Ballinlee Green Energy Ltd.

Chapter 6 Biodiversity

Appendix 6G: Baseline report on Grid Connection Route (GCR) Aquatic Ecology Surveys

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Contents

List of Figures

List of Tables

1. INTRODUCTION

1.1. Background

Ballinlee Green Energy is planning to construct a wind farm at Ballinlee in County Limerick, requiring detailed baseline ecological surveys in and around the proposed development area. The aim of this work is to provide a baseline understanding of ecological conditions in watercourses to be crossed by the proposed grid connection route (GCR), in order to enable appropriate mitigation to be designed to avoid negative impact during construction, operation and in due course decommissioning of the wind farm. This document provides a summary of the methods used to survey watercourses in the vicinity of the proposed GCR for water quality and ecological status, and presents the results obtained.

An aquatic assessment was undertaken at four locations on the River Camogue and its tributaries where it is crossed by the GCR between Ballyneety and Holycross, County Limerick. The locations surveyed are situated in an agricultural environment which consists mainly of grazing pastures bordered by a mix of stone walls and hedgerows.

1.2. Purpose of this Report

The purpose of this report is to describe the results of the aquatic surveys undertaken to describe the baseline conditions in watercourses crossed by the GCR, and to identify any potential ecological constraints within the aquatic environment.

The report covers the elements surveyed as a series of separate sections, describing the methods and results for water quality, macroinvertebrates, white-clawed crayfish *Austropotamobius pallipes*, fish and fish habitats. A general discussion then summarises the results and their implications.

1.3. Evidence of Technical Competence and Experience

Summaries of the qualifications and experience of the personnel involved in the work, and their role in delivering it, are outlined below.

Adon McFarlane and James O'Connor conducted the water quality, white-clawed crayfish, fish habitat and macroinvertebrate surveys.

This report was prepared by Tanushree Mundra and Adon McFarlane and technically reviewed by Michael Dobson.

Dr Adon McFarlane is a freshwater biologist, specialising in protected species. He is an experienced field scientist, with extensive skills in the fields of freshwater habitat assessment; freshwater pearl mussel survey; white-clawed crayfish survey, macroinvertebrate survey, fish habitat assessment and electrofishing survey. He has built up skills in the collection of data both in the field and laboratory, analysis of data using statistical software programs such as R, BORIS, RAVEN and Minitab, creation of distribution maps using GIS. Adon has very strong technical skills in both freshwater and marine laboratory and fieldwork instrumentation and equipment usage. Adon has worked on a number of ecological reports, including Appropriate Assessments, Ecological Impact Assessments (EcIA), Preliminary Ecological Appraisal Reports (PEAR) and Invasive Species Reports.

Dr James O'Connor is a Senior Ecologist with APEM group Woodrow who has a PhD in aquatic sciences and a primary technical specialism in freshwater ecology. James has prior experience in monitoring wild bird populations with Birdwatch Ireland and is heavily involved in ornithological work as part of his role with Woodrow. Here, he regularly carries out mammal surveys and also performs a supporting role as Ecological Clerk of Works (ECoW). James is first author of several peer-reviewed academic research papers and has helped draft reports to disseminate key research findings to state agencies such as the Irish Environmental Protection Agency (EPA) as well as Irish county councils.

Tanushree Mundra has an International Master of Science in Marine Biological Resources (IMBRSea), based on research focused on life history strategies in marine mammals. She has since specialised in freshwater ecology and has undertaken macrobenthic surveys in India, as well as working with freshwater turtles, dolphin, and crocodile. She has been involved in various Environmental Impact Assessment (EIA) projects in India, particularly in mangrove and wetland ecosystems. She has worked closely with fishing communities to understand the challenges posed by unplanned development and fisheries management. Her work with Woodrow focuses on aquatic macroinvertebrate identification, bat acoustic data analysis, and field work for the above.

Dr Michael Dobson FLS is a freshwater biologist with over 35 years' experience. He spent 20 years as a research scientist, specialising in ecology and management of rivers and freshwater wetlands throughout Europe and East Africa, along with developing biotic indices for river quality assessment in Central America. He was Director of the Freshwater Biological Association for six years before joining APEM in 2013, working initially in the limnology and water quality team before setting up its dedicated invasive species team in 2019 and moving to APEM Ireland in 2022. Mike has written many peer- reviewed papers in ecology and biogeography, along with two undergraduate textbooks for Oxford University Press (both in their second editions) and seven identification guides to freshwater invertebrates of Britain and Ireland. He has extensive experience of survey design, data analysis and reporting, including publication and verbal reporting for non-technical audiences. He has written and reviewed Habitats Directive assessments in both Ireland and the UK.

2. INITIAL ASSESSMENT

A desk-based study and an initial field walkover were undertaken to inform this report, as described below.

2.1. Desk Study

The GCR and the surrounding area were viewed remotely using available satellite imagery[1] The National Parks and Wildlife Service (NPWS) website[2] was accessed for information on sites designated for nature conservation in the surrounding area. Potential connectivity between the Site and the surrounding area, through features such as surface water pathways, was examined using the Environmental Protection Agency (EPA) Maps[3]. The National Biodiversity Data Centre (NBDC)[4] website and NPWS website[5] were accessed for information on rare and/or protected habitats and species known in the surrounding area.

The desk study highlighted that the River Camogue which the GCR crosses has previous records of white-clawed crayfish, with most recent observations being recorded in 2014[6] Crayfish plague, caused by the water mould *Aphanomyces astaci,* is present in the catchment, with the most recent records from the National Crayfish Plague Surveillance Programme during 2020/2021 (NPWS, 2022) and updates from Fish Health Unit at the Marine Institute[7] identifying crayfish plague to be present on the River Maigue of which the River Camogue is a tributary.

2.2. Field Walkover

The Site was visited by Adon McFarlane, and James O'Connor on 14 and 15 May 2025. The Site was walked to identify any aquatic habitats suitable for surveying. Any incidental sightings of invasive species or signs of these were noted during the field survey. For the purposes of this report invasive species are those that are subject to Regulation 49 of the European Communities (Birds and Natural Habitats) Regulations 2011 - 2021 listed in Part 1 and Part 2 of the Third Schedule within the Directive.

