Appendix 6F

Aquatic Ecology and Fish Report

This page is left intentionally blank.

MWP

Aquatic Ecology and Fish Report

Ballinlee Wind Farm

Ballinlee Green Energy Ltd.

September 2025

Contents

Tables

Figures

Appendices

Project No.	Doc. No.	Rev.	Date	Prepared By	Checked By	Approved By	Status
22635	6003	A	04/03/2025	PD	HD	AO'C	FINAL

MWP, Engineering and Environmental Consultants
Address: Reen Point, Blennerville, Tralee, Co. Kerry, V92 X2TK

www.mwp.ie

This page is left intentionally blank.

1. Introduction

Malachy Walsh and Partners (MWP), Engineering and Environmental Consultants, have been commissioned by Ballinlee Green Energy Ltd. to prepare an Environmental Impact Assessment Report (EIAR) to accompany a planning application to An Coimisiún Pleanála for the proposed Ballinlee Wind Farm in Co. Limerick. As part of the baseline surveys undertaken by MWP to inform preparation of the EIAR, a suite of freshwater aquatic ecology and fish surveys were undertaken within the wind farm site for the project. A separate aquatic ecology and fish report for the grid connection route was undertaken by Woodrow and can be found in this **EIAR, Volume III, Appendix 6G**, Baseline GCR Aquatic Ecology Report.

This report outlines the methods of obtaining survey information and data in relation to aquatic ecology at the proposed development site and waterbodies considered in the receiving environment of the project. Survey results of fish, macroinvertebrates and water quality assessments are presented. Information collated from desk studies has also been included in this report and has informed the surveys.

This report details the survey methods deployed to collect field data and also presents the data. The ecological features covered in this report are fish, macroinvertebrates and aquatic ecology with water quality assessments also carried out.

1.1 Statement of authority

Surveying to inform this report was completed by Gerard Hayes, Noreen Lynch, Petr Dobes and Deirdre O'Brien of Malachy Walsh and Partners. This report was prepared by Petr Dobes, Ecologist with MWP.

Gerard is a Senior Aquatic Ecologist with over 13 years' experience in environmental consultancy, formerly with MWP. Gerard is a full member of the Chartered Institute of Ecology and Environmental Management, the main society in Ireland for professional ecologists, and as such he is bound by their code of professional conduct. Gerard has a diverse ecological profile, with aquatic fauna, phase 1 habitat, mammal (including bats), bird, amphibian, macroinvertebrate, and tree survey experience. He has had numerous responsibilities including report writing (EIS, EIA, EA, AA, NIS), waste assimilation capacity assessment, and ecological monitoring. His project involvement has been primarily in the areas of wind energy development, waste-water treatment plants, roads/bridges, water supply, flood defense and hydro schemes. He is co-author and/or carried out surveys for NPWS Irish Wildlife Manual Nos. 15, 24, 26, 37, 45. This included juvenile lamprey electrical fishing surveys in the Boyne, Corrib, Moy and Suir catchments, the latter which he led. He has collated field data and prepared river water quality assessment reports for EPA biological monitoring of rivers as part of Water Framework Directive (WFD) monitoring. He has been formally trained in WFD river monitoring (Environmental Protection Agency), Stage 1 and Stage 2 Freshwater Pearl Mussel Surveying (Dr. Evelyn Moorkens), aquatic macroinvertebrate identification (Freshwater Biological Association).

Noreen is a former ecologist with MWP. She has three years' experience working on large infrastructure projects across a range of sectors including energy, water, wastewater, roads and bridges and flooding. She has carried out a range of targeted species surveys including otter, bat, crayfish and badger and Phase 1 ecology walkovers.

Petr has been a valuable member of MWP's Ecological team since May 2023. As a qualifying member of the Chartered Institute of Ecology and Environmental Management (CIEEM), he demonstrates a strong commitment to environmental stewardship. His fieldwork experience includes invasive species surveys, bird surveys, freshwater macroinvertebrate sampling and identification, as well as standard ecological survey methodologies such as mammal surveying and habitat mapping. He has also gained experience in conducting Appropriate Assessments (AA) and Ecological Impact Assessments (EcIA) across various projects. Additionally, Petr has received formal training in aquatic macroinvertebrate identification (Freshwater Biological Association), Biological

Water Quality Assessment using the Q-value method (Pascal Sweeney), white-clawed crayfish surveying, and Stage 1 & 2 freshwater pearl mussel surveying (Pascal Sweeney).

