9 Fisheries & Aquatic Ecology

Background

9.1 This chapter describes the fisheries and aquatic ecological interests of the watercourses draining the proposed Carnbuck Wind Farm, hereinafter referred to as 'the Proposed Development', and considers the potential effects of the construction, operation and decommissioning of the development on these interests. The assessment consists of a desk-based assessment using available published and online information in combination with data and observations collected in the field. The specific objectives of the chapter are to:

- describe the fisheries baseline;
- describe the assessment methodology and significance criteria used in completing the impact assessment;
- describe the potential effects, including direct, indirect and cumulative effects;
- describe the mitigation measures proposed to address likely significant effects;
- assess the residual effects remaining following the implementation of mitigation.

9.2 The assessment has been carried out by Paul Johnston Associates Ltd, an independent fisheries consultancy specialising in freshwater fisheries in Ireland. This chapter was compiled by David Kelly, principal consultant and director of PJA Ltd. David holds a BSc (1st Class Hons) degree in Zoology, and a PhD in Freshwater Ecology & Fisheries; he is a full member of the Chartered Institute of Ecology and Environmental Management (CIEEM), a registered member of the Institute of Fisheries Management (MIFM), and a visiting Research Fellow at Queens University Belfast. Also involved was Paul Johnston who holds a BSc (Hons) in Zoology and a PhD in Fisheries Ecology; he is also a Fellow of the Institute of Fisheries Management (FIFM) and Chartered Environmentalist (CEnv).

9.3 The practice has completed a wide range of assignments in the areas of environmental impact assessment, fisheries development and catchment management. This includes fisheries assessments in connection with a series of onshore wind farm developments in Northern Ireland and the Republic of Ireland.

9.4 **Volume 3 Figures 9.1 – 9.5** are referenced in the text where relevant.

Legislation, Policy & Relevant Guidance

Fisheries Administration

9.5 With regard to fisheries administration and legislation, the footprint of the Proposed Development lies within the jurisdiction of Inland Fisheries Division (IFD) of the Department for Agriculture Environmental and Rural Affairs (DAERA). Under the provisions of the Fisheries Act (NI) 1966, DAERA IFD has responsibility for the

conservation, protection, development and improvement of salmon and inland fisheries of Northern Ireland.

Legislation

EU Legislation

9.6 EU and local legislation relevant to fisheries and the water environment in the area of the Development includes the following:

- EC Habitats Directive (92/43/EEC);
- EU Water Framework Directive (2000/60/EC) [incorporating standards from the Fish Directive [Consolidated] (2006/44/EC) – this Directive was repealed in 2013];
- European Eel Regulation (EC) 1100/2007.

Domestic Legislation

- Fisheries (Northern Ireland) Act 1966;
- Drainage (Northern Ireland) Order 1973;
- Environment (Northern Ireland) Order 2002;
- Nature Conservation and Amenity Lands (Amendment) (Northern Ireland) Order 1989;
- Water (Northern Ireland) Order 1999;
- Water Environment (Water Framework Directive) (Northern Ireland) Regulations 2003;
- Wildlife (Northern Ireland) Order 1985;
- Wildlife and Natural Environment Act (Northern Ireland) 2011.

Policy

9.7 Policy with regard to Atlantic salmon and European eel in this region is set out in the following:

- Braid and Main Local Management Area Action Plan and Update 2013;
- Bush and Glens Local Management Area Action Plan and Update 2013;
- Atlantic Salmon Management Strategy for Northern Ireland and the Cross-Border Foyle and Carlingford catchments to meet the objectives of NASCO resolutions and agreements, 2008–2012 (DCAL);
- North Eastern River Basin District Eel Management Plan (DEFRA).
- Neagh Bann International River Basin District Eel Management Plan 2010

Guidance

9.8 Specific guidance relevant to the Proposed Development includes the following:

- Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites (DCAL undated);
- Engineering in the water environment: good practice guide River Crossings (SEPA 2nd Edtn 2010);
- Culvert Design and Operation Guide (C689) (CIRIA, 2010);
- Environment Agency Policy Regarding Culverts: Technical Guidance on Culverting Proposals (EA, 1999);

- PPG1: Understanding your environmental responsibilities – good environmental practices
- GPP2: Above ground oil storage tanks;
- GPP5: Works and maintenance in or near waters;
- PPG6: Working at construction and demolition sites;
- GPP8: Safe storage and disposal of used oils;
- PPG13: Vehicle washing and cleaning;
- PPG18: Managing fire water and major spillages;
- GPP21 Pollution incident response planning;
- GPP22 Dealing with spills;
- GPP26 Safe storage – drums and intermediate bulk containers

Scope of Assessment

9.9 The fisheries assessment has involved desk study, field work, data processing and analysis and interpretation using professional judgement. The key receptors are the Aghanageeragh River, a tributary of the Cloghmills River within the River Main catchment; a small tributary of the Killagan Water within the River Main catchment; the Tullykittagh tributary of the Clogh Water within the River Main catchment; a small tributary of the Flisk River within the Upper River Bush catchment; all the streams drain the area within the Preliminary Site Boundary, hereinafter referred to as 'the Site'.

9.10 Existing fisheries data and relevant conservation information on the River Main, Killagan, Cloghmills, Clogh, and Upper Bush was assimilated and supplemented through a bespoke fisheries survey of the Site covering the principal watercourses draining the area.

9.11 The field study consisted of walkover surveys of the principal watercourses, assessments of physical habitat conditions, measurement of basic chemistry parameters, collection of benthic invertebrate samples for assessment of biological quality, and a fish stock survey by electrofishing.

9.12 The sensitivity of each watercourse with regard to fisheries has been assessed according to a methodology for environmental sensitivity outlined in the Design Manual for Roads and Bridges, specifically with regard to effects on the water environment (DMRB, 2019). Potential effects of the construction, operation and decommissioning phases of the Development were then assessed. This assessment was based primarily on the potential effects on resident fish stocks either directly or upon their habitats.

Consultation

9.13 The principal consultee during the study was DAERA IFD as the statutory body with authority for fisheries matters in the local waters. Consultee responses are summarised in **Table 9.1**.

9.14 Consultations were also conducted with other sub-consultants on the project, notably in relation to hydrology and drainage issues which are contained within **Chapter 10: Geology and Water Environment** of this ES.

Table 9.1: Consultee Responses

Consultee		Summary of Consultation
DAERA	Inland Fisheries Division	A formal letter outlining the proposal and seeking any comments regarding fisheries interests was addressed to the local Area Fisheries Officer Nov. 18th 2019. No response was received.
	NIEA	NIEA and Inland Fisheries were consulted in March 2022 as part of the Intention to Submit. No response has been received to date.

Assessment Methodology

Baseline Characterisation

Study Area

9.15 The study area focused on tributary streams of the Killagan, Cloghmills (Aghanageeragh River) and Clogh River (Tullykittagh Water), which drain the area within the Site to the west, south-west and south, respectively. Also within the study area was a tributary of the Upper River Bush, which drains the Site to the north.

9.16 The desk assessment also includes an evaluation of fisheries in downstream reaches of the Killagan, Cloghmills, Clogh Water and Upper River Bush (See **Figure 9.1**).

Desk Study

9.17 A desk study was carried out to assimilate baseline information relating to salmonid fisheries, ecological and water quality status (under WFD) for the study area. The following sources were consulted/used:

- DAERA Inland Fisheries Division/ Agri Food and Biosciences Institute (AFBI)
- Baseline data on juvenile fish stocks for streams in the Killagan catchment for Corkey Wind Farm Repowering EIA by Paul Johnston Associates (Scottish Renewables, 2019).
- Northern Ireland Environment Agency (NIEA) – Water Management Unit (WMU) (Rivers and Lakes Team) https://appsd.daera-ni.gov.uk/RiverBasinViewer/
- NIEA - Protected Areas https://appsd.daera-ni.gov.uk/nedmapviewer/
- NIEA digital datasets https://www.daera-ni.gov.uk/articles/digital-datasets

Field Survey

General Approach

9.18 An initial walkover survey was carried out to assess the significance of the streams directly draining the Site. This was followed by more detailed surveys of the Aghanageeragh, Tullykittagh, eastern tributaries of the Killagan, and the Northern tributary of the Upper River Bush.

9.19 The surveys at each site comprised assessments of stream quality (water chemistry, physical habitat and aquatic ecology), fisheries habitat and juvenile fish stocks as described below.

Stream Quality

9.20 A series of survey sites was selected on the streams draining the Site. These sites were located downstream of the main infrastructure and were designed to capture the baseline in areas where there is potential for impacts arising from the development. The initial stream quality surveys were conducted in October 2018 and describe baseline water chemistry, physical habitat and aquatic ecology at each site. The data derived from these surveys is expected to represent the current baseline because of the upper catchment position of these watercourses and relatively low intensity farming, where overt changes in baseline state would not be expected.

Water Chemistry

9.21 A series of basic water quality parameters were measured at each site using portable meters to provide an outline profile of chemical quality.

9.22 Dissolved oxygen was measured with a Hanna Oxy-Check oxygen meter, and conductivity with a Hanna HI86303 conductivity meter; temperature measurements were made with the oxygen meter.

Physical Habitat

9.23 River physical habitat (substratum type, depth, flow velocity) was assessed based on the fully quantitative method developed by DAERA IFD and AFBI. In each site, surveys consisted of a 40m stream reach with 25 sampling points across five equidistant cross-sectional transects except on very narrow (<0.3m width) and overgrown streams where it was difficult to observe the riverbed; on these streams, up to 12 transects (1-3 sampling points per transect) were surveyed in each reach.

9.24 At each sampling point, flow velocity was recorded at 60% depth using a Geopacks flow meter, with water depth measured using the meter's impeller stick; substrate was visually assessed using a bathyscope with the dominant substrate type recorded according to a modified Wentworth Scale (Bain et al. 1985; **Table 9.2**).

Table 9.2: Substrate classification and scoring based on the Wentworth system (from Bain *et al*. 1985)

Substrate type	Size Class (mm)	Score
Sand/silt	<2	1
Gravel	2-16	2
Pebble	17-64	3
Cobble	65-256	4
Boulder	>256	5
Irregular Bedrock	-	6

9.25 The following physical characteristics were measured at each site:

- Stream width and depth at each transect (m)
- Substrate composition (visually estimated as per Bain et al., 1985);
- Percentage of deposited fine sediment (<2mm grain) on the river bed as per Clapcott et al. (2011), with the dominant fine sediment type (sand, silt, clays) determined by running the grain through the observer's fingers.

9.26 The classification system of Bain et al (1985) was used to summarise the composition of substrate in a reach based on two indices:

- Coarseness index (CI) – calculated as the mean dominant substrate score
- Heterogeneity (SD) – calculated as the standard deviation of the mean CI.

These indices show how coarse or smooth the substrate of a reach is and if it is comprised of a mixture or is dominated by a particular substrate class (Table 9.3).

Table 9.3: Substrate description inferred from sample data (from Bain *et al*. 1985)

Mean substrate score (CI)	Heterogeneity (SD)	Inferred substrate description
3.2	1.96	Heterogeneous, smooth and rough
5.0	0.00	Homogeneous, coarse
1.25	0.44	Nearly homogeneous, smooth
3.25	0.85	Heterogeneous, intermediate coarseness
5.05	0.69	Heterogeneous, coarse

Aquatic Ecology

9.27 Stream benthic communities are sensitive to a wide range of environmental stressors including nutrient enrichment and organic pollution, acidification, fine deposited and suspended sediments, and hydrocarbons/ oils. The relatively long lifespans and varying sensitivities of individual taxa mean that invertebrate communities can integrate stressor effects over longer timescales than may be indicated by physico-chemical parameters alone (Extence et al. 2013). As such, they are important for assessing both short and longer term effects.

9.28 In October 2018, baseline ecology of watercourses adjacent and downstream of the Proposed Development was assessed by sampling the benthic macroinvertebrate community in the riffle/ run habitat using a standard three-minute kick sample (hand held 1mm mesh pole net); the method is recommended by the United Kingdom Technical Advisory Group (UK-TAG) for assessing the condition of the quality element "benthic invertebrates" for WFD reporting (UKTAG, 2014). The sampling period corresponds to the preferred spring or autumn collection season when larger instars of taxa are better retained by the kick-net mesh.

9.29 Samples were collected from riffle/run habitats, fixed in 4% formalin for 1 week, followed by preservation in 70% ethanol prior to sorting and identification. In the laboratory, macroinvertebrate samples were spread across a 4 x 5, 20-square grid sorting tray to facilitate identification and to estimate relative abundance. Abundant taxa were counted in a subset of five squares and scaled to whole sample estimates as recommended in Murray-Bligh (2002). Less abundant taxa were counted in all grid squares.

Fisheries Habitat

9.30 An outline assessment of the tributary streams draining the Site was carried out in October 2018 and consisted of walkover surveys recording general characteristics to provide an outline assessment for these watercourses. Additional information of fish habitat classification was recorded during the fish stock survey in August 2019 and a further walkover survey of stream headwaters within the Preliminary Site Boundary was conducted in November 2019.