Weather conditions were suitable to carry out all walkover and aquatic surveys. The entire study area was accessed.

No invasive species were observed while conducting the field walkover.

2.3. Aquatic Ecology Survey Site Selection

The field survey identified four survey sites which were suitable for aquatic surveys which are crossed by the proposed GCR (Figure 1). The GCR crosses the River Camogue and three of its tributaries, and survey sites were chosen as follows (Figure 1: WQ refers to water quality and macroinvertebrate sampling point; WCC to white-clawed crayfish survey reach and FH to fish habitat survey).

[1] https://www.google.com/maps/@53.4622267,-9.0403252,2319m/data=!3m1!1e3 (Website accessed 07 June 2025)
[2] https://www.npws.ie/protected-sites (Website accessed 07 June 2025)
[3] https://gis.epa.ie/EPAMaps/ (Website accessed 07 June 2025)
[4] https://maps.biodiversityireland.ie/Map (Website accessed 07 June 2025)
[5] https://www.npws.ie/maps-and-data (Website accessed 07 June 2025)
[6] Maps - Biodiversity Maps (Website accessed 07 June 2025)
[7] Update on Crayfish Plague in Ireland | Fish Health Unit (Website accessed 07 May 2025)

- Rockstown Stream (EPA code 24R15) is crossed by the GCR route at 563166, 645032 ITM. This was suitable for a water quality survey at WQ01, ca. 20 m downstream of the proposed GCR crossing. It was unsuitable for a macroinvertebrate assessment by kick sampling, a fish habitat survey and a white-clawed crayfish survey due to limited flow and dense vegetation. Surveys were conducted here on 15 May 2025.
- The Camogue River (EPA code 24C01) is crossed by the GCR route at 562906, 643435 ITM. This was suitable for a water quality survey and macroinvertebrate assessment by kick sampling at WQ02, ca. 60 m downstream of the proposed GCR crossing, a fish habitat survey at FH01 and a white-clawed crayfish survey, including traps, at WCC01. The macroinvertebrate survey and fish habitat survey were conducted here on 14 May 2025, the crayfish survey was conducted on 14 and 15 May 2025 and the water quality survey was conducted on 15 May 2025.
- The Loughgur stream (EPA code 24L27) is crossed by the GCR route at 562876, 641085 ITM. This was suitable for a water quality survey and macroinvertebrate assessment by kick sampling at WQ03, ca. 110 m upstream of the proposed GCR crossing, and was selected as no accessible or suitable areas were identified downstream of the GCR. A fish habitat survey was conducted at FH02. It was unsuitable for a white-clawed crayfish survey due to water levels, lack of refuges and dense vegetation. Surveys were conducted here on 15 May 2025.
- The Ballycullane 24 stream (EPA code 24B90) is crossed by the GCR route at 562816, 639420 ITM. This was suitable for a water quality survey and macroinvertebrate assessment by kick sampling at WQ04, ca. 20 m downstream of the proposed GCR crossing, a fish habitat survey at FH03 and a white-clawed crayfish survey, excluding traps due to water levels, at WCC02. The macroinvertebrate survey, fish habitat survey and crayfish survey were conducted here on 14 May 2025 and the water quality survey was conducted on 15 May 2025.

3. WATER QUALITY

3.1. Methods

3.1.1. Field survey

Field water quality measurements were taken using an In-Situ® Aqua TROLL 500 Multiparameter Water Quality Probe. Parameters measured were temperature (°C), pH, dissolved oxygen (DO) percent saturation (%) and concentration (mg/L), conductivity (µS/cm) and turbidity (NTU).

Water samples were collected in pre-sterilised sampling bottles and rinsed with river water before the sample was taken. Water samples were taken from just below the surface, ensuring that the riverbed was not disturbed during sampling. Once sample bottles were filled, they were transported to an INAB accredited laboratory for analysis within the recommended holding time for the selected water quality parameters as shown in Table 1.

Table 1. Water quality parameters analysed and limits of detection

Type	Test	Measurement units	How measured	Limit of Detection (LoD)
General water quality indicators (measured in field)	Temperature	°C	Field probe	0.1[8]
	Electrical conductivity	µS/cm	Field probe	0.5*
	pH	n/a[9]	Field probe	0.1*
	Dissolved oxygen concentration	mg/L	Field probe	0.1*
	Dissolved oxygen saturation	Percent	Field probe	0.1*
	Turbidity	NTU	Field probe	1
Nutrients	Total nitrogen as N	mg/L	TN analyser	0.5
	Nitrate as N	mg/L	Colorimetry	0.1
	Nitrite as N	mg/L	Colorimetry	0.005
	Total phosphorus as P	mg/L	Colorimetry	0.01
	Orthophosphate as PO_4-P	mg/L	Colorimetry	0.01
Pollution indicators	BOD	mg/L	Electrometry	1
	Ammonia as N	mg/L	Colorimetry	0.005
	Suspended Solids	mg/L	Gravimetry	2

3.1.2. Data interpretation

Water quality results are compared against a number of standards, as summarised in Table 2.

1. Water Framework Directive (WFD) standards were used where available, with the threshold for Good status applied. Standards are derived from DEHLG (2019).

[8] Precision of reading
[9] pH is a unitless measure

2. Where water quality parameters were not listed under the WFD but were in the Quality of Salmonid Water Regulations 1988, these were used. Standards are derived from Department of Environment (1988).
3. The nitrate standard was derived from Water Quality in 2023 (EPA, 2024).

WFD standards are normally based on statistics derived from multiple readings (such as mean and 95th percentile). As only one reading was available per site, no such calculations could be carried out, and data were simply compared with the appropriate standard numerical value. Results are compared to these standards for indicative purposes only. This does not constitute an assessment of the overall official status of a water body.