Deirdre O'Brien has been working periodically with Malachy Walsh and Partners since 2018 and on a full-time basis since 2019. During that time, she has carried out field work which included invasive species survey's, bird surveys, freshwater macroinvertebrate sampling and identification, (sensu Q' value assessment), collection of water samples. She has also gained experience in standard field survey methodologies including mammal surveying and habitat mapping. She has been formally trained in Stage 1 and Stage 2 freshwater pearl mussel Surveying (Dr. Evelyn Moorkens). She has acquired experience in the completion of Appropriate Assessment (AA), Natura Impact Statement (NIS) and Ecological Impact Assessment (EcIA). She has experience with general ecological report writing and has helped complete numerous reports for bird survey work and is experienced in the collation of data and in field ecology survey techniques.

1.1.1 Legislation

The assessment takes into account the following legislation:

- European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. 272 of 2009) and (Amendment) Regulations 2012 and 2015
- Birds and Natural Habitats Regulations 2011 (S.I. No. 477/2011), and (Amendment) Regulations 2013 and 2015
- Wildlife Act 1976 as amended

The European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. 272 of 2009) and (Amendment) Regulations 2012 and 2015 establish legally binding quality objectives for all surface waters and environmental quality standards for pollutants for purposes of implementing provisions of E.U. legislation on protection of surface waters. These regulations clarify the role of public authorities in the protection of surface waters and also concern the protection of designated habitats.

The Water Framework Directive (WFD), (2000/60/EC) is EU legislation and a major driver for achieving sustainable management of water in Ireland and across the EU. The objective of this directive is to prevent any further deterioration in status of all inland and coastal waters and to restore polluted waterbodies to at least 'Good' ecological status. 'Good ecological status' means achieving satisfactory quality water, suitable for local communities' drinking, bathing, agricultural, industrial and recreational needs, while maintaining ecosystems that can support all the species of plants, birds, fish and animals that live in these aquatic habitats.

The European Communities Birds and Natural Habitats Regulations 2011 transpose the Habitats Directive and the Birds Directive. The Habitats Directive contributes to ensuring biodiversity in the European Union by conserving natural habitats and wild fauna and flora species. It sets up the 'Natura 2000' network, the largest ecological network in the world. Natura 2000 comprises special areas of conservation designated by EU countries under this directive and special protection areas classified under the Birds Directive (Directive 2009/147/EC).

The Wildlife Act, 1976 provided a good legislative base for nature conservation. The species protection provisions, including those regulating hunting, are quite comprehensive, to the extent, for example, that they largely foresaw similar aspects of the EU Birds and Habitats Directives.

Relevant guidance published by the National Roads Authority (NRA, now TII), and applicable to assessing watercourses in Ireland were also followed, including 'Guidelines for the Crossing of Watercourses during the

Construction of National Road Schemes' (NRA, 2005). IFI (2016) 'Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters' was also consulted in relation to necessary mitigation.

Section 171 of the Fisheries (Consolidation) Act 1959 creates the offence of throwing, emptying, permitting or causing to fall onto any waters deleterious matter. Deleterious matter is defined as not only any substance that is liable to injure fish but is also liable to damage their spawning grounds or the food of any fish or to injure fish in their value as human food or to impair the usefulness of the bed and soil of any waters as spawning grounds or other capacity to produce the food of fish. It is necessary to get written permission from Inland Fisheries Ireland to proceed with works in any areas where disturbance to the spawning and nursery areas of both salmonids and lampreys occur. Salmon, all lamprey species and their habitats are further protected under the EU Habitats Directive.

Under Section 3 of the Local Government (Water Pollution) Act, 1977 (as amended by Sections 3 and 24 of the 1990 Act), it is an offence to cause or permit any polluting matter to enter waters. Suspended solids would be a key parameter here. Likewise, any visual evidence of oil/fuel in the river would constitute an offence.

