feeghroe Stream, Rapemills River and River Shannon. Furthermore, Redwood Bog SAC is located approximately 100m inland from the River Shannon watercourse.

The proposed development would be hydrologically linked to the River Shannon Callows SAC and Middle Shannon Callows SPA, both of which are located approximately 4km downstream of the site. The proposed discharge to the Feeghroe Stream would be within the upstream catchment of the River Shannon.

As drainage from the site potentially flows to the Milltown Stream, the proposed development may also be hydrologically connected to All Saints Bog and Esker SAC and All Saints Bog SPA, located approximately 2.6km and 3.2km downstream of the development site respectively.

The principal vector for impacts upon designated European sites would be through changes in water quality arising from the proposed developments. Water quality changes could have the potential to have a negative impact upon food sources (such as fish species and vegetation) for qualifying interests.

Potential impacts upon water quality have been addressed in detail in section 10.6.1.

10.6.3 AQUATIC HABITATS

There would be a permanent loss of sections of aquatic habitat due to the culverting of section of site drainage and the development of land in sections where drainage occurs, particularly in the area of the ICW. The loss of internal site drains (FW4) would not be considered significant, due to the existing moderate to poor water quality and absence of spawning habitats. It is also noted that drainage channels are common in the area, and the volume of habitat loss would be minor. This would be considered a minor, permanent negative impact upon local habitats.

There would be no additional loss of aquatic habitats, following the construction phase of the development.

The proposed surface water drainage system would be designed to SUDS specifications, limiting storm runoff from the site to existing greenfield levels. Therefore, it is not considered that the proposed development would have a significant impact upon existing aquatic habitat through changes in the existing hydrological regime.

During the operational phase, potential long term changes to water quality would pose a risk of impacts upon habitats within the catchment, through eutrophication and macrophyte growth and siltation of gravel substrates, as discussed further in section 10.6.1.

10.6.4 PROTECTED SPECIES (FLORA & FAUNA)

There is potential to impact upon existing flora and fauna within the Feeghroe, Rapemills and Shannon catchments downstream of the site through impacts upon water quality.

During onsite assessments of the Feeghroe Stream, no rare aquatic plant species or protected flora under the Flora (Protection) Order 2015 (S.I. 356 of 2015), were recorded within the likely development area or immediate vicinity. No protected aquatic plant records for the area were submitted to the National Biodiversity Data Centre within the last decade. It is considered that there would be no significant risk of introducing invasive species during the discharge of treated effluent.

It is not anticipated that the Feeghroe Stream would be of a suitable water quality or contain suitable habitats to contain locally important populations of salmonids (brown trout) or coarse fish (cyprinids). However, the Rapemills River would be considered locally important for such species. The proposed confluence of the Feeghroe Stream and the Rapemills River is located approximately 2.5 km upstream of the confluence within the River Shannon. Significant changes to the water quality of the Rapemills in the vicinity of the Feeghroe confluence could act as a barrier to fish species from the Shannon migrating into the upper reaches of the Rapemills.

Protected species which have been identified as having the potential to be found within the Rapemills River include the White-clawed Crayfish (*Austropotamobius pallipes*) and Brook Lamprey (*Lampetra planeri*).

The White-clawed Crayfish is generally associated with good quality waters but this is not necessarily the case in Ireland where it can occur in water of lower quality, down to a Q value of around 3 or an ASPT of 4. It is now generally considered as a keystone or heritage species rather than as a bio-indicator, because of its traditional importance and its large size, longevity and dominant position in the ecosystem. The species prefers relatively cool temperatures and adequate dissolved oxygen and lime, although tolerating significant fluctuations in these parameters (King *et al.*, 2011).

As occurs with fish species, excessive suspended solids concentration in surface waters have the potential to significantly impact on white-clawed crayfish, through abrasion, disruption or clogging of gills.

Lampreys spend much of their life cycle in river sediments. Changes in siltation patterns can significantly impact on lamprey habitat (King *et al.*, 2011). Therefore, it would be considered that Brook Lamprey would be comparatively robust to potential impacts from suspended solids and siltation.

However, pollution to surface water, from diffuse and point sources, is a constant threat to all aquatic organisms. Both adult and ammocoete life stages for lamprey have been shown to be vulnerable to the effects of pollution in Irish systems (King *et al.*, 2011).