Table 2: Standards used to compare with river water quality readings

Parameter	Threshold value(s) (maximum acceptable value unless otherwise stated)	Source	Notes
Temperature	21.5°C	Quality of Salmonid Water Regulations 1988	98%ile
pH	4.5-9 (acceptable range)	Irish WFD standards	Range for soft waters (hardness < 100 mg/L $CaCO_3$)
Dissolved oxygen – concentration	6 mg/L (minimum value)	Quality of Salmonid Water Regulations 1988	
Dissolved oxygen – saturation	80-120% (acceptable range)	Irish WFD standards	Acceptable range
Nitrate as N	2.6 mg/L	EPA (2024) Water Quality in 2023	95%ile Good threshold
Nitrite as N	0.05 mg/L	Quality of Salmonid Water Regulations 1988	95%ile
Orthophosphate as PO_4-P	0.035 mg/L	Irish WFD standards	WFD mean Good threshold
BOD	1.5 mg/L	Irish WFD standards	WFD mean Good threshold
Ammonia as N	0.065 mg/L	Irish WFD standards	WFD mean Good threshold
Suspended Solids	25 mg/L	Quality of Salmonid Water Regulations 1988	Maximum allowable

3.2. Results

A summary of the results is provided in Table 3.

Dissolved oxygen concentrations remained above the minimum threshold of 6 mg/L (Table 2) at the majority of sites, with the exception of site WQ03. However, dissolved oxygen saturation levels fell below the required minimum of 80% (Table 2) at most sites, including WQ01, WQ03, and WQ04. Turbidity was also slightly elevated at site WQ01.

Nutrient concentrations were low at site WQ02. Site WQ04 had a high nitrate concentration, while site WQ01 and site WQ03 had high orthophosphate concentration, each being above the respective value indicative of Good Ecological Status (Table 2).

Pollution indicators were within acceptable ranges or below limit of detection at all sites, demonstrating no evidence for organic pollution.

Table 3: Summary of water quality parameters[10]

Type	Test	Measurement units	WQ01	WQ02	WQ03	WQ04
General water quality indicators	Temperature	oC	12.4	16.6	16.6	11.7
	Conductivity (Specific)	µS/cm	570.5	478.0	224.8	655.9
	pH		7.7	8.1	7.2	7.5
	Dissolved oxygen concentration	mg/L	7.0	10.0	5.0	6.3
	Dissolved oxygen saturation	Percent	64.8	101.9	49.8	57.8
	Turbidity	NTU	21.1	2.3	3.3	1.2
Nutrients	Total Nitrogen as N	mg/L	0.097	0.723	0.741	2.060
	Nitrate as N	mg/L	2.41	1.86	<0.44	9.39
	Nitrite as N	mg/L	<0.017	0.023	0.023	<0.017
	Total phosphorus as P	mg/L	0.08	0.05	0.09	<0.05
	Orthophosphate as PO_4-P	mg/L	0.045	0.013	0.050	<0.01
Pollution indicators	Biochemical Oxygen Demand (BOD)	mg/L	1	1	1	<1
	Ammonia as N	mg/L	0.037	0.018	0.039	0.017
	Suspended solids	mg/L	<2	<2	<2	<2

[10] Key: Green - Readings below the laboratory Limit of Detection, Orange – values exceeding standards

4. MACROINVERTEBRATE SURVEY

4.1. Methods

Kick-sampling was carried out at sites WQ02 – WQ04, according to the standard methodology used by the EPA (Toner et al., 2005).

A two-minute macroinvertebrate kick sample was conducted at each site using a standard 1 mm mesh size long-handled net, principally from the faster flowing riffle habitats, but glides, margins and pools were included according to their proportional presence. A further one-minute hand search was carried out to locate macroinvertebrates that attached themselves to solid structures such as the underside of cobbles. Each sample was preserved on site with >90% Isopropanol solution and returned to the laboratory for further analysis. Specimens were identified, under a binocular microscope, to family level in the laboratory using the standard range of identification keys published by the Freshwater Biological Association, AIDGAP and others, and their relative abundance was recorded.

An EPA Q value classification was assigned to each site. The Q values were assigned based on the presence and relative abundance of sensitive groups and the consideration of additional qualifying criteria, as described by Toner *et al.* (2005) and outlined in more detail in Appendix A.

Q values were calculated for indicative purposes only. This does not constitute an assessment of the overall official status of a water body.

4.2. Results

Results are shown in Table 4 and a full taxa list is provided in Appendix A, Table 6. The Q value scores indicate that sites WQ02 and WQ04 are indicative of Poor WFD ecological status, with very few Group A or B taxa and some Group D taxa present. Site WQ03 is indicative of bad WFD ecological status with no Group A, very few Group B taxa and abundant Group D taxa present.

The substrate at the majority of surveyed sites (WQ02, WQ03, and WQ04) was covered by a dense layer of aquatic macrophytes, particularly *Fontinalis* spp. and *Cladophora* spp. Water velocity at site WQ02 was relatively high, with flow rates exceeding 30 cm/s, distinguishing it from the lower flow rate conditions recorded at the other sites.

These results indicate a decline in water quality compared to the EPA's 2023 assessment, conducted ca. 1.95 km upstream of site WQ02, where a Q value classification of Q3-4 was recorded.[11]

[11] EPA Maps (Website https://gis.epa.ie/EPAMaps/ accessed 07 June 2025)

Table 4: Q values assigned, and total number of taxa observed at each site

River		Camogue	Loughgur	Ballycullane 24
Parameter		Site WQ02	Site WQ03	Site WQ04
Q value Classification		Q3	Q2	Q3
Number of taxa	Group A (sensitive)	3	-	-
	Group B (less sensitive)	3*	1	*
	Group C (tolerant)	23*	8*	8*
	Group D (very tolerant)	3	4	*
	Group E (most tolerant)	-	-	-
	Total	36	16	13

*Other taxa were present and counted in the total number of taxa but either had only one individual and were therefore discounted from Q value classification or were not a taxon considered in the classification system.

5. FISH AND HABITAT SURVEYS

5.1. Methods

Walkover habitat surveys were conducted along 230 m of the River Camogue at site FH01, 350 m of the Loughgur Stream at site FH02, and 210 m of the Ballycullane 24 Stream at site FH03. The extensive lengths surveyed were considered appropriate to understand the range of fish habitats in these parts of the rivers. Weather conditions were clear and dry, with a slight breeze, approximately 15% cloud cover, and an air temperature of 20°C. The river flow at this time was considered close to baseflow and therefore instream fish habitats were clearly visible.

Surveys considered habitats suitable for salmonids and lamprey; an outline of the requirements for each survey is detailed in Appendix B.