9.31 The descriptive terminology used in the survey is based on the Life Cycle Unit method (Kennedy, 1984) currently used by DAERA Inland Fisheries and the Loughs Agency (see also DANI advisory leaflet No 1). In summary, habitat type is recorded as:

- Nursery (shallow rock/cobble riffle areas for juvenile fish - fry/parr);
- Holding (deeper pools/runs for adult fish);
- Spawning (shallow gravel areas for fish spawning);
- Unclassified (unsuitable for fish – shallow bedrock areas or heavily modified sections of channel).

9.32 Each stretch of a particular river is also graded 1 to 3, based on a series of criteria as set out in Annex 1 of the DANI advisory leaflet. In essence, points 1-3 are of fisheries interest (Nursery, Holding and Spawning) whereas non-fisheries interest is unclassified and would describe a substrate of fine silt, or extensive bridge invert, or engineered channel with solid bed and possibly constrained banks.

9.33 The descriptive terminology used in the survey is based on the Life Cycle Unit method (Kennedy, 1984) currently used by DAERA Inland Fisheries (see also DANI advisory leaflet No 1).

Juvenile Fish Stocks

9.34 Monitoring of fish stocks by the DAERA IFD tends not to include sampling sites in the upper reaches of tributaries in most river systems. Therefore, this part of the fisheries assessment considered the principal streams draining the Proposed Development site with the data supplemented by DAERA IFD data for the main Cloghmills, Killagan, Clogh and Upper Bush Rivers.

9.35 The juvenile fish stock baseline for the eastern tributaries of the Killagan sub catchment was supplemented by data for Autumn 2017 published in a report by the authors on behalf of Scottish Power Renewables for Corkey Windfarm Repowering (Scottish Power Renewables, 2019).

9.36 Additional juvenile fish stock surveys were conducted for the Aghanageeragh, the Tullykittagh, and the small tributary of the River Bush at the Site entrance, by electrofishing at selected locations in August 2019).

9.37 Electrofishing was carried out according to a semi-quantitative methodology described by Crozier and Kennedy (1994). The procedure involves two operators fishing continuously in an upstream direction for five minutes at each sampling location, using an E-Fish 500W single anode electrofishing backpack (EF-500B-SYS). The system operates on 24V input and delivers a pulsed DC output of 10 to 500W at a variable frequency of 10 to 100Hz. Output voltage and frequency are adjusted according to the electrical conductivity at the survey site.

9.38 All fish were caught using a dip net and retained for general inspection and length measurement before being returned to the water live. Any additional Age 0 salmonids observed but not captured were also recorded. This method is consistent with DAERA IFD and AFBI survey and monitoring procedures.

9.39 The semi-quantitative electrofishing method has been calibrated separately for trout and salmon based on extensive studies in river reaches of known juvenile salmonid density. This has resulted in the development of an abundance classification system (Abundance Index) for salmon with five categories: Absent, Poor, Fair, Good, Excellent (**Table 9.4a**). The Abundance Index for trout has six classifications: Absent, Poor, Poor/Fair, Moderate, Good, Excellent (**Table 9.4b**).

Table 9.4: Semi-quantitative abundance categories for age 0 salmon (a) and trout (b), as developed by Crozier and Kennedy (1994); Kennedy (unpublished data)

(a) Salmon

Fry (0+) nos.	Density (No/100m2)	Abundance/ quality category
0	0	Absent
1 – 4	0.1 – 41.0	Poor
5 – 14	41.1 – 69.0	Fair
15 – 24	69.1 – 114.6	Good
25+	114.6+	Excellent

(b)Trout

Fry (0+) nos.	Density (No/100m2)	Abundance/ quality category
0	0	Absent
0 – 1	0.1 – 7.0	Poor
2 – 3	7.1 - 16.5	Fair
4 – 8	17 - 31	Moderate
9 – 17	32 - 59.9	Good
18+	60+	Excellent

Assessment of Effects

9.40 The assessment of effects was derived from methodologies outlined by:

- the Design Manual for Roads and Bridges specifically with regard to Road Drainage and the Water Environment, Volume 11, Section 3, Part 10 LA113 (DMRB, 2019);
- Guidelines for Ecological Impact Assessment in the UK and Ireland (CIEEM, 2018).

9.41 The significance of the potential effects of the Development has been classified by professional consideration of the sensitivity of the receptor and the magnitude of the potential effect.

Sensitivity Criteria

9.42 Using the information assembled through the baseline assessment, the Fisheries Significance/Sensitivity of each watercourse was graded according to the generic methodology for environmental sensitivity outlined in the Design Manual for Roads and Bridges (2019). **Table 9.5** details the framework applied in determining the sensitivity and this evaluation was used as the basis for the assessment of effects and the specification of any necessary mitigation requirements with regard to fisheries and the aquatic environment.

Table 9.5: Estimating the Sensitivity/Importance of Receptors (adapted from Table 3.70, DMRB, 2019)

Sensitivity	Criteria	Typical Examples
Very High	Nationally significant attribute of high importance	WFD Class 'High'. Site protected/designated under EC or UK habitat legislation (SAC, ASSI, salmonid water)/Species protected by EC legislation. Watercourse containing salmon and supporting a nationally important fishery or river ecosystem.
High	Locally significant attributed of high importance	WFD Class 'Good'. Major cyprinid fishery Species protected under EC or UK habitat legislation. Watercourse containing salmon or trout and supporting a locally important fishery or river ecosystem.
Medium	Of moderate quality and rarity	WFD Class 'Moderate'. Watercourse containing trout and upstream of locally important fishery or river ecosystem.
Low	Lower quality	WFD Class 'Poor'. Watercourse without salmon or trout
Negligible	Attribute has very low quality and rarity on a local scale	WFD Class 'Poor'/unspecified.

Magnitude of Impact

9.43 The magnitude of impact was assessed according to the criteria set out in **Table 9.6** and includes a consideration of the timescale of the effect (short, medium or long term).

Table 9.6: Estimating the Magnitude of Impact on Receptors (adapted from Table 3.71, DMRB, 2019).

Magnitude	**Criteria**	**Type and Scale of Effect**
Major	Results in loss of attribute and/or quality and integrity of the attribute	Loss or extensive change to a fishery. Loss or extensive change to a designated Nature Conservation Site. Reduction in waterbody WFD classification Major alteration to fish population levels in catchment as a whole, through fish mortality, habitat destruction or barrier to migration. Duration: long-term (>5 years).
Moderate	Results in effect on integrity of attribute, or loss of part of attribute	Partial loss in productivity of a fishery. Contribution to reduction in water body WFD classification

Magnitude	Criteria	Type and Scale of Effect
		Appreciable alteration to fish population levels in specific sub-catchment or zone. Duration: medium-term (1-5 years).
Minor	Results in some measurable change in attribute's quality or vulnerability	Minor loss in productivity of a fishery. Minor alteration to fish population levels in specific sub-catchment or zone. Duration: short-term (up to 1 year).
Negligible / No impact	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity	Unlikely to affect the integrity of the water environment. No measurable alteration to fish population levels.

Significance Criteria

9.44 The correlation of magnitude against the sensitivity of the receptor determines a qualitative expression for the significance of the effect on the basis of a standard matrix shown in **Table 9.7**. The greater the sensitivity or value of a receptor or resource, and the greater the magnitude of the impact, the more significant the effect.

Table 9.7: Estimating the Significance of Potential Effects (adapted from Table 3.8.1, DMRB, 2019b)

Sensitivity	Magnitude of Effect			
	Major	Moderate	Minor	Negligible
Very High	Very Large	Large/Very Large	Moderate/Large	Slight
High	Large/Very Large	Moderate/Large	Slight/Moderate	Slight
Medium	Moderate or Large	Slight	Slight	Neutral or Slight
Low	Slight or Moderate	Neutral or Slight	Neutral or Slight	Neutral or Slight

9.45 The five significance categories with typical effects are shown in **Table 9.8**. Effects evaluated as being Moderate, Large or Very Large are considered to be significant for the purpose of the EIA in line with the EIA Regulations and will require mitigation. Those effects assessed as Slight or Neutral are not considered to be significant in terms of the EIA.

Table 9.8: Descriptors of the Significance of Effect Categories (adapted from Table 3.7, DMRB, 2019b).

Significance category	Descriptors of effects
Very large	Only adverse effects are normally assigned this level of significance. They represent key factors in the decision-making process. These effects are generally, but not exclusively, associated with sites or features of international, national or regional importance that are likely to suffer a most damaging impact

Significance category	**Descriptors of effects**
	and loss of resource integrity. However, a major change in a site or feature of local importance may also enter this category.
Large	These beneficial or adverse effects are considered to be very important considerations and are likely to be material in the decision-making process.
Moderate	These beneficial or adverse effects may be important, but are not likely to be key decision-making factors. The cumulative effects of such factors may influence decision-making if they lead to an increase in the overall adverse effect on a particular resource or receptor.
Slight	These beneficial or adverse effects may be raised as local factors. They are unlikely to be critical in the decision-making process, but are important in enhancing the subsequent design of the project.
Neutral	No effects or those that are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.

Baseline Conditions

Outline

9.46 This element of the assessment consisted of:

- Desk studies to collate baseline information on fisheries, conservation designations, and ecological status of waterbodies hydrologically connected to the Site; and
- Field surveys focused on the streams draining the Site to assess baseline physical habitat conditions, biological quality, salmonid habitat, and fish distribution. Field survey work was therefore carried out both within the Site Boundary and in the immediate downstream reaches of the drainage streams connecting to the Killagan, Cloghmills, Clough Water and Upper River Bush.

Catchment Status

Designated Sites

9.47 There are no designations relating to Fisheries and Aquatic Ecology with respect to SACs or ASSIs in the immediate or downstream area of the Site.

Lough Neagh RAMSAR and ASSI

9.48 Lough Neagh ASSI/ RAMSAR is linked to the Site via the River Main, but is over 45km downstream. Lough Neagh is designated as a Special Protection Area based on the bird species present and the availability and type of associated habitat; however, the following aspects are relevant to fisheries and aquatic ecology;

9.49 Lough Neagh and Lough Beg RAMSAR site - The Loughs qualifying criteria include its size as the largest freshwater lake in the British Isles, its range of aquatic and wetland habitats, and the presence of rare species including Pollan, *Coregonus autumnalis,* a salmonid fish which is elsewhere in Europe, two aquatic snails, the freshwater opossum shrimp *Mysis relicta* and 12 species of dragonfly.

9.50 Lough Neagh ASSI – The Lough was designated under Article 24 of the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985. In terms of fisheries and aquatic ecology, it is habitat to a number of rare invertebrates and fish. Pollan is a key species of interest (EHS NI, 2008), with the Lough Neagh population the largest in Ireland. Pollan is listed as a UK Priority Species for Conservation and is classified as endangered in the Irish Red Data Book (King et al, 2011). Additional species of interest include populations of river lamprey that unusually are non-migratory, and "dollaghan", a sub-species of brown trout that grows and matures in the lough before migrating upstream to various inflowing tributaries (including the River Main and tributaries) that are used as spawning and nursery habitats.

EU Water Framework Directive

Local River Catchments

9.51 The Proposed Development is located in the River Main and River Bush catchments. The Killagan, Cloghmills and Clogh River are the three key tributaries of the River Main into which streams draining the southern and south-eastern portion of the Site flow (**Figure 9.1**). All watercourses within the Main catchment are assigned to the Neagh Bann International River Basin District under the Water Framework Directive.

9.52 The majority of the Site area is drained by the Aghanageeragh tributary of the Cloghmills Water with a source at over 350m elevation. The Cloghmills Water meets the Killagan Water approximately 9km downstream of the Site to form the River Main.

9.53 In the north-west of the Site, a smaller proportion of the Site area drains to two small tributaries that drain west to the Killagan River, which has its confluence with the Cloghmills Water over 11km downstream of the Site.

9.54 On the eastern fringe of the Site boundary, the upper Tullykittagh Water drains to the Clogh Water, which is over 15km from the River Main confluence.

9.55 A single stream in the northern area of the Site drains to the Upper River Bush catchment, which is assigned to the North Eastern River Basin District under the Water Framework Directive.

9.56 Land use in the upper reaches is predominantly grazing by sheep over rough pasture and blanket bog, although cattle grazing also occurs on the gentler gradients. In the Upper Bush outside of the Site, land use is predominantly conifer plantation.

Ecological Status & Water quality

9.57 To achieve the ecological objectives of the Water Framework Directive (WFD), River Basin Management Plans (RBMPs) have been implemented through a series of Local Management Areas (LMAs) during the 2010 to 2015 planning cycle, now extended into the subsequent 2016 to 2021 cycle, and with provision under WFD for a third cycle from 2022 to 2027.

9.58 The Proposed Development lies almost entirely within the Braid and Main LMA, with a smaller proportion where the northern stream occurs lying within the Bush LMA.