It is not considered that the proposed development would pose a significant risk to aquatic flora and fauna from changes to water quality, as discussed further in section 10.6.1.

The construction phase would result in increased noise emissions. The effect of noise on fish and aquatic fauna is not fully known, though some studies have shown that significant noise sources can halt migrating fish or result in death in extreme cases. However, noise emissions are not considered to pose a significant risk to aquatic species owing to the transient nature of the proposed works and the distance to main river channels.

10.6.4.1 Protected Species – Ammonia Toxicity

Under intensive culture conditions or in highly alkaline waters (pH >9), ammonia may have sub-lethal effects, such as a reduction in growth rate, or may be acutely toxic [Stickney, 1991] at un-ionised ammonia levels above 0.02 mg/l NH_3 N [Hellawell, 1986]. Exposure to sub-lethal doses affects the gills and may predispose fish to higher rates of bacterial infections, especially in poor quality water [Stevensen, 1987].

The 96 hour LC_{50} for ammonia (concentration where 50% of fish will die after 96 hours of exposure), as NH_3, is typically approximately 1.1 mg/l for most species of freshwater fishes [Russo and Thurston, 1991]. In acute toxicity tests, 24 hour LC_{50} for ammonia (NH_3 N) were between 0.07-0.39 mg/l for Rainbow trout (*O. mykiss*) [Russo *et al.*, 1974, Solbé and Shurben, 1989] and 0.28 mg/l for Atlantic Salmon (*Salmo salar*) [Hellawell, 1986], a close relative of Brown Trout (*S. trutta*).

The standard prescribed for un-ionised ammonia in Salmonid Rivers is 0.02 mg/l as NH_3 (0.0164 mg/l NH_3-N), as per the revoked Salmonid Regulations (S.I. No. 273 of 1988).

Total Ammonia in water exists as an equilibrium of toxic Un-ionised Ammonia (NH_3) and benign Ionised Ammonium (NH_4^+); [NH3 + H2O ↔ NH_4^+ +OH^-]. The principal factors mediating this equilibrium are pH and temperature. As pH and temperature increase, the levels of Un-ionised Ammonia in solution increase.

It should be noted that, in the absence of the proposed discharge and at existing monitored Total Ammonia levels, the Feeghroe Stream alone has been predicted to reach toxic levels of Un-ionised Ammonia (> 0.016 mg/l NH_3-N) at a pH of 8 and temperature of 20°C. These conditions may be common in un-shaded stretches of the Feeghroe Stream, particularly in summer months.

As outlined in assimilative capacity summary table for the Feeghroe (Table 10.4), while the proposed discharge would slightly reduce the levels of Un-ionised Ammonia in the stream,

the proposed discharge would not significantly mitigate against existing toxicity levels during periods with these ambient pH and temperature conditions.

The proposed maximum discharge of Total Ammonia is at a lower concentration than the existing monitored levels within the Feeghroe Stream. Therefore, the proposed discharge would dilute the existing concentration of Ammonia, and Un-ionised Ammonia, within the stream in proportion to the relative volume of the discharge.

It is not considered that that there would be a significant positive or negative deviation in existing toxic effects from Un-ionised Ammonia within the Feeghroe Stream as a result of this proposed discharge.

10.6.5 CUMULATIVE IMPACT

There are no other licenced industrial discharges to the Feeghroe Stream. Therefore, it is not anticipated that there would be a significant cumulative effect on the Feeghroe.

It is not considered that there would be a cumulative impact upon the quality of the Rapemills River, as there are no other discharges to the current river upstream or downstream of the proposed site.

The existing discharge from Banagher Concrete is to a historic section of the Rapemills River which is now isolated from the main channel. There is potential for cumulative impacts with this discharge during flood events on the River Shannon.

Owing to the similar nature of treated effluents, there is potential for cumulative impacts of discharges from Banagher UWWTP, other wastewater treatment plant emissions within the catchment and diffuse domestic pollution on the quality of the River Shannon.

The contribution to cumulative impacts from the proposed Banagher Chilling Ltd effluent discharge to water quality on the Shannon Catchment would be considered to be long term, slight negative impact.