2. Methodology

2.1 Desktop study

A desktop review was carried out to collate information on fish and to identify features of aquatic ecological importance within the study area, defined as fluvial habitats (watercourses) potentially affected by the proposed development, including within the proposed development site, and those downstream, within the receiving environment. Records of protected aquatic species in the environs of the proposed development were identified. This information was obtained by accessing the website of the National Parks & Wildlife Service (NPWS)[1] and Inland Fisheries Ireland (IFI)[2] on 12th December 2022. The database of the National Biodiversity Data Centre (NBDC)[3] was consulted on 6th July 2024 to assess the presence of aquatic faunal species and records of protected species from the study area. The document 'Quantification of the freshwater salmon habitat asset in Ireland' by McGinnity *et al*. (2003) was also reviewed to classify the salmonid habitats in the study area. Watercourse names follow EPA nomenclature. Stream order is described using the classification system given in Strahler (1957) which defines stream size based on a hierarchy of tributaries (with 1st order streams being the smallest).

Results were compared to chemical status on a scale of High-Good-Moderate-Poor-Bad based on water quality standards given in Surface Water Regulations (DoEHLG, 2009), the Freshwater Fish Directive (78/659/EEC) and the Salmonid Water Regulations (1998)[4]. **Table 2-1** shows the physio-chemical parameter thresholds for achievement of Water Framework Directive 'High' and 'Good' Status.

Table 2-1: Physico-chemical parameter thresholds for achievement of Water Framework Directive 'High' and 'Good' Status. From the Surface Water Regulations (SWR, 2009 and as amended)

Parameter	High Status	Good Status
BOD	≤1.3 (mean) or ≤2.2 (95%ile)	≤1.5 (mean) or ≤2.6 (95%ile)
Total Ammonia	≤0.040 (mean) or ≤0.090 (95%ile)	≤0.065 (mean) or ≤0.140 (95%ile)
Orthophosphate	≤0.025 (mean) or ≤0.045 (95%ile)	≤0.035 (mean) or ≤0.075 (95%ile)

[1] https://www.npws.ie/maps-and-data
[2] https://www.fisheriesireland.ie/
[3] http://www.biodiversityireland.ie/
[4] http://www.irishstatutebook.ie/eli/1988/si/293/made/en/print

Maps were produced using shapefiles of the layout of the proposed development site, grid route and publicly available GIS data.

2.2 Field surveys

2.2.1 Scope of field surveys

The study area was defined as fluvial habitats (watercourses) potentially affected by the proposed development, within the receiving environment. Sites were selected on waterbodies representative of the receiving aquatic environment for the proposed wind farm development site as indicated in **Figure 2-1** and **Table 2-3**.

The field surveys comprised an evaluation of aquatic habitats, fish assessments and biotic assessment using aquatic macroinvertebrates, as well as on-site physico-chemical water quality measurements. Water quality affects the viability and quality of salmonid habitat so is useful in assessing habitats for trout and salmon. To this end, biological sampling and water quality indices were used to evaluate watercourses at selected locations. Aquatic field work was carried out on the 15th and 18th July and the 27th September 2022. Amphibian surveys took place on 2nd February 2023 and water quality sampling was undertaken on the 16th and 17th January 2025.

Table 2-2: Aquatic ecology and fish survey locations on watercourses draining the proposed development.

Hydrometric Area	Subbasin	Watercourse	Site	Coordinate (ITM)		Survey			
				X	Y	Aquatic Habitat	Fish Survey	Biological Sampling	Physico-chemical
24 – Shannon Estuary South	Morningstar_050	Morningstar (River)	1	561435	636704	✓			✓
	Morningstar_060	Camas South	2	561314	634659	✓	✓	✓	✓
		Morningstar (River)	3	560385	636916	✓	✓	✓	✓
		Parkroe	4	560066	636657	✓	✓	✓	✓
		Morningstar (River)	5	559452	636672	✓		✓	✓
		Ballinrea	6	560275	634232	✓	✓	✓	✓
		Ballinlee South	7	560117	634129	✓	✓	✓	✓
		Rathcannon	8	559718	634402	✓	✓	✓	✓
		South Ballinlee	9	559372	634877	✓	✓	✓	✓
		Rathcannon	10	559622	635462	✓	✓	✓	✓
		Killorath	11	558868	637365	✓	✓	✓	✓