9.59 Within the Braid and Main LMA, the application area is located in three waterbodies defined as the Killagan Water (UKGBNI1NB030302212) the Cloghmills Water (UKGBNI1NB030302234) and Clogh River (UKGBNI1NB030308211). Within the Bush LMA, the application area is located within the River Bush (Ballyhoe) waterbody ((UKGBNI1NB040405127)

9.60 Ecological and water quality monitoring to inform waterbody status is conducted by the NIEA Water Management Unit to comply with statutory monitoring for WFD compliance. The most recent ecological assessment for these waterbodies was available for 2018 based on data provided by NIEA and is summarised in **Table 9.9.** The overall classification and status with regard to each of the principal parameters monitored was "GOOD" for each of the key waterbodies draining the Site.

Table 9.9: Classification of individual quality elements contributing to overall WFD status of relevant water bodies in Braid and Main, and the Bush LMAs, 2018 (Source: NIEA)

Parameter	Killagan Water (Ref 2212)	Cloghmills Water (Ref 2234)	Clogh River (Ref 8211)	Bush River (Ballyhoe; Ref 5127)
Benthic Invertebrates	Good	Good	Good	Good
Macrophytes	High	High	Good	Good
Phytobenthos	High	High	Good	High
Fish	No Data	No Data	No Data	No Data
Biochemical Oxygen Demand	High	High	High	High
Temperature	High	High	High	High
Dissolved oxygen	High	High	High	High
pH	High	High	High	High
Soluble Reactive Phosphorus	Good	Good	Good	High
Ammonia	High	High	High	High
Hydrological regime	High	High	High	Good
Morphological conditions	No Data	No Data	-	-
Overall Status	GOOD	GOOD	GOOD	GOOD

9.61 NIEA has developed a series of RMBPs for each River Basin District including the current published plans for the Neagh Bann and North Eastern RBDs covering the period 2015-2021. These documents set out the latest assessment of pressures and impacts on the water environment; they describe the progress NIEA made towards achieving objectives for 2015 and explain the significant water management issues that still need to be addressed. Consultation on a draft 3rd cycle RBMP for Northern Ireland for the period 2021-2027 is currently underway.

EC Fish Directive

9.62 The EC Freshwater Fish Directive (Consolidated) 2006/44/EC (FWFD) set physical and chemical water quality objectives for salmonid waters and cyprinid waters, specifically with regard to dissolved oxygen, ammonia, pH and total zinc.

9.63 The main stem channels of the Clogmills, Killagan, Clogh River and tributaries draining the Site, including the Tullykittagh, Aghanageeragh, and Upper Bush, were designated as "salmonid" under the Surface Waters (Fish Life Classification) Regulations (Northern Ireland) 1997, which implements the EC Freshwater Fish Directive**.**

9.64 The Fish Directive was repealed by the Water Framework Directive at the end of 2013, and the ecological status defined in the WFD sets the same protection to waterbodies designated for fish under the original directive. Areas designated under the Fish Directive have become areas designated for the protection of economically significant aquatic species under WFD and placed on a Register of Protected Areas.

WFD Fish Monitoring

9.65 Water Framework Directive compliant fish surveys at surveillance stations are required under national and European law. Annex V of the WFD stipulates that rivers should be included within monitoring programmes and that the composition, abundance and age structure of fish fauna should be examined (Council of the European Communities, 2000). However, there was no recent data available from WFD fish monitoring for each of the relevant waterbodies (**Table 9.9**).

9.66 The following fish species are recorded as being present in the River Main and River Bush catchments:

- Atlantic salmon (*Salmo salar*);
- Brown trout and migratory dollaghan (*Salmo trutta*);
- Eel (Anguilla anguilla);

The following species may be present although there are no substantive records:

- Three-spined stickleback (*Gasterosteus aculeatus*);
- Minnow (Phoxinus phoxinus);
- Stone loach (Barbatula barbatula)
- River/Brook lamprey (*Lampetra* sp);
- Sea lamprey (Petromyzon marinus)

Significant Freshwater Species

9.67 This section outlines the current status of Annex II freshwater species and other species of conservation interest in the River Bush and Main catchments.

Atlantic salmon

9.68 As an anadromous species, Atlantic salmon use both the freshwater and marine environment for the completion of the life cycle. The relevant conservation designations for Atlantic salmon give the species national and international significance. Atlantic salmon is listed in Annexes IIa and Va of the EC Habitat and Species Directive (Directive 92/43/EEC), Appendix III of the Bern Convention, and has a IUCN status of threatened in the Irish Red List No 5 (King et al, 2011). The species was added to the UK Biodiversity Action Plan (BAP) list in 2007 as a priority species for conservation action.

9.69 Adult salmon mature at two to four years of age with spawning occurring between November and December usually in the upper reaches of suitable tributaries. Juvenile fish remain in freshwater for one or two years to attain sufficient size before becoming smolts, when they migrate to sea during April and May. The marine phase represents a period of rapid growth associated with greater food availability. Many salmon will return to freshwater in the following year as one sea-winter fish (grilse) but a proportion may remain at sea for another year to return as two sea-winter fish.

9.70 The North Atlantic Salmon Conservation Organisation (NASCO) has endorsed a precautionary approach to the conservation, management and exploitation of the salmon resource and the environments in which it lives; Northern Ireland, through the UK and EU, is a Party to NASCO.

9.71 Atlantic salmon stocks in general are in serious decline with some stocks threatened with extinction. As a conservation measure, the Fisheries Regulations (Northern Ireland 2014 saw the introduction of a series of regulations by DCAL (now DAERA) including the closure of commercial salmon fisheries and mandatory catch and release of salmon caught by anglers within the its jurisdiction.

9.72 The River Bush and River Main are two of seven Index Rivers utilised by DAERA to provide the basis for salmon management throughout Northern Ireland. Each river has been chosen to represent a different catchment type and provides key information on stock levels to inform regional policy.

Brown trout

9.73 Brown trout are a priority species for conservation action in Northern Ireland, as required under the Wildlife and Natural Environment Act (Northern Ireland) 2011. They are widely distributed in the River Main and River Bush catchments and a small proportion of the stock migrates to sea and returns to freshwater to spawn.

9.74 A unique variety of Brown trout, the Dollaghan, occurs in Lough Neagh and most of its tributaries including the Main (and its tributaries). The life cycle is similar to the Sea trout in that spawning and the juvenile life stages take place in the inflowing rivers, with subsequent migration to the lough where a period of rapid growth is followed by a return migration to natal rivers to spawn. These fish can grow to a large size (3-8kg), and are highly sought after by anglers.

Eel

9.75 The European eel the stock has been in rapid decline throughout its range since around 1980. This has led to the passing of the European Eel Regulation (EC) 1100/2007 which aims to return the European eel stock to more sustainable levels of adult abundance and juvenile eel recruitment. Member States are required to implement Eel Management Plans in each eel river basin, in this case the Neagh Bann International River Basin District and the North Eastern River Basin District.

9.76 The European eel is not listed under Annexe II but has recently been added to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species in the category of Critically Endangered (King *et al*, 2011).

9.77 There is no data available on the distribution of eel in the river Main and Bush catchments.

Lamprey

9.78 Sea and River lampreys are parasitic and migrate between the freshwater and marine environments, returning to freshwater to breed. In contrast, Brook lamprey are resident in freshwater throughout their life cycle and are non-parasitic. Brook lamprey are widely distributed in Northern Ireland but River and Sea lamprey have a more limited distribution (Goodwin *et al*, 2009). For example, sea lamprey do not occur in the River Main or any of the Lough Neagh tributaries due to an impassable barrier on the Lower River Bann; but a landlocked variety of River lamprey is present in the lough and migrates into the tributaries to spawn. While there is no data available on the distribution of River or Brook lamprey in the River Main nor on any of all three species in the River Bush, it is highly likely that either of the species is present.

9.79 All three species of Lamprey are designated under Annex II of the EU Habitats Directive (Directive 92/43/EEC) although none are listed as a site selection feature in five large SACs in Northern Ireland.

Salmon & Trout Stock Data

9.80 Annual monitoring of salmon (and trout) stocks in the River Bush and River Main catchments is conducted by DAERA IFD and AFBI.

River Bush Salmon Project

9.81 The River Bush Salmon Project is run by DAERA and supported by AFBI. This project was established in 1972 by the former Department of Agriculture as a long-term study into the dynamics of a wild salmon population and to investigate the factors influencing those dynamics. Under the terms of the lease DAERA controls the fishing rights throughout the entire freshwater network of Bush River.

9.82 The long-term research programme on survival of wild salmon during the freshwater and marine phases of the life cycle has provided a unique data series, and has

facilitated the development of conservation limits on other monitored rivers in the DAERA jurisdiction. The research programme has led to the recognition of the Bush River as an index river by the International Council for the Exploration of the Sea (ICES) which integrates the results with other index rivers in the North-East Atlantic region.

9.83 Data from the project on conservation requirements for salmon and on exploitation of salmon stocks at sea is central to the DAERA's Salmon Management Plan and also contributes to the assessment of salmon stocks at international level through ICES.

9.84 Within the Bush project, DAERA operates a high quality recreational salmon fishery on the river.

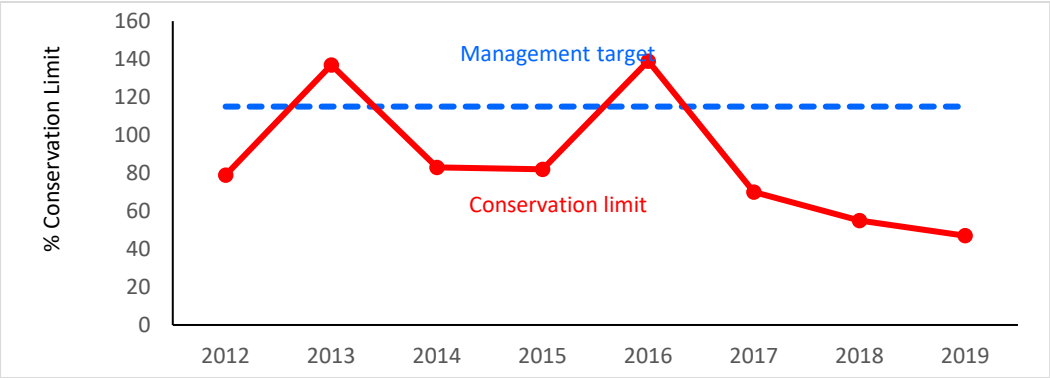
Adult Salmon Runs and Conservation Limits

9.85 A key factor in assessing the status of salmon stocks is determination of Conservation Limits for individual river systems. The Conservation Limit for Atlantic salmon is defined by NASCO as: *the spawning stock level that produces long term average maximum sustainable yield as derived from the adult to adult stock and recruitment relationship.* In simpler terms the Conservation Limit for a river is the number of spawning salmon required to ensure that salmon are reproducing in sufficient quantities to produce the next generation of fish.

9.86 DAERA IFD operates a management regime for salmon rivers within its jurisdiction which aims to manage salmon fisheries and spawning populations in a sustainable manner. The management target is a precautionary abundance reference point and represents 115% of the conservation limit as it allows for fish losses due to catches andpredation.

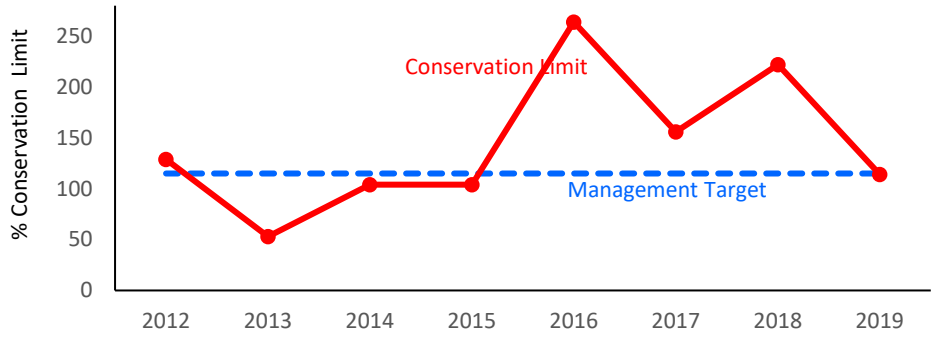
9.87 Annual returns of wild adult salmon to the Bush are computed from adult fish captured in the trap at Bushmills, and in the River Main from partial counts of adult fish at the installation in Randalstown. Charts **9.1 and 9.2** show percentage compliance with the conservation limit and management target in each river for the period 2012-2019. For the River Bush, there is considerable variability in the annual return of adult fish (Chart **9.2**); the conservation limit and management target have been achieved in only one of the last five years (2016) with a steady decline since then.

Chart 9.1 River Bush: percentage compliance with conservation limit and management target, 2012-2019 (Source: Kennedy et al. 2019 and 2020)



9.88 For the River Main, there was been a steady increase in the annual return of adult fish since 2013, with the target for the conservation limit achieved in each of the last five years and that of the management target achieved in 3 of the last 5 years (Chart **9.2**). Although the attainment of the management objective has resulted in a harvestable surplus of fish, the wide historical variability in return data meant that a low number of tags were allocated Kennedy et al. 2020).

Chart 9.2 River Main: percentage compliance with conservation limit and management target, 2012-2019 (Source: Kennedy et al., 2019 and 2020)



9.89 Generally, there has been an overall decline in the runs of adult fish in index rivers that has been attributed to a significant reduction in natural survival of young salmon during the marine phase. Marine survival has declined from approximately 30% between 1987 and 1993 to <6% for the period 2008-2017 (Kennedy et al. 2019).