10.6.6 "DO-NOTHING" IMPACT

Should the development not go ahead, there would be no changes to the existing water quality, habitats or species within the Feeghroe Stream, Rapemills Stream or wider Shannon catchment.

Water quality within the Feeghroe Stream would be expected to remain of "moderate" to "bad" status under the water framework directive, due to the influence of feed-waters from the Mullaghakaraun Bog.

There would be no loss of field drain (FW4) habitat within the boundary of the proposed development. As these habitats are of low ecological value, predominantly due to existing water quality and substrates, it is unlikely that the proposed site would be of significant ecological value in the future.

10.7 MITIGATION MEASURES

10.7.1 CONSTRUCTION PHASE

The following mitigation measures would be proposed to ensure there is no significant impact upon water quality or the aquatic biodiversity of the area owing to a deterioration in water quality:

- The construction works contractor would adhere to standard construction best practice, taking cognisance of the Construction Industry Research and Information Association (CIRIA) guidelines "*Control of Water Pollution from Construction Sites; guidance for consultants and contractors*" 2001 and "*Control of Water Pollution from Construction Sites – Guide to Good Practice*", 2002;
- Cognisance would be taken of the 2016 guidelines published by Inland Fisheries Ireland, "*Guidelines on Protection of Fisheries During Construction Works in and adjacent to Waters*";
- Daily visual inspections would be undertaken of the Feeghroe Stream during construction works;
- Provision of silt control features where appropriate, such as silt fencing;
- Silt fencing (comprising of a porous filter fabric which detains sediment) would be provided along the entirety of the boundary of the Feeghroe Stream. Silt fencing would remain in place until the completion of construction works;
- Silt fencing would also be provided adjacent the drainage ditches onsite where required (it was noted during ecological visits that a number of the ditches were dry). Silt fencing would remain in place until such time as works have commenced on re-directing drainage channels (as per drawing IE1796-003 of the Site Specific Flood Risk Assessment report);
- Additional silt fencing would be placed adjacent to storage areas of stockpiled soil, until such time as the excavated soil has been used in landscaping / re-instatement works or removed offsite by a licenced waste contractor;
- Silt control features would be inspected on a daily basis and maintained as appropriate;
- Where spoil is generated, this would only be stored temporarily and away from watercourses. Where possible, spoil would be covered or alternatively, graded to avoid ponding or water saturation;
- Excavations and earth-moving activities would be planned outside periods of heavy rainfall, to limit the potential for suspended solids to become entrained within surface water run-off;
- Should water be encountered during excavation works, water would be pumped to a constructed silt control feature, such as a settlement pond or detention pond. A filter would be provided at the pump inlet and, where required, dewatering bags or silt fences would be used at the outlet to retain any potential silt entrained in the water. Pumping operations would be supervised at all times;
- Where possible, surface water run-off would be diverted from any areas of bare / exposed ground;

- All construction plant machinery and equipment would be maintained in good working order and regularly inspected;
- The temporary site compound would be used for the storage of all machinery and plant when not in use, the re-fuelling of plant and the storage of all associated oils and fuels for plant;
- Self-contained port-a-loos / holding tanks would be located at the temporary site compound and would be emptied by a licenced contractor on a regular basis;
- Any fuels, oils or chemicals would be stored in accordance with the EPA guidance on the storage of materials, in designated bunded areas at the temporary site compound, with adequate bund provision to contain 110% of the largest drum volume or 25% of the total volume of containers;
- Material storage areas would be appropriately labelled and marked;
- The designated area for the storage of hydrocarbons would be inspected on a regular basis;
- Deliveries of fuels and oils to the site would be supervised and records maintained;
- All loading and unloading of hydrocarbons would take place within the bunded area where possible;
- Fuels / oils would be handled and stored with care to avoid spillage or leakage;
- Where appropriate, small construction plant equipment would be placed on drip trays;
- Any waste fuel / oils would be collected in bunded containers at a designated area within the temporary construction compound and properly disposed of to an authorised waste contractor;
- Spill kits, adequately stocked with spill clean-up materials such as booms and absorbent pads, would be readily available onsite;
- In the unlikely event of a hydrocarbon spillage, contaminated spill clean-up material would be properly disposed of to an authorised waste contractor;
- Where re-fuelling of construction plant is required to take place onsite, re-fuelling would take place within a bunded area, within the temporary site compound. Under no circumstances would re-fuelling take place within the immediate vicinity of watercourses, including drainage ditches;
- Where construction plant shows signs of hydrocarbon leakage, site personnel would cease the operation of the item in plant in question. Any defective plant would be kept out of service until the necessary repairs are undertaken;
- The use of pre-cast concrete where possible;
- The delivery and pouring of concrete would be supervised at all times;
- The pouring of concrete would be avoided during periods of expected heavy rainfall;
- Concrete would be poured directly into the shuttered formwork from the Ready-Mix Truck, reducing the risk of spillage;
- The wash-out of Ready-Mix Truck drums would not be permitted onsite, in the environs of the site, or at a location which could result in a discharge to surface water;