The methodology applied to the habitat survey follows Hendry & Cragg-Hine (1997). This field mapping technique involves hand drawing onto a high-resolution map (1 km tiles) at a scale of 1:10,000 using a field tablet. The riverbank was walked, noting habitat features in the river channel and drawing these directly onto the map, with the boundaries of the different habitat classifications being drawn to represent their actual position within the river, and with annotations as required. Prominent features, such as log jams, macrophyte beds, weirs and bridges, were noted and their locations confirmed using a handheld GPS unit. This allows exact representation of the areas of individual habitat types encountered. In this manner, a mosaic of the different habitat types can be drawn along the whole section of the river. The drawings of the habitat types along the section of the river were subsequently digitised using ArcMap GIS.

5.2. Results

5.2.1. Site FH01

The section surveyed (Figure 2, Plate 5) was approximately 230 m in length and ca. 10 m wide. It was characterised predominantly by glide, with riffle, mixed juvenile, pool and silted spawning habitat present. The substrate was composed of cobble and boulder covered with a layer of macrophyte growth, particularly *Fontinalis* and *Cladophora* (Plate 5), and occasional algal growth, with areas of gravels present throughout the channel. *Ranunculus* and hornwort *Ceratophyllum demersum* were abundant along the survey stretch. Salmonid spawning habitat was observed downstream of the bridge, but this was considered mostly suboptimal owing to siltation and algal cover. Salmonids were observed actively swimming and feeding during the survey, while two salmonid fry and a lamprey transformer (representing the transitional life stage between ammocoete and adult) were captured during kick sampling at WQ02 confirming their active use of the surveyed stretch. Bankside vegetation consisted of willow *Salix sp.* and hawthorn *Crataegus monogyna* which provided ample shading. Poaching was observed on the left-hand bank from livestock access ca. 20 m downstream of the bridge.

Overall, the River Camogue at FH01 provides a good mix of aquatic habitats, favoured by a range of fish species, with potential salmonid and lamprey spawning habitat being observed on the reach surveyed. Although the surveyed area included substrate types and flow conditions potentially suitable for lamprey, no definitive lamprey ammocoete (larval) habitat was observed during the walkover. Fine, silt-laden or soft sediment areas suitable for ammocoete burrowing were absent or limited.

5.2.2. Site FH02

The section surveyed (Figure 3, Plate 6) was ca. 350 m in length and ca. 1.5 m in width, with a low flow. This river reach exhibited a poor diversity of fish habitats, with only riffle, glide and standing water habitats recorded. The substrate was primarily composed of gravel, with cobble, silt and filamentous algae also present. Macrophyte growth was evident, dominated by fool's watercress *Apium nodiflorum*, particularly in upstream and downstream areas of WQ03 where standing water had developed due to dense macrophyte growth within the channel. The right-hand bank upstream of the bridge comprised a steep brick retaining wall, situated immediately adjacent to the road.

Overall, the Loughgur Stream at FH02 provides a limited range of aquatic habitats and is considered unsuitable for supporting salmonid and lamprey species.

5.2.3. Site FH03

The section surveyed (Figure 4, Plate 7) was c. 210 m in length and c. 1.5 m in width, with a low flow. This river reach exhibited a poor diversity of fish habitats, with only riffle, glide and standing water habitats recorded. The substrate was primarily composed of cobble, with boulder, gravel and silt present. Exposed boulder and cobble were present along the stretch surveyed. Macrophyte growth was evident upstream of the bridge, dominated by fool's watercress, where standing water had developed due to dense macrophyte growth within the channel. Severe poaching was present along the survey stretch from livestock access. The area was heavily shaded by overhanging vegetation including willow and hawthorn, limiting instream macrophyte growth. Minnow *Phoxinus Phoxinus* were observed near to the bridge culvert in a small shoal.

Overall, the Ballycullane 24 stream at FH03 provides a limited range of aquatic habitats and is considered unsuitable for supporting salmonid and lamprey species.

6. CRAYFISH SURVEY

6.1. Methods

Licences for white-clawed Crayfish (WCC) surveys were secured from National Parks and Wildlife Service (NPWS) prior to commencement of the survey (Licence No. C124/2025).

Two WCC surveys were carried out according to the standard methodology used by Peay (2003), Reynolds *et al.* (2010) and Gammell *et al.* (2021). Weather conditions were clear and dry, with a slight breeze, approximately 15% cloud cover, and an air temperature of 20°C. The river flow at this time was considered close to base flow. On arrival, channel conditions were assessed, and a 100 m stretch of suitable river was chosen for survey within the 500 m survey stretch (Plate 8-9). Hand-searching of 50 potential refuges within 5 patches was carried out in this chosen 100 m stretch. Potential refuges were defined as any suitable substrate (e.g. gravel, cobble, woody debris) that would be resistant to high flows and capable of providing cover for WCC. Refuges were searched facing upstream to minimise the disturbance of the soft substrate. Where possible, refuges were replaced after searching. Habitat features for each patch were recorded.

Site WCC01 was also surveyed using traps with two strings of four (eight total) trappy funnel baited crayfish traps, laid out and left overnight within an area of suitable habitat including abundant refuges and vegetation. Traps were spaced approximately 4 m apart and laid parallel to the shore. Each end of the rope was secured to the shore in order to prevent the baited traps from being moved. Each trap was baited with approximately 40 g of mackerel (*Scomber scombrus*). Traps were left overnight and checked early the following morning. Water levels were not suitable for trapping at site WCC02.

6.2. Results

No crayfish were found during surveys at WCC01 and WCC02. Extensive areas of suitable habitat were found at site WCC01 in the form of large cobble and boulders within the glide sections as well as along river margins with overhanging vegetation and undercut banks (Plate 8). Despite the presence of abundant cobble and boulder refuges, as well as undercut banks and tree roots at site WCC02, overall habitat suitability was considered poor due to low water levels, variable flow conditions, and evidence of severe poaching from livestock access.

7. DISCUSSION

7.1. Ecological quality of the River Camogue (Site WQ02)

From a water chemistry perspective, the River Camogue at site WQ02 is generally of good water quality. Macroinvertebrate surveys did, however, suggest impacts on water quality, with site WQ02 achieving Q3 status, indicating poor ecological status and moderate pollution. Extensive growth of macrophytes such as *Fontinalis*, *Cladophora* and *Ranunculus*, along with occasional filamentous algae, was recorded, reflecting nutrient-enriched conditions.