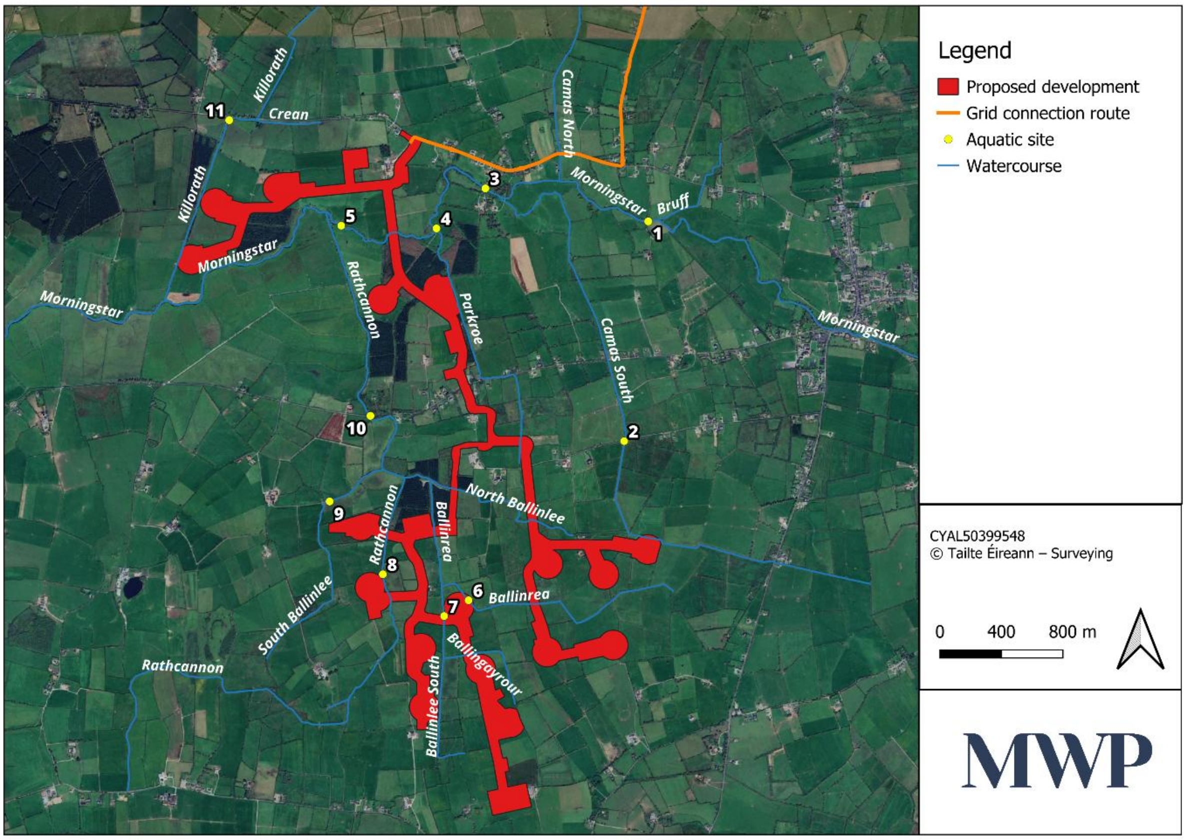

Figure 2-1: Watercourses and aquatic survey sites examined as part of the aquatic ecology studies for the proposed development.

2.2.2 Aquatic habitats

Habitat assessments were carried out at survey sites using the methodology given in the Environment Agency's 'River Habitat Survey in Britain and Ireland Field Survey Guidance Manual 2003' (EA, 2003) and the Irish Heritage Council's 'A Guide to Habitats in Ireland' (Fossitt, 2000). Watercourses were photographed at survey site locations and at various locations throughout the study area. Anthropogenic and livestock influences on fluvial and riparian habitats were noted along the surveyed stretches. Aquatic survey sites were assessed in terms of:

- Stream width and depth and other physical characteristics;
- Substrate type, listing substrate fractions in order of dominance, i.e. large rocks, cobble, gravel, sand, mud etc.;
- Flow type, listing percentage of riffle[5], glide[6] and pool[7] in the sampling area;
- Instream vegetation, listing plant species occurring and their percentage coverage of the stream bottom at the sampling site (as applicable) and on the bankside; and
- Estimated cover by bankside vegetation, giving percentage shade of the sampling site.