- Surplus uncured concrete would be returned to the batching plant where possible;
- An impermeable concrete washout area would be installed, if required, by the construction works contractor at the temporary site compound. Excess uncured concrete not returned to the batching plant, in addition to chute washings, would be deposited in the designated concrete washout area. The construction works contractor would arrange for the removal of concrete from this area at regular intervals during the construction phase;
- It is not envisaged that vehicle wheel wash facilities would be required. However, in particularly dry weather, additional dust control measures may be required, including the provision of a wheel wash facility. Should a wheel wash facility be required, it would be located at an area isolated from any watercourses. The associated run-off would be collected via a settling pond;
- Particular care would be taken during the construction of the discharge point outfall. Plant operation within the Feeghroe Stream would be avoided. Mitigation measures specified above for suspended solids, concrete and hydrocarbons would be followed;
- To minimise any potential impacts on salmonid fish, outfall works would be undertaken in the July to September period where possible, which would avoid the salmonid spawning season. Should outfall works be required outside the July – September timeframe, works would only commence upon prior agreement with IFI;
- Where possible, works on re-directing drainage ditches would be undertaken in dry weather conditions, preferably when the drainage ditches are dry. The proposed new channels would be first constructed, with the existing drains then blocked off / diverted to the new channels. The existing channel within the western portion of the site would be incorporated within the proposed ICW system;
- Monitoring of receiving water for suspended solids would be undertaken where required;
- In the unlikely event of a suspected deterioration in water quality within any of the watercourses due to construction works at the development site, works would immediately cease, an investigation into the cause undertaken and the relevant NPWS and Inland Fisheries Ireland personnel informed;
- The construction work contractor would prepare a detailed Construction Environmental Management Plan (CEMP) for all construction activities, in line with the Outline CEMP prepared as part of this application. The CEMP would describe how construction work would be undertaken in an environmentally sensitive manner and would include measures for the protection of water quality such as the implementation of silt control features.

10.7.2 OPERATIONAL PHASE

The following mitigation measures would be proposed to ensure there is no significant impact upon water quality or aquatic biodiversity of the area owing to a deterioration in water quality during the operational phase:

- The site would ensure that any fuels, oils or chemicals would be stored in accordance with the EPA guidance on the storage of materials, in designated, bunded areas, with adequate bund provision to contain 110% of the largest drum volume or 25% of the total volume of containers. Bunds and bunded areas would undergo integrity testing every three years, as is best practice;
- The site would ensure that an adequate supply of spill clean-up material is readily available, in the event of any spillages onsite, thereby minimising the potential for spills / leaks to impact upon the biodiversity of the area;
- The proposed WWTP would be bunded by design, which would ensure that any potential spills within this area would be returned to the wastewater treatment process;
- Drainage from hardstand areas would pass through a SuDS storm water system, which would reduce the rate of emissions and remove suspended solids. The system would include a silt trap and by-pass separator;
- The final sump of the WWTP would have an emergency return connection to the balancing tank, providing storage for emergencies or other such contingency purposes;
- Should planning consent be granted, Banagher Chilling Limited would apply to Offaly County Council for a Local Authority Section 4 (Trade Effluent) Discharge Licence. Proposed emission limit values would be assessed by Offaly County Council, and once agreed, would be specified within the discharge licence;
- Banagher Chilling Limited would be required to undertake scheduled monitoring of the discharge for the parameters specified by the County Council in the discharge licence. This monitoring would ensure that final treated effluent quality would remain high, and that any slight increases in parameter results would be identified and addressed prior to the potential for impact upon the Feeghroe Stream.