Juvenile Fish Stocks

9.90 Fry distribution and abundance are an indication of the distribution and level of spawning by adult fish. Trends in abundance of juvenile salmon and trout are monitored by DAERA IFD/ AFBI through annual or rotational semi-quantitative

electrofishing surveys according to a methodology developed by Crozier & Kennedy (1994).

9.91 The semi-quantitative electrofishing method has been calibrated separately for trout and salmon based on extensive studies in river reaches of known juvenile salmonid density. This has resulted in the development of an abundance classification system (Abundance Index) for salmon with five categories: Absent, Poor, Fair, Good, Excellent (Crozier and Kennedy, 1994). The Abundance Index for trout has six classifications: Absent, Poor, Poor/Fair, Moderate, Good, Excellent (Kennedy, unpublished).

9.92 The locations and abundance classes of trout and salmon detected at DAERA IFD monitoring sites on the Upper Bush, Killagan, Cloghmills and Clogh River in 2018, which are hydrologically connected to the Site, are indicated for salmon and trout in **Figures 9.2** and **9.3**. Data for the Bush and Cloghmills are for 2018 whereas the Killagan and Clogh data are for 2016.

9.93 This data demonstrates that, immediately below the Altnahinch Dam, there is limited salmon spawning in the Upper River Bush with Poor-Fair abundance or absence across the DAERA survey sites. In the Killagan Water, salmon fry are widely distributed at Moderate to Good abundance from approximately 6km and greater downstream of the Site.

9.94 In the Cloghmills Water, which drains the majority of the Site, salmon are present from approximately 3 km downstream of the Site, where they occur at Poor to Good abundance. In the Clogh River, salmon are present at Fair to Good abundance immediately downstream of the confluence of the Tullykittagh Stream, approximately 5km downstream of the Site.

9.95 In contrast to salmon fry, trout fry are present in the Upper River Bush immediately below Altnahinch Dam at Good to Excellent abundance, with a reduced abundance in more distant downstream lower gradient reaches. In the Killagan Water, and again in contrast to the distribution of salmon fry, trout fry are absent for 4-5km from approximately 6km downstream of the Site.

9.96 In the Cloghmills Water, trout fry are present just below the Preliminary Site Boundary and for several kilometres downstream at Moderate to Excellent abundance. In the Clogh River, trout fry are present at Good to Excellent abundance downstream of the confluence of the Tullykittagh Stream.

9.97 The dataset demonstrates that salmon spawning is widely distributed in the main rivers into which streams draining the Site flow. Similarly, trout spawning is widely distributed although their distribution extends further upstream and is thus closer to the Site boundary.

Angling

9.98 The River Main is a popular salmonid angling system with excellent quality fishing in main channel and its tributaries such as the Clogh River, Braid Water, and Kells Water. Fishing Rights in the lower stretch of the Main are owned by Shanes Castle

Estate whereas local angling clubs administer most of the remaining stretches apart from areas retained by local riparian landowners.

9.99 Adult salmon run the river from July if water levels are sufficiently high and fishing can proceed until 31st October. Migratory Lough Neagh dollaghan run the river from August, while a stock of native brown trout is present.

9.100 The Main Enhancement Partnership was set up by local angling clubs and fishery owners during the 1990's with the aim of improving fish stocks. The MEP preceded the recently formed Maine Rivers Trust, which aims to conserve, protect and rehabilitate watercourses of the catchment.

9.101 The key angling clubs and fishery owners are: Braid Angling Club, Glenravel and Clogh Angling Club, Gracehill Galgorm and District Angling Club, Kells Vonnor and Glenwhirry Angling Club, Maine Angling Club, Randalstown Angling Club, Demense Anglers (Shanes Castle Estate).

9.102 On the River Bush, salmon angling is administered through DAERA who operate four managed stretches (or beats) in the Bushmills area at the lower end of the catchment, each of which is restricted to between three and six rods. Angling on the rest of the river is also controlled by DAERA but is open access without rod limits or any bookings.

Site Survey: Fisheries Habitat

Overview

9.103 The Proposed Development is located within three sub-catchments of the River Main - the Killagan, Cloghmills and Clogh Rivers - and a small part of the River Bush catchment. The majority of the Site is drained from the north-east to south-west by the Aghanageeragh River, and two of its tributaries near Magheraboy; all drain into the Cloghmills River (**Figure 9.4**).

9.104 In the western corner of the Site, the upper most sections of two small watercourses drain into the Killagan Water. In the south-eastern corner, just outside the Site boundary, the uppermost section of the Tullykittagh Water drains to the Clogh River. On the north-eastern corner of the Site, a very small tributary of the Flisk Burn, drains to the Upper River Bush catchment. Site drainage is described in further detail in **Chapter 10 Geology & Water Environment**.

9.105 The fish habitat survey consisted of a walkover assessment of the main drainage streams within and downstream of the Site boundary (**Figure 9.4**).

9.106 In addition, a walkover assessment of salmonid habitat was conducted within the Site in the headwaters of these small watercourses, with a focus on areas of watercourse and site track intersection. The aim was to inform on potential culverting requirements for fish passage.

General Description / Observations

Flisk tributary

9.107 This watercourse drains a small area in the north-east of the Site of mainly blanket bog and marshy grassland, initially flowing north before flowing north-west just beyond the Site where it runs parallel to the Altnahinch road. This headwater stream has been diverted from its original path; it previously crossed beneath the road via a culvert to join the upper River Bush amongst plantation forestry but now flows through a series of culverts into the Flisk Burn approximately 2km downstream. The Flisk Burn joins the Bush after a further 2.5km.

9.108 The stream is initially very narrow and cuts through steep sided peat banks where it flows over cobble substrate within the Site; the stream is steep with good flow and a mixture of grade 2 and 3 salmonid nursery habitat (**Plate 9.1**).

9.109 Downstream of the Preliminary Site boundary, the stream flows over a base of peat and cobble/ pebble with relatively low fisheries potential. A series of culverts situated along its course parallel to the Altnahinch Road are impassable to fish (**Plate 9.2**).

Plate 9.1: Flisk tributary – view upstream into Site

Plate 9.2: Flisk tributary – long culvert 40m downstream of Site boundary

Tullykittagh Water

9.110 This watercourse is outside the Site to the south-east. It is sourced from blanket bog in an area grazed extensively by sheep. After approximately 1km, the true left bank enters an area of defined field boundaries grazed by sheep whereas the true right bank is bounded by blanket bog (**Plate 9.3**). The gradient is moderate and the substrate indicative of good salmonid habitat with cobble and pebble in riffle/ run flow habitat.

9.111 A waterfall 1.4m high, and impassable to migratory trout, is located approximately 1.6km from the streams source (**Plate 9.4**). Below this, habitat is a mixture of fast runs and chutes over bedrock and cobble/ gravel. Both banks show signs of erosion

and collapse (**Plate 9.5**). Salmonid habitat is mainly grade 3 pool with grade 2 and 3 nursery, indicative of moderate fisheries potential.

Plate 9.3: Tullykittagh Water at Preliminary Site Boundary

Plate 9.4: Tullykittagh Water showing impassable waterfall

Plate 9.5: Tullykittagh Water - eroded/ collapsed banks in area below waterfall

Plate 9.6: Aghanageeragh River – 450-500m downstream of Preliminary Site boundary

Aghanageeragh River

9.112 The Aghanageeragh River is the major watercourse within the Site; it drains the main area of the Proposed Development where surrounding land use is a mixture of rough grazing by cattle and sheep, blanket bog and marshy grassland. The stream is crossed approximately 300m downstream of the Site by a farm track that forms a concrete ford over a multi-barrel pipe culvert series that appears impassable to migratory salmonids. Downstream of the ford, the gradient is moderately steep with a series of cascades, fast riffles and pool pockets; the width is approximately 2.5-3.0m (**Plate 9.6**). Nursery habitat is good to excellent quality.

9.113 135m downstream of the farm track, a large impassable cascade and waterfall extends over approximately 25m of channel and drops by several meters in height

(**Plate 9.7**). Below the falls, there is some bank erosion on the true left side although habitat quality remains good with runs/ riffles over boulder/ cobble substrate and good to excellent nursery habitat (**Plate 9.8**)

9.114 Above the farm track and ford, the stream is 2.5-3.5m wide but shallower and dominated by boulder and cobble in good quality salmonid nursery habitat. Further upstream within the Site, the channel narrows to approximately 1.5-1.8m wide and a depth of 0.1-0.25m. Flow habitat is a series of riffles, runs, and small cascades and pools. Habitat is of good with high potential for supporting trout (**Plate 9.9**).

Plate 9.7: Aghanageeragh River – Waterfalls ca. 600m downstream of Site

Plate 9.8: Aghanageeragh River – Waterfalls ca. 700m downstream of Site

Plate 9.9: Aghanageeragh River – within Site north-west of proposed turbine T7

Aghanageeragh tributary

9.115 This very small tributary (ca. 0.5m wide) in the southern part of the Site is crossed by a farm track approximately 300m downstream of the Site. The watercourse drains an area of rough grazing, marshy and semi-improved grassland and is incised above the farm track (**Plate 9.9**). The banks are poached by cattle and sheep although the depth is good with moderate flows and a substrate of coarse sand, silt and pebbles; fisheries potential is low.

9.116 Below the farm track, the channel is subject to heavy livestock poaching and appears "drain-like". Substrate is mainly fines with occasional cobbles and boulder in grade 3 nursery/ pools with low fisheries potential **(Plate 9.10)**.

Plate 9.9: Aghanageeragh tributary looking upstream to its source

Plate 9.10: Aghanageeragh tributary - heavy poaching and channel widening

Plate 9.11: Magheraboy Burn upstream of farm track

Plate 9.12: Magheraboy Burn - view downstream below farm track

Magheraboy Burn (Aghanageeragh)

9.117 The upper part of this small watercourse runs close to the southern boundary of the Site south-east of proposed turbine no. 5 and drains an area of blanket bog and extensive rough grazing. The Burn then flows through more intensive managed sheep grazing and joins the main Aghanageeragh 2.5km from its source.

9.118 The Burn crosses a farm track approximately 750m below the Site and is relatively steep above this with mainly grade 2/3 nursery over a mixed cobble/ boulder and pebble bed (**Plate 9.11**).

9.119 Below the farm track, the gradient is moderate and the stream flows through sheep pasture and silage fields. Salmonid habitat quality improves with mainly cobble and boulder in run/ riffle flow habitat with occasional small pools (**Plate 9.12**).

Killagan eastern streams

9.120 The upper part of the eastern Killagan tributary is formed by a series of small drains before flowing west/ south-west downstream of the Site boundary near proposed turbine no. 1.

The stream is narrow (circa. 0.5-0.7m wide), shallow, and relatively steep with heavy bank poaching by sheep and poor quality salmonid habitat dominated by finer substratum (**Plate 9.13**).

Another small tributary entering the eastern tributary from the south is incised with high levels of peat bank erosion and collapse. The bed is a mixture of boulder, cobble, pebble and coarse fines and is at best grade 3 nursery though with large areas unsuitable for trout (**Plate 9.14**)

Plate 9.13: Killagan stream at 310939E 420962N

Plate 9.14: Killagan tributary at 311004E 420914N

Site Survey: Stream Quality

9.121 Six sites were surveyed in the watercourses draining the Proposed Development (Sites 1-7; **Volume 3 - Figure 9.4**) as follows:

- Site 1 – Main Aghanageeragh River at south-western boundary of Site.
- Site 2 – Aghanageeragh tributary below Site southern boundary.
- Sites 3 – Magheraboy Burn below Site southern boundary.
- Sites 4 – Tullkittagh Water below Site boundary.
- Site 5 – Flisk tributary at Site north-eastern boundary.
- Site 6 – southern Killagan stream at western boundary of Site

Chemical Water Quality: Basic Parameters

9.122 All streams had high and satisfactory dissolved oxygen levels with very low conductivity recorded in the Main Aghanageeragh, Flisk tributary, the Tullykittagh Water, and the eastern Killagan tributary, and low conductivity in the remaining survey sites **(Table 9.11)**.

Table 9.11: Water chemistry parameters measured at six survey sites, Oct. 2019.

Site	River/ stream location	Diss. Oxygen (mg/l; % sat)	Conductivity (µS/cm)
1	Main Aghanageeragh River	11.9 (97%)	63
2	Aghanageeragh tributary	11.9 (98%)	130
3	Magheraboy Burn	12.1 (99%)	128
4	Tullykittagh Water	11.8 (98%)	55
5	Flisk tributary	11.8 (97%)	51
6	Eastern Killagan stream	11.5 (95%)	60

9.123 It should be noted that spot measurements of physico-chemical parameters provide only a snap-shot of stream water quality; consensus on overall quality should consider consider additional indicators such as those provided by stream macroinvertebrate communities (see below).

Physical Habitat Quality

9.124 Most of the survey sites on streams draining the Site (sites 2-6) were narrow, of moderate depth and moderate to high flow velocities (**Table 9.12**). The exception was site 1 on the Aghanageeragh, which was the largest stream draining the site with high flow velocity and substrate coarseness. It should be noted that these streams would have had much lower baseline depths and flows since surveys were conducted at the onset of spate conditions.