[5] Described in EA (2003) as shallow, fast-flowing, water with a distinctly disturbed surface over unconsolidated gravel-pebble, or cobble, substrate
[6] Laminar flow where water movement did not produce a disturbed surface
[7] Little/no observable flow

2.2.2.1 Macroinvertebrate habitat evaluation

Habitat has a key influence on the macroinvertebrate communities which occur in rivers and streams. The physical habitats of study sites were assessed in relation to macroinvertebrates using a method given by Barbour and Stribling (1991). This method assesses habitat parameters and rates each parameter as optimal, sub-optimal, marginal or poor (scores 5, 10, 15 and 20 respectively). The scores for each parameter are then added up to give an overall habitat score. Appendix 1 shows how habitats are assessed using this method.

2.2.2.2 Fish habitat evaluation

The results of the aquatic habitat survey were used in conjunction with the document 'Ecology of the Atlantic Salmon' (Hendry and Cragg-Hine, 2003) to assess habitat suitability for salmonids at selected representative sites. An evaluation of lamprey nursery habitat was also carried out based on the habitat requirements of juvenile lampreys as outlined in Maitland (2003). Searches for juvenile lampreys were carried out using agitation sampling where suitable nursery habitat occurred.

The results of the stream habitat surveys were used in conjunction with the leaflet 'The Evaluation of habitat for Salmon and Trout' (DANI, 1995) to assess habitat suitability for salmonids at selected representative sites. This leaflet (Advisory leaflet No. 1) was produced by the Department of Agriculture for Northern Ireland Fisheries Division and was designed for use in the EU salmonid enhancement programme.

2.2.3 Benthic macroinvertebrates

Semi-quantitative sampling of benthic macroinvertebrates, or aquatic insects, was undertaken at river sites 2 to 11, using kick-sampling (Toner *et al*., 2005 & NRA. 2009). Benthic (bottom dwelling) macroinvertebrates are small stream-inhabiting creatures that are large enough to be seen with the naked eye and spend all or part of their life cycle in or on the stream bottom. Three replicate, 3-minute, multi-habitat kick samples were taken within a 50m stretch using a 1mm mesh kick net (see Plate 2-1). All samples of invertebrates were combined for each site and live sorted on location, fixed in ethanol and labelled for subsequent laboratory identification. The relative abundance and numbers of macroinvertebrates was recorded on-site at each site.

Macroinvertebrate sampling was carried out in accordance with ISO 5667-3:2004: 'Water Quality – Sampling – Part 3: Guidance on the Preservation and Handling of Water Samples' and ISO 7828: 'Water Quality – Methods of biological sampling – Guidance on Hand net sampling of aquatic benthic macro-invertebrates'. Macroinvertebrates were identified using keys listed in the references section. Biological water quality assessments and Functional Feeding Group (FFG) analysis was carried out for each site using biotic indices, based on the range and abundances of macroinvertebrates recorded. Details of biotic indices are provided in Appendix 2.

Plate 2.1: Electrical fishing sampling apparatus employed during the on-site investigations (left). Macroinvertebrate sampling kit used during biological water quality assessment (right)

2.2.4 Biological water quality

Benthic macroinvertebrates, or aquatic insects, were used as an indicator of water quality at each sampling site, apart from site 1. The Quality Rating (Q) System and other biotic indices described below were used to classify biological water quality at aquatic survey sites (See Table 2-3 and Figure 2-1).

2.2.4.1 Biotic indices

Biotic indices used to assess water quality are described here. Further detail is provided in Appendix 2.

Quality rating (Q) system

The Quality Rating (Q) System devised by Toner *et al.* (2005) was used to obtain a water quality rating, or Q-value. As per S.I. No. 258 of 1998, 'biological quality rating' means a rating of water quality for any part of a river based principally on the composition of macroinvertebrate communities/faunal groups present and their general sensitivity to organic pollution. This method categorises invertebrates into one of five groups (A-E), depending on their sensitivity to pollution. Q values range from Q1-Q5 with Q1 being of the poorest quality and Q5 representing pristine/unpolluted conditions. The Q index system is used by the Environment Protection Agency (EPA) and is currently the standard biological assessment technique used in surveying rivers in Ireland under the Water Framework Directive (WFD).