10.8 RESIDUAL IMPACTS

Assuming all mitigation measures are put in place, there would be no significant residual impacts to the aquatic environment from the proposed development.

10.9 DIFFICULTIES ENCOUNTERED IN COMPILING INFORMATION

Surface water physico-chemical monitoring results, which informed the Assimilative Capacity Assessment of the Feeghroe Stream, were average results of three samples taken over the course of approximately 1 month, between September 2018 and October 2018. There were no other historic monitoring records for the Feeghroe Stream. While these results provide representative samples of the existing water quality of the stream, they comprise a small sample of the overall water quality regime.

Every effort has been made to provide an accurate assessment of the situation pertaining to the site. However, an ecological survey can only assess a site at a particular time, and is limited by various factors such as the season, timing of the survey, climatic conditions and species behaviour. Ecological surveys are therefore snapshots in time and should not be regarded as a complete study. Direct observations or evidence of protected species is not always recorded during ecological surveys. However, this does not indicate that the species is absent from the site.

10.10 REFERENCES

BREF Document for Slaughterhouses and Animals By-products Industries (2005). *Reference Document on Best Available Techniques in the Slaughterhouses and Animal By-Products Industries.*

Chartered Institute of Ecology and Environmental Management (2016) *Guidelines for Ecological Impact Assessment in the UK and Ireland*.

CIRIA (2002) *Control of Water Pollution from Construction Sites – Guide to Good Practice.*

CIRIA (2001) *Control of Water Pollution from Construction Sites; guidance for consultants and contractors*.

Council Directive (EC) 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy – more commonly known as the Water Framework Directive.

DoEHLG (2009) *Appropriate Assessment of Plans and Projects in Ireland - Guidance for Planning Authorities*.

Environmental Protection Agency Ireland (Environmental Protection Agency) (2001). *Parameters of Water Quality: Interpretation and Standards.* Environmental Protection Agency, Wexford.

Environmental Protection Agency (2017) Draft. *Guidelines on the information to be contained in Environmental Impact Assessment Reports*.

Environmental Protection Agency (2010). *A Handbook on the Implementation of the Regulations for Water Service Authorities for Public Water Supplies.* Available at: http://www.epa.ie/pubs/advice/drinkingwater/publicwatersupplieshandbook/Introduction.pdf

Environmental Protection Agency (2008). *Drinking Water Regulations Guidance Booklet No.4*.

EPA Envision Online Mapping, Available at: http://gis.epa.ie/Envision/

EPA Catchment Information Mapping, Available at: https://www.catchments.ie/maps/

EPA (2018) *WFD Cycle 2 – Lower Shannon – Sub Catchment Shannon [Lower]-SC-40 Assessment Report*, Available at: https://www.catchments.ie/wp-content/files/subcatchmentassessments/25B_1%20Shannon[Lower]_SC_040%20Subcatchment%20Assessment%20WFD%20Cycle%202.pdf

ESBI & Aquatic Services Unit (2018) *West Offaly Power Thermal Discharge Synthesis Report*, Available at: https://westoffalypower.ie/documents/Environmental_Docs_Vol_3_EIAR_Appendices/Appendix%206.2%20WOP%20Synthesis%20Report.pdf

ESB (2013), *Fisheries Conservation Annual Report 2013*, Accessed at: https://www.esb.ie/docs/default-source/investor-relations-documents/esb-annual-report-2013

European Communities Environmental Objectives (Surface Waters) Regulations (S.I. No. 272 of 2009).

European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (S.I. 296 of 2009)

European Communities (Quality of Salmonid Waters) Regulations (S.I. No. 293 of 1988).

European Communities (Quality of Surface Water Intended For The Abstraction of Drinking Water) Regulations (S.I. No. 294 of 1989).

Fossitt J. (2000). *A Guide to Habitats in Ireland*. Heritage Council.