9.125 Apart from the Aghanageeragh, substrate was mainly of low to intermediate coarseness, dominated by cobbles, gravels and pebbles, with low riverbed cover of fine sediment. The exception was site 2, where the substrate comprised finer material including silts, coarse sand and small pebbles, and fine sediment cover exceeding the 29% threshold where benthic diversity may be compromised.

9.126 Only at sites 1 and 5 were riverbed coarseness indices generally above or close to values reported in rivers with good salmonid habitat elsewhere in Northern Ireland (Johnston, 2012).

Table 9.12: Stream habitat quality at each site from baseline surveys, October 2018.

Site	River/ stream	Sediment cover (%) & type	Mean width (m)	Mean water depth (m)	Mean flow velocity (ms-1)	Coarse-ness index (CI)	Substrate hetero-geneity (SD)	Inferred substrate
1	Main Aghanageerag h River	0	2.9	0.32	0.63	4.1	0.4	Almost heterogeneou s; coarse
2	Aghanageerag h tributary	34; sand & silt	0.5	0.35	0.27	2.4	1.0	Mixture; almost smooth
3	Magheraboy Burn	12.0; silt	2.1	0.3	0.27	3.4	0.86	Mixture; inter-mediate coarseness
4	Tullykittagh Water	8.4; peat; silt	1.15	0.45	0.51	3.05	0.9	Mixture; inter-mediate coarseness
5	Flisk tributary	0	0.95	0.11	0.35	3.9	0.8	Mixture; inter-mediate coarseness
6	Eastern Killagan stream	4.2; sand & silt	0.6	0.08	0.21	2.8	0.8	Mixture; low to inter-mediate coarseness

Aquatic Ecology

9.127 Recorded ecological quality for the six survey sites is shown in **Table 9.13**. Based on the benthic invertebrate indicator element, and the "one out, all out" philosophy, all sites, except for sites 2 and 6, were classed as having "HIGH" WFD-based ecological quality (**Table 9.13**).

9.128 Sites 2 and 6 were classed as "GOOD" ecological quality largely on the basis of the slightly reduced number of taxa observed compared to that expected based on RICT predictions, which may be related to the higher cover of fine sediment or finer substrate material at these sites. Nonetheless, the overall assessment generally corresponds with the relatively un-impacted physical habitat, moderate elevation, and lack of intensive agriculture in land use upstream of all sampling locations.

Table 9.13: WFD-based ecological quality classes at each site derived from benthic invertebrate baseline surveys, October 2018.

Site	River/ stream	BMWP WHPT score	Number of taxa	N-TAXA WFD-based invert. class	WHPT ASPT	ASPT WFD-based invert. class
1	Main Aghanageeragh River	121	18	HIGH	6.7	HIGH
2	Aghanageeragh tributary	109.7	17	GOOD	6.4	HIGH
3	Magheraboy Burn	100.6	15	HIGH	6.7	HIGH
4	Tullkittagh Water	139.5	19	HIGH	7.3	HIGH
5	Flisk tributary	141.4	21	HIGH	6.7	HIGH
6	Eastern Killagan stream	95.6	15	GOOD	6.47	HIGH

Site Survey: Juvenile Fish Stocks

9.129 The survey of fish stocks was conducted in early September 2019 at locations corresponding with Stream quality survey sites; additional sites were surveyed on the main Aghanageeragh River north of proposed turbine 7 (site 1c) and downstream of site 1 and an impassable waterfall (site 1b), the Magheraboy Burn downstream of site 3 and a potentially impassable culvert (site 3b), and the Flisk Burn tributary, 500m downstream of site 5 **(site 5b; Table 9.14; Volume 3 - Figure 9.5)**.

9.130 Baseline data for the Killagan streams downstream of the Site was transcribed from a published report for the Corkey Windfarm Repowering project (Scottish Power Renewables, 2019).

9.131 In the current surveys, salmon were absent at all survey sites. Trout were present at 5 of the 10 survey sites in 2019, including the main Aghanageeragh River north of proposed turbine no. 7 and, upstream and downstream of the falls below the Site boundary (sites 1a and 1b), the Magheraboy Burn downstream of the farm track (site 3b), the Tullykittagh Water (site 4), and the Aghanageeragh tributary (Aged 1++ only, site 2; **Figure 9.5**), and in the eastern Killagan tributary 500m downstream of the Site; **Figure 9.5**).

9.132 In the eastern Killagan tributaries draining the Site, published data for 2017 showed that trout were present 500m downstream of the Site and beyond.

9.133 Aged 0 trout abundance ranged from Poor to Good, indicating a low level of spawning in the Magheraboy tributary of the Aghanageeragh, the Killagan

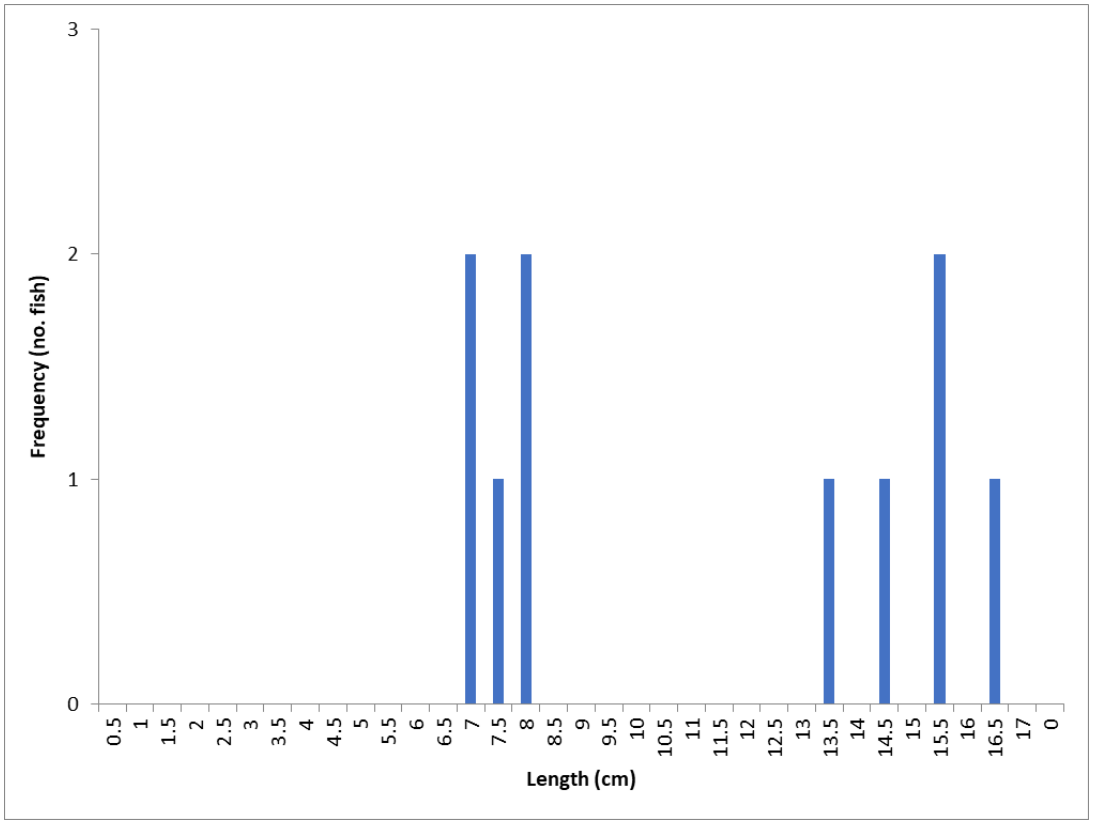
tributaries, and the Tullykittagh Water, and moderate to good spawning in the main Aghanageeragh River; these abundance classes undoubtedly reflect the quality of habitat measured in each of the watercourses.

9.134 Although a single Aged 1 trout was recovered in the Aghanageeragh tributary (site 2), no Aged 0 trout were present. No fish were present in the Flisk tributary survey sites (site 5 and 5b). No other fish species were recorded at any of the sites.

Population Age Structure

9.135 The age structure of the trout stocks across the sampling sites was verified by constructing composite length frequency distributions (Chart **9.3**).

Chart 9.3: Length frequency distribution of trout caught in watercourses draining the Site boundary.



9.136 The trout length frequency shows a clear separation of Age 0 fry (<9 cm) from Age greater than 1 fish (>13 cm). The trout length frequency indicates that there appears to be an absence of fish in the size range 9.0-13cm, which could indicate a lack of recruitment in spring 2018. Fish greater than 14.0cm are likely to be Age 2 or older.

Fish Distribution & Abundance

9.137 The results of the semi-quantitative survey are shown in **Table 9.14** with the numbers of trout at each site separated into age groups based on observed fish length as outlined above.

9.138 The lack of salmon in any tributary draining the Site appears to be consistent with the distribution of salmon indicated by DAERA IFD, which is constrained to the main Cloghmills, Killagan, and Clogh River, and the River Bush downstream of Altnahinch Dam **(Figure 9.2)**.

9.139 Of the streams draining the Site, the Killagan, the Aghanageeragh River and its Magheraboy Burn tributary, and the Tullykittagh Water contained Aged 0 trout. Trout recruitment in these watercourses reflects the moderate to excellent quality nursery habitat recorded during physical habitat and walkover surveys.

9.140 Although trout presence in the Aghanageeragh and Tullykittagh is consistent with their wide distribution indicated by DAERA IFD monitoring data, trout in the Killagan appear to be restricted to the upper reaches, including the eastern streams draining the Site, since salmon appear to dominate in the middle to lower reaches of the main Killagan (Vol 3 **Figures 9.2 & 9.3**).

9.141 In the Aghnageeragh tributary (site 2), the lack of Aged 0 trout recruitment reflects the generally poor quality nursery habitat recorded during physical habitat surveys.

9.142 In the Flisk tributary sites (5 and 5b) trout absence is most likely influenced by impassable culverts along its diversion route parallel to the Altnahinch Road, although trout were notable at Good and Excellent abundance below the confluence of the Flisk Burn with the River Bush.

Table 9.14: Summary results of 2019 electrofishing survey indicating numbers of age 0 and older (1++) trout and salmon caught; fry abundance indices also indicated.

Site	Stream	Trout (Age)		Salmon (Age)		Fry abundance index	
		(0)	(1++)	(0)	(1++)	Trout	Salmon
1	Aghanageeragh u/s of ford	5	1	0	0	Moderate	Absent
1b	Aghanageeragh 220m d/s waterfall	6	6	0	0	Moderate	Absent
1c	Aghanageeragh NW of proposed turbine 7	10	0	0	0	Good	Absent
2	Aghanageeragh tributary d/s farm track	0	1	0	0	Absent	Absent
3	Magheraboy Burn u/s farm track	0	0	0	0	Absent	Absent

Site	Stream	Trout (Age)		Salmon (Age)		Fry abundance index	
		(0)	(1++)	(0)	(1++)	Trout	Salmon
3b	Magheraboy Burn d/s farm track	1	3	0	0	Poor	Absent
4	Tullykittagh Stream	1	0	0	0	Poor	Absent
5	Flisk tributary – Site boundary	0	0	0	0	Absent	Absent
5b	Flisk tributary 500m d/s Site	0	0	0	0	Absent	Absent
6	Eastern Killagan tributary	0	0	0	0	Absent	Absent

Assessment of Effects

9.143 Potential effects were assessed for construction, operational and decommissioning phases of the Proposed Development. Construction impacts cover the discharge of suspended solids, release of other pollutants and temporary interruption of fish passage. Post-construction (operational) impacts include habitat loss at watercourse crossings, permanent obstruction of fish passage and surface water run-off.

9.144 Impact assessments are primarily based on their effect on salmonids either directly or upon their habitats but are relevant to eels and lamprey if present in these waters.

Fisheries Significance / Aquatic Ecological Sensitivity

9.145 Using the information assembled through the baseline assessment, the Fisheries and Aquatic Ecological Sensitivity for the main watercourses draining the area within the Site boundary and downstream sensitive watercourses, is shown in **Table 9.15**. A watercourse was deemed to have a Very High sensitivity if its WFD class was High and/or Annexe II species were present (e.g. salmon).

9.146 Of the Site drainage streams, the Aghanageeragh tributary was assessed at High sensitivity since; although only trout Aged 1 or older were present, WFD-based ecological quality was Good. Similarly, the eastern Killagan tributary was assessed at High sensitivity because of Good WFD-based ecological quality and the presence of trout downstream of the Site.

9.147 All other streams draining the Site were assessed at Very High sensitivity due primarily to High WFD-based ecological quality and/ or trout presence.

9.148 The downstream main channel rivers, the Killagan, Cloghmills, Clogh Water and the Upper River Bush, were assessed at Very High sensitivity due to the presence of

Annexe II listed Atlantic salmon although all had Good WFD-based ecological quality.

Construction Phase

9.149 The potential for impacts on fisheries and aquatic habitats during the construction phase is mainly associated with ground disturbance and the entrainment of sediments in surface water drainage. There is also a potential impact from the accidental spillage of other hazardous substances (oil and fuel) used in the construction process.