The fish habitat survey along the River Camogue covered an extensive reach and was considered appropriate for characterising the range of habitats present. The river supports good fish habitat overall, including juvenile and adult salmonid habitats, with salmonids observed feeding and actively swimming in glide habitat. Two salmonid fry and one lamprey transformer were captured in samples taken at WQ02. However, spawning and possible nursery habitat was generally suboptimal, primarily due to siltation and filamentous algae growth. Despite these constraints, resting and holding areas (pools) and adult salmonid passageways (fast glides) were present throughout the surveyed reach. All species recorded during the survey are presumed present and should be considered in designing mitigation measures for the proposed project.

The absence of any records of WCC, or of evidence such as partial remains from predation, despite an intensive search in a suitable reach with suitable habitat, would suggest the absence of this species from the River Camogue at site WCC01. It is possible, therefore, that crayfish plague is now found as far as the River Camogue at Holycross, Co. Limerick, accounting for the absence of the species in the reach surveyed. While WCC are apparently now absent from the River Camogue, there is good habitat present, and the sites surveyed have the potential for reintroduction in due course, subject to confirmation that crayfish plague is not present in the catchment at the time. WCC require a varied habitat to support all stages of its life cycle. This includes riparian shrubs and trees, and the extension of their roots into the water, gravel or macrophytes to provide shelter for juveniles, and larger cobbles and boulders to act as refuges for adults, or suitable undercut banks in which they can burrow. Typically, 0.75 – 1.25 m depth with good water quality (Demers *et al.* 2003, Gallagher *et al.* 2006, Smith *et al.* 1996). All are present in the river.

7.2. Ecological quality of Tributary Sites (WQ01, WQ03 and WQ04)

In contrast to the River Camogue, the tributary sites exhibited poorer ecological quality with some elevated nutrient concentrations recorded. Elevated nitrate concentrations were noted at WQ04 on the Ballycullane 24 stream, likely linked to agricultural activity and severe poaching observed on site. Dissolved oxygen levels were notably low at all sites, falling below the 80% threshold for acceptable WFD standards in Ireland, reinforcing the presence of organic pollution and further degraded water quality. Macroinvertebrate surveys also suggested impacts on water quality with site WQ03 achieving Q2 status, indicating bad ecological status, and site WQ04 achieving Q3, reflecting poor ecological status.

The distance covered during the fish habitat surveys was extensive and considered appropriate to understand the range of fish habitats in these parts of the rivers. Extensive *Apium* growth was observed at sites WQ03 and WQ04, with its proliferation contributing to reduced flow regimes. The

Ballycullane 24 stream, along with the Loughgur and Rockstown streams, provides a limited range of aquatic habitats and is considered unsuitable for supporting WCC, salmonid or lamprey species.

The absence of any records of WCC, or of evidence such as partial remains from predation, despite a hand-search at WCC02, would suggest the absence of this species from the Ballycullane 24 stream. Habitat suitability was also considered poor.

7.3. Limitations

Water quality can be variable, and will change under different flow and runoff conditions, so a single sample or set of readings can only give an indication of conditions at that point of time. There may also be seasonal differences as a consequence of biological changes or land use activities. It is advisable, therefore, to take repeat water quality readings before drawing definitive conclusions about water quality. Repeat water quality readings will be undertaken as part of updated pre-construction baseline surveys.

The macroinvertebrate survey partially overcomes this issue by recording a biological feature that will react to the full range of physicochemical conditions experienced in the river over a period of several months. The macroinvertebrate dataset is from a single year and while it will integrate environmental conditions over the several months covered by the life cycles of the taxa recorded, it cannot give an indication of interannual variation. Where possible, therefore, it is always advisable to take repeat samples in multiple years. Repeat macroinvertebrate surveys will be undertaken as part of updated pre-construction baseline surveys.

The detailed walkover fish habitat survey, along with observing salmonid and lamprey species within the habitat reduces the limitations in determining species present.

A WCC survey of this type, based on a single site visit, always has the risk of missing presence of the species elsewhere in the area to be affected, however the complete absence of records would suggest either genuine absence or very low and localised populations. Notwithstanding the probable absence of WCC, the previous records of WCC on the River Camogue means that consideration of this species is required going forward, particularly with respect to habitat restoration following the works. Repeat WCC surveys will be undertaken as part of updated pre-construction baseline surveys.

The level of surveying undertaken and associated results are sufficient with regard to the objective of the surveys – to assess the baseline conditions in watercourses crossed by the GCR, and to identify any potential ecological constraints within the aquatic environment.

8. REFERENCES

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Plates

Plate 1. Water quality sampling site WQ01

Plate 2. Water quality and macroinvertebrate sampling site WQ02

Plate 3. Water quality and macroinvertebrate sampling site WQ03

Plate 4. Water quality and macroinvertebrate sampling site WQ04

Plate 5. Fish habitat survey at site FH01 showing growth of *Cladophora* and *Fontinalis* observed during survey