The Ecological Quality Ratio (EQR) represents the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in reference (pristine) conditions applicable to that body. The EQR classifies sites according to ecological quality status as required by river basin management planning under the WFD. It allows comparison of water quality status across the European Union since each member state has an EQR value for 'High'; 'Good', 'Moderate', 'Bad' and 'Poor', based on an intercalibration of boundaries between water quality categories (McGarrigle & Lucey, 2009). Appendix 2, Tables A2.1 and A2.2 provide a description of each of the ecological status classes based on the definitions in the WFD and the typical ecological responses associated with each class.

Biological Monitoring Working Party (BMWP)

The other main biotic index used was the Biological Monitoring Working Party (BMWP) score. In the revised BMWP scheme (Walley and Hawkes, 1997), each family recorded in the sample is assigned a habitat specific score. This score depends on the pollution sensitivity of the invertebrate family together with the characteristics of the site where the invertebrates were found. A site is classed as one of the following depending on substrate type: riffle (>= 70% boulders and pebbles), pool (>= 70% sand and silt) or riffle/pool (the remainder). The BMWP score is the sum of the individual scores of the families recorded at each site - a family scores if present. A higher BMWP score is considered to reflect a better water quality and a score over 100 is indicative of very good water quality. **Appendix 2** shows revised BMWP scores for riffled locations and the BMWP scoring system. Each site was assigned a biological status on a scale of High-Good-Moderate-Poor-Bad.

The Habitat Specific Scores are based on the following substrate compositions:

- Riffles: >= 70% boulders and pebbles
- Pool: >= 70% sand and silt
- Riffle/Pool: the remainder

Average Score Per Taxa

Each site was allocated an Average Score Per Taxa (ASPT). A weakness of the BMWP system, in common with many other score systems, is the effect of sampling effort. A prolonged sampling period can be expected, under most circumstances, to produce a higher final score than a sample taken quickly. To overcome this inherent weakness of the BMWP system, it became common practice to calculate the ASPT. The ASPT index calculation is based on the average value of each taxa (families) sampled, calculated by summing up the indicator values and their division by numbers of taxa (families) sampled, and ranges from 0 to 10. A high ASPT index value indicates thus high ecological status and low values indicate bad/degraded ecological status. In general, the higher the number of taxa present, the better the biological quality of the reach, especially where the ASPT values are high (greater than 5.5).

EPT Index

Biological water quality was also assessed using the EPT (**E**phemeroptera **P**lecoptera **T**richoptera) index. The EPT index (Lenat, 1988) uses three orders of aquatic insects that are easily sorted and identified: mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera), and is commonly used as an indicator of water quality. The EPT index is calculated by summing the number of taxa represented by these three insect orders. The EPT Index is based on the premise that high-quality streams usually have the greatest species richness. Many aquatic insect species are intolerant of pollutants and will not be found in polluted waters. The greater the pollution, the lower the species richness expected.

2.2.5 Physico-chemical water quality

Water samples were collected from all eleven aquatic sites (see **Figure 2-1** for locations) and sent to Southern Scientific Services based in Co. Kerry for laboratory analysis (see **Appendix 6** for laboratory results). The samples were tested for physico-chemical water quality parameters, including:

- Biological Oxygen Demand (BOD)
- Conductivity
- Hydrogen Ion (pH)
- Suspended Solids
- Chemical Oxygen Demand (COD)
- Nitrite
- Nitrite (calculated)
- Total Phsophorus
- Total Organic Carbon (TOC)

- Total Dissolved Solids (TDS)
- Orthophosphate
- Total Hardness
- Total Ammonia
- Temperature

2.2.6 Fish

An electric fishing survey was carried out under licence from the Department of Communication, Energy and Natural Resources under Section 14 of the Fisheries Act (1980). See **Figure 2-1** and **Table 2-4** for locations. **Table 2-4** presents the upstream and downstream limits of the electrical fishing surveys. The purpose of this survey was to assess fish populations present at selected sites on watercourses draining the proposed development. Sites were surveyed following the methodology outlined in the CFB guidance 'Methods for the Water Framework Directive - Electric Fishing in Wadable Reaches' (CFB, 2008). An electrical fishing unit was used during the assessment (see **Plate 1**).