9.150 Obstruction of fish passage within the Site is a potential impact at several watercourses if culvert crossings are proposed.

Table 9.15: Sensitivity of receiving watercourses within the Preliminary Site Boundary and downstream to the Upper Bush, Killagan, Cloghmills and Clogh Rivers.

River/Stream	Key Species/ receptors	WFD class	Sensitivity
Site drainage streams			
Main Aghanageeragh River	High proportion of stream within Site boundary; trout present within and below Site boundary, with evidence of Moderate spawning.	HIGH	Very High
Aghanageeragh tributary	Stream partly within Site boundary; trout present below Site boundary.	GOOD	High
Magheraboy Burn	Stream partly bordering Site boundary; trout present below Site boundary with evidence of limited spawning.	HIGH	Very High
Tullykittagh Water	Stream outside Site boundary but with potential to intercept drainage; trout present.	HIGH	Very High
Flisk Burn tributary	Stream source within Site boundary; No fish present within or immediately downstream of Site.	HIGH	Very High
Eastern Killagan stream	Fish absent in section within Site boundary but trout present below boundary at low abundance	GOOD	High
Sensitive downstream watercourses			
Killagan Water	Receiving watercourse; located downstream of the Site; Annexe II species: Salmon present at Moderate to Good abundance from approximately 6km downstream of Site; lamprey species probably present. Brown trout present	GOOD	Very High
Cloghmills Water	Receiving watercourse; located downstream of the Site; Annexe II species: Salmon present at Poor to Good abundance from approximately 3km downstream of Site; lamprey species probably present. Brown trout present	GOOD	Very High
Clogh Water	Receiving watercourse; located downstream of the Site; Annexe II species: Salmon present at Moderate	GOOD	Very High

River/Stream	Key Species/ receptors	WFD class	Sensitivity
Site drainage streams			
	to Excellent abundance from approximately 5km downstream of Site; lamprey species probably present. Brown trout present		
Upper River Bush	Receiving watercourse; located downstream of the Site; Annexe II species: Salmon present at Poor to Fair abundance from approximately 4.5km downstream of Site; lamprey species probably present. Brown trout present	GOOD	Very High

Sediment Run-off

9.151 The release of fine sediment (grain size <2mm) is potentially a major cause of environmental impacts and is associated with clearly defined negative impacts (Newcombe and Jensen, 1996; Turley et al. 2014). Sensitive fish species such as brown trout and Atlantic salmon are highly vulnerable to suspended and deposited sediment in spawning and nursery habitats (Kemp et al. 2011). In spawning gravels, incubating salmonid eggs require good water circulation to provide oxygen and remove waste products. As deposited fine sediment content increases, gravels become embedded, resulting in restricted water circulation and reduced egg and alevin survival. After emergence, juvenile salmonids (fry) disperse downstream to suitable nursery rearing habitat generally within 100m (Kennedy, 1984), often in faster flowing riffles/ runs, where they establish feeding territories and compete for food.

9.152 Suspended sediment can lower water clarity leading to reduce prey capture efficiency and may affect respiration rates by clogging of gills (Kemp et al. 2011). Deposited sediment can reduce habitat complexity and quality by in-filling of substrate, thus reducing territory size leading to increased aggression and ultimately lower carrying capacity. Deposited fine sediment can also indirectly affect growth and survival of juvenile salmonids by reducing the quality of habitat for preferred invertebrate prey species (Suttle et al., 1994).

9.153 Adult salmonids are prone to gill-clogging and visual impairment at high levels of suspended sediment but are much less reliant on substrate complexity, tending to occupy deeper pools, particularly during the spawning season. Adult salmonids are also more mobile than sessile eggs or juvenile stages, and thus more capable of avoiding adverse local conditions (Kemp et al. 2011).

9.154 Freshwater benthic macroinvertebrates are also an important component of river ecosystems, acting both as sentinels of general water and habitat quality, and as an important food resource for higher trophic levels such as fish and birds. Pulses of fine sediment can cause behavioural drift, whereas excessive fine sediment can reduce the quality of physical habitat by smothering and blocking of interstitial spaces and water flow (Allan, 1999). As fine sediment infiltration increases,

invertebrate abundance and community diversity is reduced, resulting in the replacement of sensitive taxa (mayfly, stonefly and caddis) by more tolerant types (worms, midge larvae, molluscs; Matthaei et al. 2006; Kemp et al. 2011).

9.155 Sediment release and entrainment can also increase the risk of nutrient addition and alterations in channel morphology and hydrology (Levesque and Dube, 2007). For example, excavated bank material or soils associated with the construction process could increase inputs of sediment bound phosphorus, which could negatively affect aquatic biota by causing excessive algal and macrophyte growth, and depressed oxygen levels.

9.156 Fine sediment is partly managed by the water quality objectives and standards of the EC Freshwater Fish Directive 2006/44/EC (FWFD), where a mean total suspended solids (TSS) concentration of 25 mg/L is specified for salmonid waters. While Article 6 of the Water Framework Directive has now repealed the FWFD, new standards that provide the same level of protection have been proposed (WFD-UKTAG, 2010). However, there is no national environmental standard or guideline for deposited fine sediment in the UK. Fine sediment cover above a threshold of 20% bed cover, based on recommendations in New Zealand by Clapcott et al. (2011), and published research in the United Kingdom (e.g. O'Connor & Andrew,1998; Kemp et al. 2011), provides a general indication of increasing risk for both invertebrates and salmonids.

9.157 The discharge of suspended solids during construction of the proposed Carnbuck wind farm could result from:

- Excavations associated with construction of access tracks and turbine foundations
- Excavations associated with watercourse crossings
- Surface peat disturbance and subsequent erosion of the underlying soils
- Stockpiling of soils and excavated materials
- Run-off from access roads
- Landslide resulting from slippage of access roads or excavated materials.

9.158 The proposed site is hydrologically connected to watercourses of significant fisheries interest via on-site and off-site watercourses which are potential routes for suspended solids run-off. The Aghanageeragh, Tullykittagh and eastern Killagan tributaries are of local fisheries significance as they provide spawning and nursery rearing habitat for trout, which would be vulnerable to suspended sediment.

9.159 Sensitive watercourses further downstream of the Site drainage streams include the Killagan, Cloghmills, Clogh Water and the River Bush, which are of particular significance as they support salmon, trout and recreational angling. Salmon also are an EC Habitats Directive Annexe II listed species.

Release of other pollutants

9.160 As the Site drains a number of tributaries and downstream sensitive watercourses, there is potential for spillage or release of diesel, oil or other polluting substances, with consequences for resident trout or salmon together with invertebrate organisms that underpin the generally Good or High ecological quality recorded for these streams.

9.161 During construction, with high usage of plant fuel and oil, there is an increased risk of accidental spillage and discharge to the any of the drainage streams and thence to the more sensitive Killagan, Cloghmills, Clogh, and Bush rivers. Similarly, the application of ready-mix concrete in construction processes carries some risk of inadvertent discharge with the potential to impact on resident fish and invertebrate organisms and the water body WFD classifications.

Fish passage: temporary obstruction

9.162 Poor management of works adjacent to stream banks or at crossing points may lead to obstruction of the channel during periods of fish migration and spawning.

9.163 The layout of the proposed site tracks would indicate thirteen key areas where crossing of a watercourse will be necessary within the planning application boundary (see Figure 1.3 Infrastructure layout).

9.164 Of these proposed track crossings, only the main Aghanageeragh River west of proposed turbine 7 has trout in the immediate vicinity where an impact of a culvert would be expected.

9.165 The absence of juvenile fish in the vicinity of the proposed crossing in the eastern Killagan tributary (south of proposed turbine 1) is likely due to poorer nursery habitat and a lack of suitable spawning gravels. A culvert at this location would not have any impacts on the movement of fish.

Operational Phase

9.166 The potential for any impacts will be significantly reduced during the operational phase with the construction process complete, site infrastructure in place, and a reduced requirement for any hazardous materials on-site. Potential impacts at Carnbuck are essentially limited to surface water run-off, permanent fish passage obstruction, and loss of habitat.

Surface Water Run-off

9.167 Surface water run-off from hard surfaces (access tracks, hard stands, control buildings) could lead to sediment-laden run-off to the receiving watercourses with potential effects on fish and other forms of aquatic life as outlined above; however, the effects are expected to be less severe because no soil/ peat disturbance will occur. Any local effects on fish are more likely in the Aghanageeragh River within the Site, given its proximity to the various proposed site tracks.

9.168 Effects may also occur in more distant reaches downstream from the planning application boundary (e.g. in the Flisk, Killagan, Cloghmills and Clough Water).

9.169 Wash-out of areas of excavated peat during or following periods of heavy rainfall could also result in run-off of sediment to the receiving watercourses with potential increases in sediment load.

Fish Passage obstruction/ inhibition

9.170 The construction of bridges and culverts has the potential to prevent or hinder normal fish movement within the stream or upstream migrations of pre-spawning adults unless consideration is given at the design stage.

9.171 Obstructions can occur if inverts are not sufficiently embedded to below the water level or if the length and gradient over which the culvert is installed causes high flow and an inability to find flow refugia due to a lack of baffles or natural stream substrate.

9.172 An assessment of the upper Aghanageeragh River just upstream of the proposed crossing west of turbine 7 indicates the presence of good abundance of juvenile trout and thus indirect evidence of adult fish spawning within this reach. The proposed installation of a bottomless culvert at the main crossing point of the Aghanageeragh River will avoid any obstacle within the channel and thus remove the risk of obstructing fish passage.

Habitat loss at stream crossings

9.173 Depending on the length of culvert used, a watercourse crossing may result in significant loss of habitat, particularly where the original channel bed is lost and cannot be restored. Removal of bed material also can result in long term loss of fish habitat and channel diversity. Enclosure of the channel over significant lengths restricts light penetration which inhibits growth of benthic algae and aquatic plants, in turn leading to reduced potential for macroinvertebrate and fish productivity

9.174 However, the crossing on the Aghanageeragh River will not result in loss of good quality physical habitat because a bottomless (clear-span) culvert will be installed.

Decommissioning Phase

9.175 Decommissioning of the Proposed Development would have potential effects on fish stocks and aquatic habitats in the drainage tributaries and the more distant Killagan, Cloghmills, Clogh and Bush rivers. Impacts will be similar to those predicted for the construction phase but will ultimately depend on the level of reinstatement required.

9.176 In this case the decommissioning process will involve the removal of all above ground structures, removal of underground structures to one metre below ground level, and reinstatement of disturbed areas; access tracks are likely to remain for farm use. However, it is unlikely that any of the structures at or near to the main watercourses will be removed or modified in any way.

9.177 The effects of decommissioning on fish habitats and fish stocks are therefore likely to be similar to those of construction for sediment run-off and the release of other pollutants, although of lower magnitude. No effect on fish passage or habitat loss is expected since structures within watercourses will remain in place to allow for use of farm access tracks.

Mitigation

Construction Phase

Sediment Run-off

9.178 Mitigation measures to control sediment run-off are described in detail in **Chapter 10 (Geology & Water Environment)** and summarised as follows:

Buffer Zones

9.179 During the construction phase it is important that works should be avoided within the area of sensitive watercourses, with the preservation of intact vegetated buffer zones between the development infrastructure and stream channels. To this end, buffer zones of 10m and 50m minimum width are specified in Chapter 10 for minor and major watercourses, respectively. The larger minimum buffer of 50m will apply to the more sensitive main Aghanageeragh River, which is a key watercourse within the Site in terms of fisheries sensitivity.

9.180 Turbine bases, access roads (apart from at stream crossings) and associated infrastructure will be located out-with buffer zones.

9.181 The application of buffer zones will minimise the risk of sediment run-off from site construction works to on-site watercourses and the most sensitive downstream reaches (Aghanageeragh River, Magheraboy Burn, Tullykittagh, eastern Killagan tributaries) and more distant receiving reaches in the Killagan, Cloghmills, Clogh and Bush rivers.

Timing of Works

9.182 DCAL (now DAERA) Inland Fisheries produced Guidelines for Fisheries Protection during Development Works (undated) which identify the likely impact of construction and development work on fisheries habitat and outlines practical measures for the avoidance and mitigation of damage.

9.183 The Proposed Development will require watercourse crossings on the main Aghanageeragh and the eastern tributary of the Killagan Water. The Aghanageeragh has good abundance of juvenile trout at the proposed crossing and is clearly accessed by mature adult trout. The eastern Killagan tributary does not have fish present and there is very low potential for its use by adult trout.

9.184 Although DAERA guidelines for work within watercourses recommends that construction works are avoided between October 1st and April 30th, it is proposed to install a bottomless culvert at the main crossing point of the Aghanageeragh

River and avoid any in-channel works; if bottomless culverts are used, then timing is less restrictive provided that other conditions/ precautions are applied to avoid sediment inputs. In the eastern Killagan, timing of works is not an issue for fish passage but sediment mitigation measures should apply.

9.185 All works at stream crossings will adhere to the measures outlined in the Guidance for Pollution Prevention: Works and maintenance in or near water: GPP 5 (Environment Agency, 2018). It is also recommended that to minimise the risk of suspended sediment entrainment in surface water run-off, the site drainage system should only be constructed during periods of low rainfall and therefore low run-off rates.