Hellawell, J.M. 1986. Biological indicators of freshwater pollution and environmental management. (Pollution monitoring Series, K. Mellanby (ed.)). Elsevier Applied, Science, London. 546 p

Inland Fisheries Ireland (2016). *Guidelines on Protection of Fisheries During Construction Works in and adjacent to Waters.*

King, J.L., Marnell, F., Kingston, N., Rosell, R., Boylan, P., Caffrey, J.M., FitzPatrick, Ú., Gargan, P.G., Kelly, F.L., O'Grady, M.F., Poole, R., Roche, W.K. and Cassidy, D. (2011). *Ireland Red List No. 5: Amphibians, Reptiles and Freshwater Fish.* National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Koivunen, J., Siitonen, A. and Heinonen-Tanski, H. (2003). Elimination of enteric bacteria in biological-chemical wastewater treatment and tertiary filtration units. *Water Research*, 37, pp. 690-698.

Midland Regional Authority (2010) *Regional Planning Guidelines for the Midland Region 2010 – 2022*.

Mittal, G.S. (2004). Characterization of the Effluent Wastewater from Abattoirs for Land Application. *Food Reviews International*, 20(3), pp. 229-256.

National Roads Authority (2008) *Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes*.

NPWS (2018). *Conservation Objectives: River Shannon Callows SAC 000216.*

NPWS (2013). *Site Synopsis: River Shannon Callows SAC 000216.*

NPWS & Browne Dunne Roche (2002). *A Preliminary Study of the Upper Shannon Floodplain*. Unpublished Report, National Parks and Wildlife Services, Department of Arts, Heritage and the Gaeltacht

NPWS (2013a) *The Status of Protected EU Habitats and Species in Ireland*. Volume 1. Unpublished Report, National Parks and Wildlife Services, Department of Arts, Heritage and the Gaeltacht.

NPWS (2013b) *The Status of EU Protected Habitats and Species in Ireland.* Habitats Assessments Volume 2. Version 1.0. Unpublished report. National Parks and Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin.

NPWS (2013c) *The Status of EU Protected Habitats and Species in Ireland.* Species Assessments Volume 3. Version 1.0. Unpublished report. National Parks and Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin.

National Parks & Wildlife Service, Available at: http://www.npws.ie/protected-sites

Offaly County Council (2014) *Offaly County Development Plan 2014 – 2020*. Available at: https://www.offaly.ie/eng/Services/Planning/Development-Plans/County-Development-Plan-2014-2020/

Rajala, R.L., Pulkkanen, M.P, Pessi, M. and Heinonen-Tanski, H. (2003). Removal of microbes from municipal wastewater effluent by rapid sand filtration and subsequent UV irradiation. *Water Science & Technology*, 47(3), pp. 157-162.

Reynolds, J.D. (1998) Conservation management of the white-clawed crayfish, Austropotamobius pallipes. Part 1. *Irish Wildlife Manuals*, No. 1. National Parks and Wildlife Service.

Russo, R.C., Smith, C.E. and Thurston, R.V. 1974. Acute toxicity of nitrite to rainbow trout (Salmo gairdneri). J. Fish. Res. Board Can. 31: 1653-1655.

Russo, R.C. and Thurston, R.V. 1991. Toxicity of ammonia, nitrite and nitrate to fishes, pp 58-89. In, Brune, D.E. and Tomasso, J.R. (editors), Aquaculture and Water Quality. The World Aquaculture Society, Baton Rouge, Los Angeles. 606 p.

Solbé, J.F. de L.G. and Shurben, D.G. 1989. Toxicity of ammonia to early life stages of rainbow trout (Salmo gairdneri). Wat. Res. 23: 127-129.

Stickney, R.R. 1991. Salmonid life histories. In, Stickney, R.R. (editor), Culture of Salmonid Fishes. CRC Press, Inc. Boca Raton. pp 1 - 20.

USEPA (2004). *Technical Development Document for the Final Effluent Limitations – Guidelines and Standards for the Meat and Poultry Products Point Source Category*.

Wcislo, R. and Chróst, R.J. (2000). Survival of Escherichia coli in Freshwater. *Polish Journal of Environmental Studies*, 9(3), pp. 215-222.

World Health Organisation, (2002). *Managing Water in the Home: Accelerated Health Gains from Improved Water Supply*.

WSTG (2011). *Guidance, Procedures and Training on the Licensing of Discharges to Surface Waters, Groundwater and to Sewer for Local Authorities: Volume 1 – Technical Guidance Manual.* Water Services Training Group, Monastery Road, Roscrea, Co. Tipperary.