Plate 6. Fish habitat survey at site FH02

Plate 7. Fish habitat survey at site FH03

Plate 8. White-clawed crayfish survey site WCC01

Plate 9. White-clawed crayfish survey site WCC02

Figures

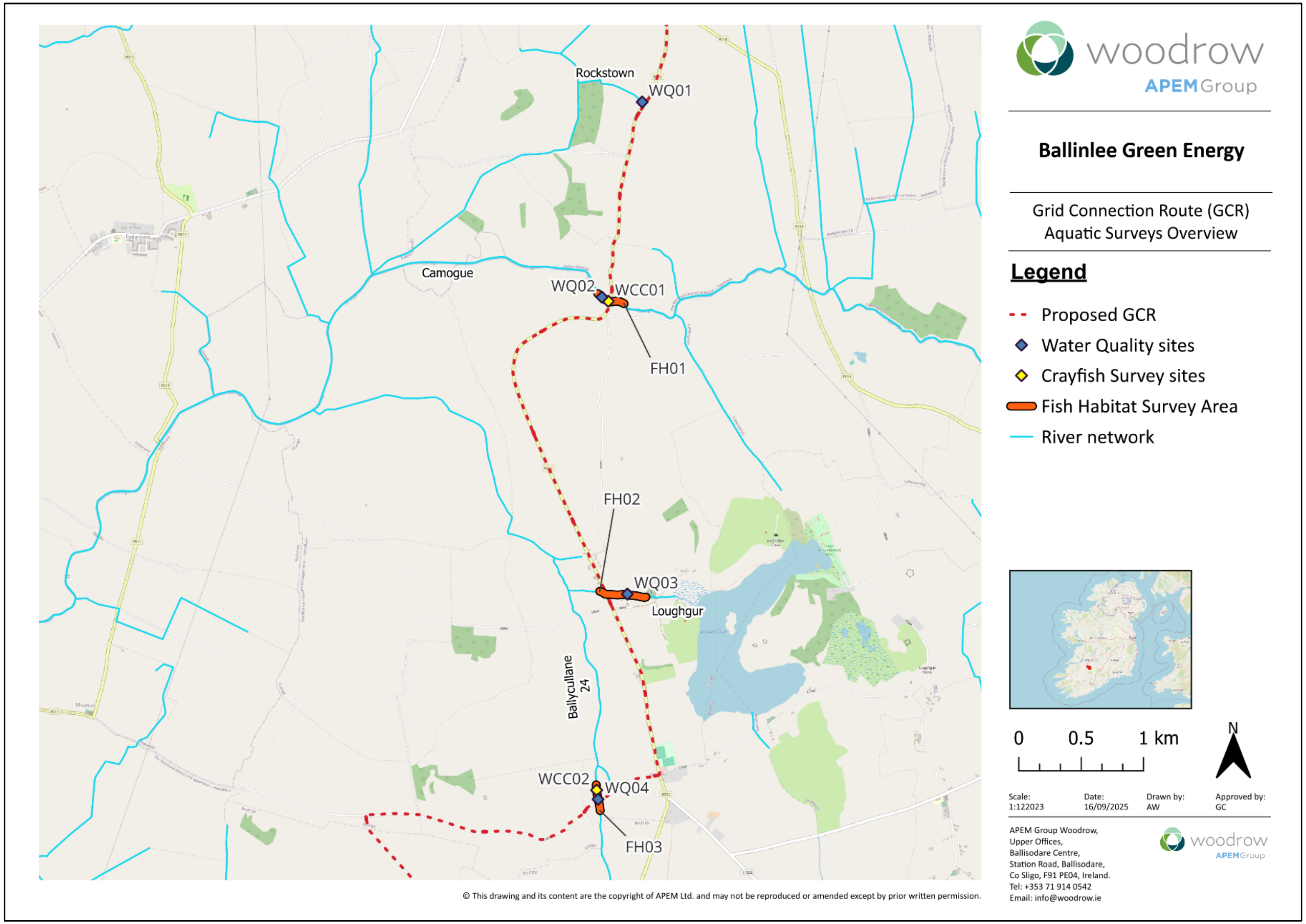

Figure 1: Site location and aquatic survey sampling sites

Figure 2: Fish habitat survey site FH01

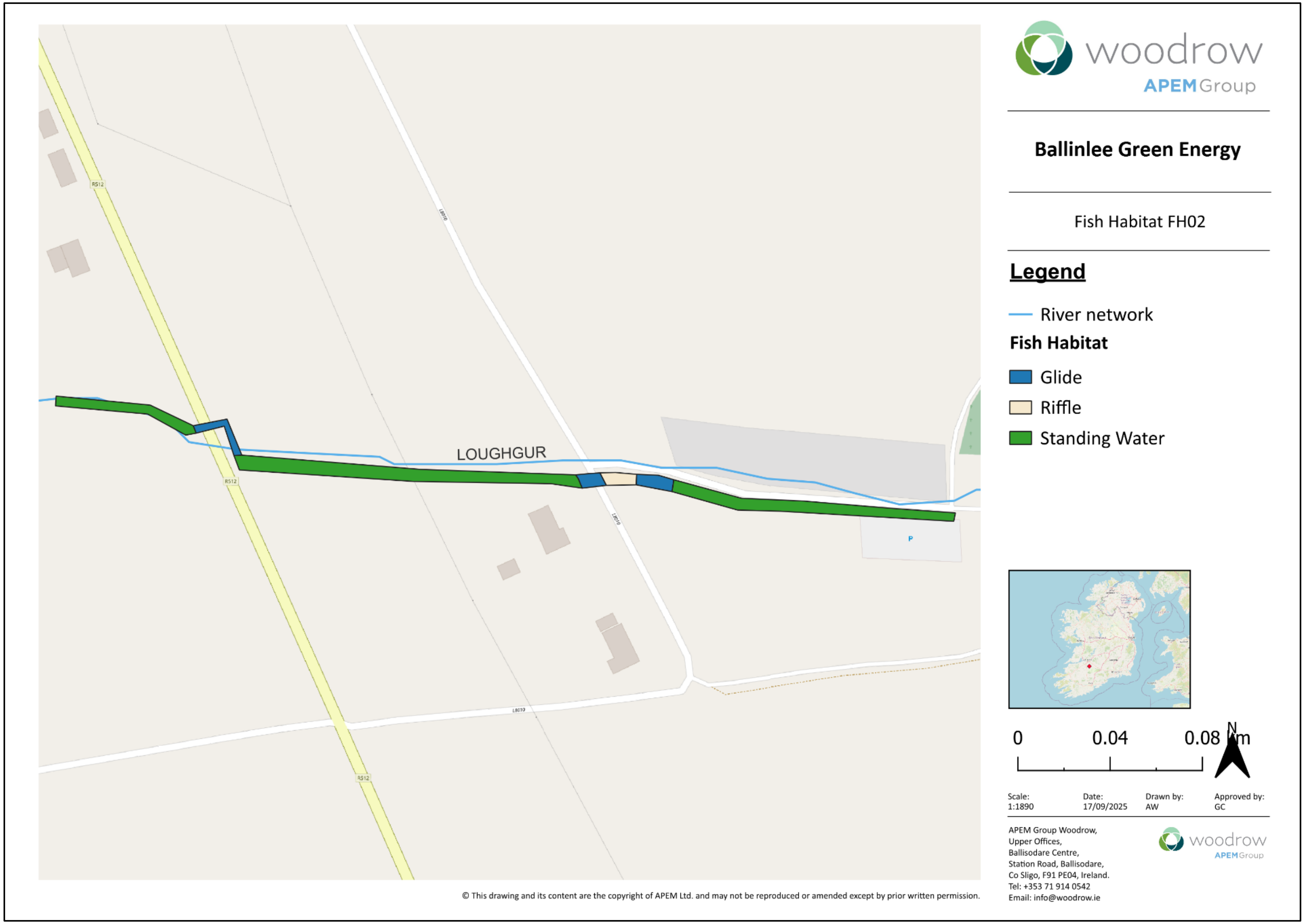

Figure 3: Fish habitat survey site FH02

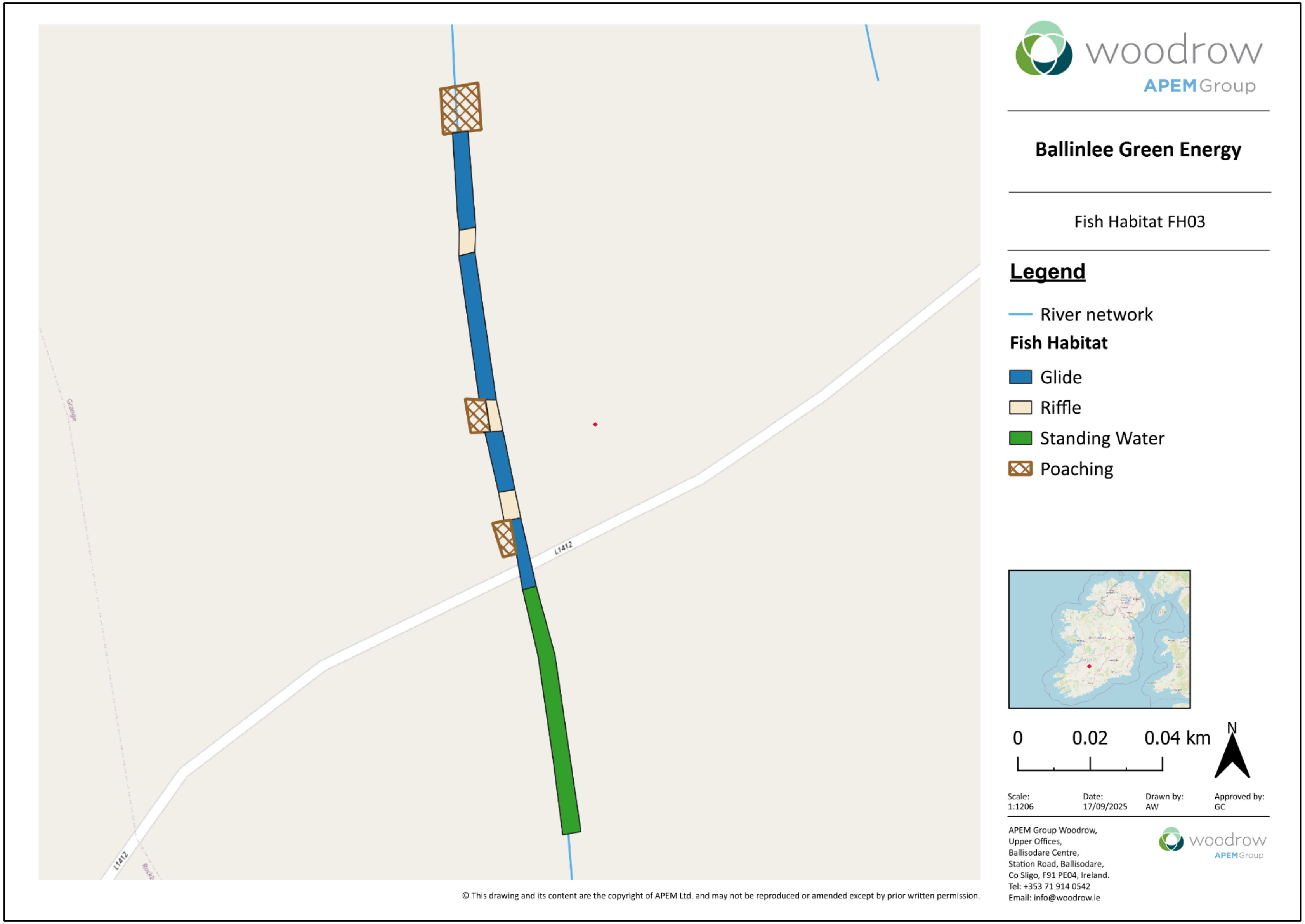

Figure 4: Fish habitat survey site FH03

Appendix A. Description of Q Value Assessment and Taxa List

Q Value Assessment

The EPA Q-value classification is assigned based on the assessment of the macroinvertebrate sample, which involves recording the taxa present at a suitable and attainable taxonomic resolution (under field conditions) and their categorical relative abundance determined using approximate counts (as described in Feeley *et al*., 2020). From this, the number of taxa present and categorical relative abundance of sensitive (Group A), less sensitive (Group B), tolerant (Group C), very tolerant (Group D) and most tolerant (Group E) taxa to organic pollution is examined. Additional Qualifying Criteria are also considered, consisting of recording the abundance of *Cladophora* sp, Macrophytes, and slime growths / sewage fungus, as well as the Dissolved Oxygen Saturation % and the level of substratum siltation. Then, based on the combination of number and relative abundance of the sensitive or tolerant groups present, a Q-value is assigned. Details on the assignment of the scores can be found in Toner *et al*., (2005).

In Ireland, macroinvertebrates are the main Biological Quality Element (BQE) determining the ecological status in rivers (required by the Water Framework Directive; WFD) and are based on the Q-value. The WFD requires BQE scores to be expressed as an Ecological Quality Ratio (EQR) to standardize and provide a common scale of ecological quality across participatory Member States using differing national methods. Intercalibration of the Q-value with the EQR and the corresponding ecological status are described in Table 6.