Surface Water Management

9.186 The potential for pollution of watercourses by silt-laden runoff is addressed in detail in Chapter 10: Geology & Water Environment. A surface water management plan will be developed using the principles of Sustainable Drainage, based on the on-site retention of flows and use of buffers, swales, check-dams and other silt removal techniques.

9.187 Implementation of the management plan will prevent any adverse effects on the ecology of the principal receiving watercourses during the construction phase of the project.

Water Quality Monitoring

9.188 Chapter 10 also proposes the implementation of a water quality monitoring programme to examine the effects of the infrastructure construction works on surface water quality. It is recommended that the monitoring programme be continued through the operation and decommissioning phases of the Proposed Development.

Release of other pollutants

Site Management

9.189 All precautions will be taken to avoid spillages of diesel, oil or other polluting substances during the construction phase. This will be achieved through good site practices as described in the Good Practice Guidance notes proposed by EA/SEPA/NIEA (Environment Agency, 2014), including:

- PPG1: General Guide to the Prevention of Water Pollution;
- GPP5: Works in or near to Watercourses;
- PPG10: Working at Construction and Demolition Sites.

9.190 A Pollution Prevention Plan will be included as part of the Construction Environmental management Plan (CEMP) for the Proposed Development, to be agreed with the local planning authority at the pre-construction stage. This will incorporate a contingency plan setting out the procedure to be followed in the event of a significant spillage occurring.

Surface Water Management

9.191 The proposed surface water management plan and associated SuDS system will also facilitate the interception of diesel, oil or other polluting substances during the construction phase.

Fish passage: temporary obstruction

9.192 Unless bottomless culverts are used, instream works to install crossings should be avoided between October 1st and April 30th so as to minimise disruption to the free movement of pre-spawning trout resident trout and any incubating eggs. This should apply to the following location;

- Access track over Aghanageeragh River north-west of proposed turbine 7.

Operational Phase

Surface Water Run-off

9.193 As outlined in Chapter 10, site drainage will use the principles of SuDS, with installations to incorporate a "treatment train" of two to three stages of pollutant removal to all surface water runoff during the operational phase, as with the construction and decommissioning phases. Additional measures to prevent the release of suspended solids will include:

- Preservation of natural run-off patterns;
- Reduction of flow rates from access tracks through use of attenuating check-dams;
- Use of shallow ponds to aid settlement;
- Linear track drainage swales with regular outflow points throughout the SuDS system to limit the potential for large flows at single outflow points;
- Avoidance of peat storage within denoted watercourse buffer zones or in areas of overland water flow.

Fish passage obstruction/ inhibition

9.194 The installation of a bottomless (clear-span) culvert is proposed at the sensitive watercourse crossing on the Aghanageeragh River. This will ensure free movement of any fish present in the channel and would prevent any change in channel morphology or flow alteration due to in-stream structures.

Loss of habitat at stream crossings

9.195 The installation of a short bottomless (clear-span) culvert on the Aghanageeragh River will ensure no loss of the habitat of fish or sensitive benthic invertebrates.

Decommissioning Phase

9.196 Mitigation measures during decommissioning will be the same as during the construction phase with regard to addressing the potential for run-off of suspended solids and other polluting substances. However, the level of mitigation will be determined by the level of reinstatement required.

Residual Effects

9.197 The potential effects of the Proposed Development on fish stocks and their habitats in the Site drainage streams (Aghanageeragh River and tributaries, Tullykittagh Water, Killagan tributaries, Flisk Burn tributary) and sensitive receiving watercourses downstream of the Site, are measured against proposed mitigations, as a means of assessing the residual effects of the project.

9.198 The magnitude of the potential effects and their residual significance were assessed according to the procedure outlined in the Methodology section of this chapter. It is the residual effects associated with the Proposed Development that most accurately reflect the overall predicted effects on fisheries and the aquatic environment during the construction, operational and decommissioning phases.

Construction Phase

9.199 Mitigation measures employed through the surface water management plan outlined in Chapter 10based on SuDS technology to control drainage and silt management on the Development site will remove the potential for damage to fish or their habitat from siltation of spawning and nursery habitats. These measures in association with the Pollution Prevention Plan will also minimise the risk for release of other construction related polluting substances into the river network.

9.200 The proposed installation of a bottomless culvert at the main crossing point on then Aghanageeragh River will avoid any in-channel works and the risk to temporary obstruction of fish passage. There will be no effect on fish migrations or spawning activity in any other stream.

9.201 The magnitude and significance of potential effects during the construction phase before mitigation are summarised for each watercourse in **Table 9.16** along with the predicted residual effects after mitigation. For watercourses draining the immediate Proposed Development, without mitigation the effects during the construction phase are predicted to be at worst of ***Moderate Magnitude*** and of **Large/ *Very Large Significance***, depending on specific effects and the sensitivity of individual watercourses e.g. sediment run-off, the release of other pollutants in the Aghanageeragh River could have an impact of Moderate magnitude with Large/ Very Large significance of effect as a watercourse classed at High WFD-based ecological status and good abundance of juvenile trout; this would equate to the potential for partial loss of productivity of a fishery and/ or the contribution to a reduction in the water body WFD status class (as defined in Table 9.6). However, with mitigation the effects are reduced to ***Neutral***.

9.202 The same assessment applies to the sensitive watercourses downstream of the Site drainage streams, including the main Killagan, Cloghmills, Clogh Waters and Flisk Burn/ River Bush.

Operational Phase

9.203 Although there will be an increase in the area of hard surface due to the Proposed Development, the surface water management plan / drainage design features for the control and attenuation of storm water run-off will protect receiving watercourses from excessive inputs of sediment. Several watercourses will not be influenced by direct run-off from hard surfaces since they will be sufficiently distant or outside of the Site boundary (e.g. Magheraboy Burn, Tullykittagh Water).

9.204 Of the watercourses within the Site that have potential fisheries and aquatic ecological interest, only the main Aghanageeragh River and a few associated small tributaries, will be crossed by tracks. Provided that the proposed bottomless culvert is installed in the main Aghangeeragh River, there will be no loss of salmonid habitat or reduced stream productivity nor any impact on fish passage obstruction.

9.205 The installation of solid invert culverts on the Eastern Killagan tributary crossing is likely to have an impact no more than Negligible because of the absence of fish.

9.206 The magnitude and significance of potential effects during the operational phase before mitigation are summarised for each watercourse in **Table 9.17** along with the predicted residual effects after mitigation.

9.207 Without mitigation the effects during the operational phase are predicted to be at worst of ***Minor Magnitude*** and of Moderate***/ Large Significance***, depending on specific effects and the sensitivity of individual watercourses. For example, Surface water run-off in the main Aghanageeragh River would have the potential to have an impact of Minor magnitude and Moderate/ Large significance of effect, equating to minor loss in productivity in a fishery if affecting the survival of trout and incubating eggs or causing deterioration in physical habitat quality. However, with mitigation the effects are reduced to ***Neutral***.

Decommissioning Phase

9.208 Effects during the decommissioning phase will be similar to those during the construction phase, with sediment run-off and the release of other pollutants the key concerns because it is expected that watercourse crossing will remain in-situ for use by land owners.

9.209 The magnitude and significance of potential effects during the decommissioning phase before mitigation are summarised for each watercourse in **Table 9.18** along with the predicted residual effects after mitigation.

9.210 Without mitigation the effects during the decommissioning phase are predicted to be at worst of ***Moderate Magnitude*** and of **Large*/* Very Large *Significance***, depending on specific effects and the sensitivity of individual watercourses. Mitigation measures will ensure that the effects remain as ***Neutral***.

Table 9.16: Construction Phase - Magnitude and Significance of Effects without Mitigation, and Residual Effects after Mitigation.

River/ Stream	Key receptors	Sensitivity	Potential Effect	Magnitude of Impact (degree of change)	Significance without Mitigation	Residual Effect after Mitigation
Aghanageeragh tributary	Trout present; WFD status Good	High	Sediment run-off	Moderate	Large	Neutral
			Release of other pollutants	Moderate	Large	Neutral
			Fish passage: temp. obstruction	No change	Neutral	Neutral
Main Aghanageeragh River ***effect applies only at proposed track intersection**	Trout present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral
			Fish passage: temp. obstruction*	No change	Neutral	Neutral
Magheraboy Burn	Trout present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral
			Fish passage: temp. obstruction	No change	Neutral	Neutral
Tullykittagh Water	Trout present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral
			Fish passage: temp. obstruction	No change	Neutral	Neutral
Flisk Burn tributary	No fish present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral
Eastern Killagan tributary	Trout locally absent but present downstream; WFD status Good	High	Sediment run-off	Moderate	Large	Neutral
			Release of other pollutants	Moderate	Large	Neutral
			Fish passage: temp. obstruction	No change	Neutral	Neutral
		Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral

River/ Stream	Key receptors	Sensitivity	Potential Effect	Magnitude of Impact (degree of change)	Significance without Mitigation	Residual Effect after Mitigation
Main downstream receiving watercourses (Killagan, Cloghmills, Clogh, Upper Bush)	Salmon & Trout present; potential Lamprey spp. WFD status Good		Release of other pollutants	Moderate	Large/ Very Large	Neutral

Table 9.17: Operational Phase – Magnitude and Significance of Potential Effects without Mitigation, and Residual Effects after Mitigation.

River/ Stream	Key Species	Sensitivity	Potential Effect	Magnitude of Impact (degree of change)	Significance without Mitigation	Residual Effect after Mitigation
Aghanageeragh tributary	Trout present; WFD status Good	High	Surface water run-off	Minor	Slight/ Moderate	Neutral
			Fish passage obstruction	No change	Neutral	Neutral
			Habitat loss at stream crossings	No change	Neutral	Neutral
Main Aghanageeragh River *****_effect applies only at track intersection_	Trout present; WFD status High	Very High	Surface water run-off	Minor	Moderate/ Large	Neutral
			Fish passage obstruction*	No change	Neutral	Neutral
			Habitat loss at stream crossings*	No change	Neutral	Neutral
Magheraboy Burn	Trout present; WFD status High	Very High	Surface water run-off	No change	Neutral	Neutral
			Fish passage obstruction	No change	Neutral	Neutral
			Habitat loss at stream crossings*	No change	Neutral	Neutral
Tullykittagh Water	Trout present; WFD status High	Very High	Surface water run-off	No change	Neutral	Neutral
			Fish passage obstruction	No change	Neutral	Neutral
			Habitat loss at stream crossings	No change	Neutral	Neutral

River/ Stream	Key Species	Sensitivity	Potential Effect	Magnitude of Impact (degree of change)	Significance without Mitigation	Residual Effect after Mitigation
Flisk Burn tributary **effect applies only at proposed track intersection - trout are absent*	No fish present; WFD status High	Very High	Surface water run-off	Minor	Moderate/ Large	Neutral
			Fish passage obstruction	No change	Neutral	Neutral
			Habitat loss at stream crossings*	Negligible	Neutral	Neutral
Eastern Killagan stream **effect applies only to tributary intersecting site access track*	Trout locally absent but present downstream; WFD status Good	High	Surface water run-off	Minor	Moderate/ Large	Neutral
			Fish passage obstruction	No change	Neutral	Neutral
			Habitat loss at stream crossings*	Negligible	Neutral	Neutral
Main downstream receiving watercourses (Killagan, Cloghmills, Clogh, Upper Bush)	Salmon & Trout present; potential Lamprey spp. WFD status Good	Very High	Surface water run-off	Minor	Moderate/ Large	Neutral
			Fish passage obstruction	No change	Neutral	Neutral
			Habitat loss at stream crossings	No change	Neutral	Neutral

Table 9.18: Decommissioning - Magnitude and Significance of Effects without Mitigation, and Residual Effects after Mitigation.

River/ Stream	Key receptors	Sensitivity	Potential Effect	Magnitude of Impact (degree of change)	Significance without Mitigation	Residual Effect after Mitigation
Aghanageeragh tributary	Trout present; WFD status Good	High	Sediment run-off	Moderate	Large	Neutral
			Release of other pollutants	Moderate	Large	Neutral
Main Aghanageeragh River	Trout present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral

River/ Stream	Key receptors	Sensitivity	Potential Effect	Magnitude of Impact (degree of change)	Significance without Mitigation	Residual Effect after Mitigation
Magheraboy Burn	Trout present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral
Tullykittagh Water	Trout present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral
Flisk Burn tributary	No fish present; WFD status High	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral
Eastern Killagan stream	Trout locally absent but present downstream; WFD status Good	High	Sediment run-off	Moderate	Large	Neutral
			Release of other pollutants	Moderate	Large	Neutral
Main downstream receiving watercourses (Killagan, Cloghmills, Clogh, Upper Bush)	Salmon & Trout present; potential Lamprey spp. WFD status Good	Very High	Sediment run-off	Moderate	Large/ Very Large	Neutral
			Release of other pollutants	Moderate	Large/ Very Large	Neutral

Cumulative Effects

Additional Developments

9.211 This section considers other wind farm developments which, in combination with the Proposed Development, could give rise to the potential for cumulative effects on fisheries and the aquatic environment in local rivers. In this context, the potential for cumulative effects is only relevant with regard to existing or proposed developments that are either hydrologically connected or which drain to the same receiving environment. It is therefore more important to consider additional developments in the context of river catchments, both locally and on a wider river basin scale.