Table 5: EPA water quality status summary[12]

Q value Score	EQR	Pollution Gradient	WFD Ecological Status
Q5	1.0	Unpolluted	High
Q4-5	0.9	Unpolluted	High
Q4	0.8	Unpolluted	Good
Q3-4	0.7	Slightly Polluted	Moderate
Q3	0.6	Moderately Polluted	Poor
Q2-3	0.5	Moderately Polluted	Poor
Q2	0.4	Seriously Polluted	Bad
Q1-2	0.3	Seriously Polluted	Bad
Q1	0.2	Seriously Polluted	Bad

[12] Comparing the Q-value, ecological quality ratio (EQR), corresponding Water Framework Directive (WFD) status and pollution gradient resulting from anthropogenic pressures (Feeley *et al*., 2020).

Macroinvertebrate taxa and proportional abundance recorded.

Table 6: List of macroinvertebrate taxa and abundance recorded at each site

Taxon	Group	Site WQ02	Site WQ03	Site WQ04
Ecdyonurus sp.	A	10	-	-
Ephemera danica	A	2	-	-
Heptagenia sp.	A	2	-	-
Limnephilidae	B	6	4	-
Baetis muticus	B	25	-	-
Leptoceridae	B	8	-	-
Sericostoma personatum	B	1*	-	1*
Hydroptilidae	B	1*	-	-
Goera pilosa	B	1*	-	-
Gammarus duebeni	C	256	-	288
Ancylus fluviatilis	C	2	-	-
Potamopyrgus antipodarum	C	2364	-	-
Elmidae	C	383	7	9
Chironomidae	C	515	101	43
Simuliidae	C	585	3	148
Dicranota sp.	C	3	-	13
Planorbidae	C	4	558	-
Rhyacophila sp.	C	3	-	1*
Caenis sp.	C	4	-	-
Theodoxus fluviatilis	C	4	-	-
Serratella ignita	C	78	-	-
Caenis rivulorum	C	337	-	-
Rhyacophila munda	C	5	-	-
Cheumatopsyche lepida	C	42	-	-
Hydropsyche sp.	C	31	-	-
Brychius elevatus	C	35	-	-
Limoniidae	C	3	-	-
Baetis rhodani/atlanticus	C	274	10	86
Haliplidae	C	17	1*	-
Gyrinidae	C	3	-	-
Caenis luctuosa/macrura	C	46	-	-
Wormaldia sp.	C	1*	-	-
Lumbricidae	C	2	-	4

Taxon	Group	Site WQ02	Site WQ03	Site WQ04
Lumbriculidae	C	-	23	-
Hydrophilidae larva	C	-	4	-
Dytiscidae	C	-	1*	-
Helophorus sp.	C	-	1*	-
Tipulidae	C	-	-	1*
Scirtidae	C	-	-	2
Sphaeriidae	D	2	30	-
Erpobdellidae	D	2	28	-
Glossiphoniidae	D	2	12	-
Asellus sp.	D	-	4584	1*
Physa fontinalis	D	-	-	1*
Total Number of individuals		5059	5412	598
Number of Taxa		36	16	13

*Where one individual present, this individual is ignored for the purposes of the Q value, but recorded nonetheless

Appendix B. Fish habitat surveys

1. Salmonid habitat assessment

The principal instream physical habitat variables that determine suitability for juvenile salmonids are water depth, water velocity, streambed substratum and cover (Heggenes 1990). The habitat types and their descriptions are outlined in Table 7 and were recorded, where present, during the survey.

Table 7: Habitat classification system for salmonids

Habitat type	Description
Spawning Gravel	Ideally stable but not compacted, with a mean grain size 25 mm or less for trout, but up to 80 mm for salmon. 'Fines' (< 2 mm grain size) to be less than 20% by weight.
Fry (0+) habitat	Shallow, < 20 cm deep, fast flowing (> 30 cm/s), with surface turbulence and a gravel and cobble substrate
Parr (>1+) habitat	20 - 30 cm deep, fast flowing (>30 cm/s), surface turbulent, with gravel / cobble / boulder substrate.
Riffles	Shallow (< 30 cm deep), fast-flowing (> 50 cm/s), surface turbulent, gravel / cobble / boulder substrate.
Glides	= or > 30 cm deep, moderate velocity in range 10-30 cm/sec, surface smooth and unbroken, relatively even substrate of cobbles with finer material
Pools	= or > 40 cm deep, slow flowing (< 10 cm/s), surface unbroken, substrate with a high proportion of sand and silt.

In addition to the habitats listed in Table 7, other features within the study site are noted including:

- The existence of physical barriers to fish migration which are graded 1-3 (G1 being impassable at Q90 flow conditions and G3 passable under Q90 flow conditions)
- Areas of excessive erosion which could cause siltation of spawning habitat- e.g., areas where cattle enter the river
- Anthropogenic alterations to the channel which could affect fish migration
- Areas which could cause difficulties for migrating or spawning individuals during periods of low water levels (e.g., shallow areas near weirs, spawning gravels etc.).
- Locations where branches cross the entire channel giving rise to tunnel vegetation.

2. Lamprey habitat assessment

The guidance published in JNCC (2015) was applied to lamprey habitat assessments. Our approach followed Natura 2000 guidance for the monitoring of river, brook and sea lamprey (*Lampetra fluviatilis, Lampetra planeri* and *Petromyzon marinus*; Harvey and Cowx 2003) and included assessment of habitats using visual mapping of substrates suitable for adult and Juvenile lamprey (Maitland 2003). The habitats suitable for lamprey spawning and larval lamprey (ammocoetes) are outlined in Table 8 and were recorded, where present, during the survey.

Table 8: Definitions of ecologically functional habitat types for lamprey[13]

Species / Life stage	Habitat Description
Lampetra spp. spawning	Areas of small stones and gravel in flowing water
Petromyzon marinus spawning	Flowing shallow water amid gravel
Lampetra spp. ammocoetes	Stable fine sediment or sand > 15 cm deep, low water velocity and the presence of organic detritus
Petromyson marinus ammocoetes	Non-marginal (open channel) sites of >1.5 m depth featuring fine sand and silt accumulations; lower velocity areas of pools and glide habitat

[13] Based on Maitland 2003; Harvey & Cowx 2003; Teague et al. 2014