9.212 There are two listed Wind Farm developments (Altaveedan and Cloonty) within the River Bush catchment that might thus be considered to have the potential for cumulative impacts on the freshwater environment (**Table 9.19**).

9.213 There are fourteen listed (Corkey and Corkey Repowering are considered as the same site) developments within the wider River Main catchment that might thus be considered to have the potential for cumulative impacts on the freshwater environment (Table 9.19).

Table 9.19: Additional Wind Farm developments/ proposals within the River Main and River Bush catchments indicating their location by WFD waterbody within the Braid and Main, and Bush LMAs

Wind Farm	Planning Reference	WFD waterbody	No. of turbines	Status
Altaveedan Wind Farm	D/2010/0356/F	River Bush	9	Operational
Cloonty Wind Farm	D/2009/0142/F	Bush River (Bushmills)	4	Operational
Ballymena Wind Park Limited	G/2009/0470/F	Lower Braid	2	Operational
Carnalbanagh Windfarm (Resubmission)	LA02/2017/0594/F	Glen Burn (Upper Braid); Glenarm River	7	Approved but under holding direction
Castlegore Wind Farm	G/2011/0136/F	Kells Water	7	Awaiting Construction
Connaught Road	T/2008/0358/F	Lower Main	2	Operational
Corby Knowe	T/2006/0832/F	Kells Water (Kells)	3	Operational
Corkey Wind Farm	<Null>	Killagan Water	10	Operational
Corkey Windfarm (repowering)	LA01/2019/0772/F	Killagan Water	5	Consented

Wind Farm	Planning Reference	WFD waterbody	No. of turbines	Status
Elginny Hill Resubmission	G/2011/0041/F	Clogh River / Upper Braid River (Artoges tributary)	11	Operational
Elliot's Hill Wind Farm		Kells Water (Moorfields)	10	Operational
Glenbuck II	D/2006/0599/F	River Main (Dunloy)	5	Operational
Gruig Wind Farm	D/2004/0790/F	Cloghmills Water	10	Operational
Long Mountain	D/2006/0104/F	Dunnstown Burn (Upper Main)	12	Operational
Rathsherry (Revised Application)	G/2011/0162/F	Clogh River	9	Operational
Unshinagh Wind Farm	LA02/2021/0939/DETEIA	Braid River (Aghacully); Glencloy River	14	Application Submitted
Whappstown Windfarm (Resubmission) (Castlegore)	LA02/2018/0897/F	Kells Water (Moorfields)	3	Consented
Wolf Bog Wind Farm	G/2004/1532/F	Kells Water (Moorfields)	5	Operational

Assessment

9.214 The greatest risk to the aquatic environment from Wind Farm developments is during the construction phase when land excavation and possible in-river works are conducted, resulting in a heightened risk of sediment, release of other pollutants, and obstruction of fish passage. Although there have been documented incidents of sediment run-off from a wind farm at Bin Mountain in County Tyrone, and a large peat-slip at Meenbog Wind Farm on the Donegal/ Tyrone border (November 2020), no reports of similar issue shave been documented in any of the operational sites in the River Main catchment.

9.215 The Castlegore Wind Farm is planning approved but awaiting construction and is located where streams drain to the Kells Water sub-catchment of the River Main, over 20km upstream of where the Kells Water has its confluence with the River Main; the lower Kells Water confluence with the River Main is over 23km downstream of where the Tullykittagh/ Clogh River – the closest of the watercourses to drain the Proposed Development - has its confluence with the River Main. Hence the distance between the developments to the receiving River Main, coupled with mitigations outlined in the Environmental Statement that accompanied the Planning Application for Castlegore Wind Farm (ABO Wind, 2011),

will ensure that there is a very low likelihood of cumulative impacts on fisheries and aquatic ecology of the River Main.

9.216 The Carnalbanagh Wind Farm planning application resubmission was recently approved by Mid and East Antrim Borough Councils Planning Committee but as of early November 2021, was placed under a Holding Order by the Department for Infrastructure. The northern extent of the application area has the potential to interact with a small tributary of the Glen Burn, a tributary of the River Braid that is over 19km distance from the confluence with the River Main, itself over 13km downstream from the confluence with the Tullykittagh/ Clogh River.

9.217 The information in the ES for Carnalbanagh (Chapter 9: Hydrology, Hydrogeology and Peat Stability), which assessed that there were no significant water features within the application area and that the proposed mitigations, including implementation of SUDS measures, shallow drains, check dams, watercourse buffers, development of a surface and groundwater monitoring plan, avoidance of watercourse crossings and adherence to all relevant PPGs, would result in only a marginal increase in the risk of impacting on sensitive water environments such as wells and springs close to construction works. This mitigation, together with the great distance between the drainage from the Proposed Development, would mean that the likelihood of cumulative impacts on the fisheries and aquatic ecology interests in the River Main downstream are very low.

9.218 The planning application for the proposed Unshinagh Wind Farm was submitted in 2021. The location of this development drains partly to the Ticloy Water, part of the Upper Braid catchment, and is situated over 25km upstream of the confluence with the River Main. This confluence is itself over 13km downstream from the confluence with the Tullykittagh/ Clogh River. Chapter 8 of the ES for Unshinagh contains a range of measures for mitigating potential effects of the construction and operational phases of the development on fisheries and aquatic ecology; the chapter concluded that, assuming full implementation of the specified mitigations, the development would have a neutral impact.

9.219 In view of the mainly operational nature of the majority of Wind Farm developments listed in **Table 9.19** (thirteen; two in the River Bush catchment and eleven in the River Main catchment), and the distance and proposed mitigations for the Castlegore, Unshinagh, and Carnalbanagh Wind Farms, implementation of the measures as described for the current Proposed Development will ensure that no cumulative impacts occur on the fisheries and aquatic ecology interests in the Tullykittagh/ Clogh, Aghanageeragh/ Cloghmilss, and Killagan tributaries of the River Main, and in the main channel River Main downstream. Similarly, the operational nature, lack of reported impacts, and implementation of the measures as described for the current Proposed Development will ensure that no cumulative effects occur on fisheries and aquatic ecology in the Flisk tributary of the River Bush or the main channel River Bush downstream.

Summary

9.220 This chapter outlines the potential effects of the Proposed Development on the fish stocks and fish habitats of the receiving watercourses in the sub-catchments of the Killagan, Cloghmills and Clogh rivers within the River Main catchment, and the Flisk Burn within the Upper River Bush catchment. It provides relevant baseline information on fisheries and aquatic ecological status enabling the potential effects to be identified and evaluated.

9.221 It has been determined that potential impacts are primarily related to sediment run-off and the release of other pollutants to the receiving watercourses with related effects on fish stocks and the wider stream ecosystem. Additionally, where the site access tracks cross the Flisk and eastern Killagan tributaries, the installation of culverts will cause the loss of a small area of habitat but the lack of fish means that the impact will be of negligible magnitude. Without mitigation it is considered that the impacts of sediment run-off and the release of other pollutants have the potential to be of Moderate Magnitude and of Large/ Very Large Significance depending on the sensitivity of individual watercourses.

9.222 A series of specific mitigation measures have been designed to avoid adverse effects on fisheries with regard to both construction and operational phases of the project.

9.223 Hydrology and site drainage issues have been considered in detail in Chapter 10, which outlines a surface water management system and drainage (SuDS) designed to control drainage and silt management on the Site.

9.224 It is concluded that, provided the mitigation measures are implemented as specified, construction and operation of the Proposed Development will have a neutral impact on the fish stocks and aquatic ecology of Site drainage streams and the main downstream receiving watercourses.

References

Allan, J.D. (1999). Stream Ecology: Structure and Function of running waters. Kluwer Academic Publishers. Pp. 388.

Bain M., Finn J. and Brooke, H. (1985). Quantifying stream substrate for habitat analysis studies. N Am J Fish Manage 5, 499-500.

Clapcott, J.E., Young, R.G., Harding, J.S., Matthaei, C.D., Quinn, J.M. and Death, R.G. (2011) Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.

Chartered Institute of Ecology & Environmental Management (2018). Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine.

Crozier WW & Kennedy GJA (1994) Application of semi-quantitative electrofishing to juvenile salmonid stock surveys. Journal of Fish Biology 45, 159-164.

DAERA (2019). Digest of the statistics for salmon and inland fisheries in the DAERA jurisdiction 2019.

Design Manual for Roads and Bridges (DMRB, 2019). Road Drainage and the Water Environment, Volume 11, Section 3, Part 10, LA113.

Design Manual for Roads and Bridges (DMRB, 2019b). Sustainability and Environmental Appraisal: Environmental Assessment and Monitoring, Section 2, Part 4, LA102.

Environment and Heritage Service NI (2008). Lough Neagh, Views About Management, The Environment (NI) Order 2002 Article 28 (2). A statement of Environment and Heritage Service's views about the management of Lough Neagh Area of Special Scientific Interest ("the ASSI").

Environment Agency (2018) Guidance for Pollution Prevention. Works and maintenance in or near water: GPP5. http://www.netregs.org.uk/media/1418/gpp-5-works-and-maintenance-in-or-near-water.pdf?utm_source=website&utm_medium=social&utm_campaign=GPP5%202711 2017

Extence CA, Chadd RP, England J, Dunbar MJ, Wood PJ & Taylor ED (2011). The assessment of fine sediment accumulation in rivers using macro-invertebrate community response. River Research and Applications, 29,17–55.

Goodwin CE, Dick JTA & Elwood RW (2009) A Preliminary Assessment of the Distribution of the Sea lamprey (Petromyzon marinus LL)), River lamprey (Lampetra fluvialilis (L)) and Brook lamprey (Lampetra planeri (Bloch)) in Northern Ireland. Biology and Environment: Proceedings of the Royal Irish Academy, Vol. 109B, No. 1, 4752

Johnston PM (2012) A6 Londonderry to Dungiven Dualling - Supplementary Fisheries Report: Physical Habitat Characteristics And River Sediment Analysis. Paul Johnston Associates/AECOM.

Kemp, P, Sear, D., Collins, A, Naden, P., and Jones, I. (2011). The impacts of fine sediment on riverine fish. Hydrological Processes, 25, 11, 1800-1821.

Kennedy GJA (1984) The ecology of salmon habitat re-instatement following river drainage schemes. IFM Annual Study Course, Magee College, Londonderry, 18pp.

Kennedy, R.J., Rosell, R., Ensing, D., Gargan, P. and Boylan, P. (2019). Standing Scientific Committee - Advice on DAERA Area Salmon Stocks 2019. (Executive Summary)

Kennedy, R.J., Rosell, R., Ensing, D., Gargan, P. and McCartney, J. (2020). Standing Scientific Committee - Advice on DAERA Area Salmon Stocks 2020. (Executive Summary)

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. & Cassidy, D. (2011) Ireland Red List No. 5: Amphibians, Reptiles & Freshwater Fish. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Levesque, L.M. and Dube, M.G. (2007). Review of the effects of in-stream pipeline crossing construction on aquatic ecosystems and examination of Canadian methodologies for impact assessment. Environmental Monitoring and Assessment, 132, 395-409.

Matthaei C.D., Weller, F., Kelly, D.W. & Townsend, C.R. (2006) Impacts of fine sediment addition to tussock, pasture, dairy and deer farming streams in New Zealand. *Freshwater Biology,* 51, 2154-2172.

Murray-Bligh, J. (2002) UK Invertebrate Sampling and analysis for EU-Star project. EUSTAR http://www.eu-star.at/pdf/RivpacsMacroinvertebrateSamplingProtocol.pdf

Newcombe, C.P. and Jensen, J.O.T. (1996). Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management, 16, 4, 693-727.

O'Connor WCK & Andrew TE (1998) The effects of siltation on Atlantic salmon, Salmo salar L, embryos in the River Bush. Fisheries Management and Ecology 5 (5), 393-401.5 (5), 393-401.

Scottish Power Renewables (2019). Corkey Windfarm Repowering: Technical Appendix A8.4: Fisheries & Aquatic Ecology. Volume 3 – Technical Appendices, June 2019.

Suttle, K.B., Power, M. E., Levine, J. M., and McNeely, C. (2004). How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecological Applications, 14,4, 969-974.

Turley, M. D., Bilotta, G. S., Extence, C. A., and Brazier, R. E. (2014). Evaluation of a fine sediment biomonitoring tool across a wide range of temperate rivers and streams. Freshwater Biology, 59, 2268-2277.

WFD-UKTAG (2010). Water Framework Directive: An approach to revoked Directives:- the Freshwater Fish Directive, the Shellfish Directive and the Dangerous substrances Directive.

WFD-UKTAG (2014). UKTAG River Assessment Method: Benthic Invertebrate Fauna. Invertebrates (General Degradation): Walley, Hawkes, Paisley & Trigg (WHPT) metric in River Invertebrate Classification Tool (RICT).