Fishing was carried out continuously for 10 minutes at each site. Captured fish were transferred to a container of river water using dip nets. On completion of the survey, fish were then anaesthetised using a solution of clove oil, identified, and measured to the nearest mm using a measuring board. Subsequent to this the fish were allowed to recover in a container of fresh river water before being released alive. Release of fish was spread evenly over the sampling area. If suitable habitat—characterized by fine-grained sediment deposition—was identified, a 1 m² area was electro fished using six 20-second pulses, totalling two minutes of sampling time (Harvey & Cowx, 2003), to detect the presence of lamprey species.

Table 2-3: Downstream and upstream limits of the electrical fishing surveys undertaken on watercourses draining the proposed development

Tributary - Sub-tributary / EPA Code	River segment code	Site	Upstream co-ordinate (ITM)		Downstream co-ordinate (ITM)		Length fished (m)	Area fished (m²)
			X	Y	X	Y		
Camas South	24_1618	2	561286	635236	561288	635270	45	9
Morningstar (River)	24_1657	3	560407	636903	560387	636918	20	110
Parkroe	24_1556	4	560088	636621	560066	636657	42	21
Ballinrea	24_1632	6	560304	634198	560275	634232	50	15
Ballinlee South	24_1633	7	560116	634085	560117	634129	43	34.40
Rathcannon	24_1089	8	559722	634368	559718	634402	38	38
South Balinlee	24_1146	9	559338	634874	559372	634877	34	8.5
Rathcannon	24_1138	10	559637	635435	559622	635462	30	51
Kilorath	24_1566	11	558390	636443	558868	637365	20	58

Following completion of the fishing, the dimensions and physical habitat characteristics of each site were recorded, including area and flow characteristics. Any fish captured during biological sampling and electrical fishing were recorded and identified with reference to the Freshwater Biological Association's publication 'Key to British Freshwater Fish with notes on their ecology and distribution' (Maitland, 2004) and other referenced sources.

Catch Per Unit Effort (CPUE) indices were derived for each site surveyed based on numbers of fish captured and time fished. Length - % frequency distribution graphs were derived for all salmonids captured during the surveys, at locations where statistically significant numbers were recorded.

2.2.7 Amphibians

The proposed development site was surveyed for the presence of frog spawn on 2nd February 2023. The focus of this survey was on wetter parts of the site, namely drainage ditches and depressions holding water. The location of any frog spawn was recorded. The number of clumps of frog spawn at each location was recorded. The drainage ditches at the site were also surveyed and any tadpoles seen were recorded.

2.2.8 Biosecurity

In cognisance of the risk of spread of non-native invasive alien species, the IFI document 'Biosecurity Protocol for Field Survey Work' (IFI 2010) was followed at all stages of field work. All equipment (including waders etc.) was disinfected with spray bleach disinfectant after use, washed, dried out and put in storage.

2.2.9 Survey limitations

Electrical fishing efficiency was reduced at several locations due to dense instream vegetation. The level of surveying undertaken was sufficient with regard to the objective of these surveys however i.e., to assess the fish populations present.

3. Results

This section provides a description of the aquatic habitats, macroinvertebrates and fish species recorded in the study area, based on the survey sites examined.

3.1 Description of surface water features

The proposed development site comprises fields used primarily for agricultural purposes alongside forestry plantations within the proposed site boundary. Drainage is by overland flow, percolation to ground and aided by occasional field drains along field boundaries. The watercourses into which these drains outflow are low gradient watercourses categorised as 'depositing/lowland rivers' with reference to Fossitt (2000). They drain lands predominantly overlying limestone geology. The overburden is mostly till derived from limestone and deep well drained mineral soil derived from mainly calcareous parent material, so is naturally nutrient rich.

Surface drainage from the proposed development varies by location. The southern section drains northward through 2nd orders streams, Rathcannon and Ballinlee South, as well 1st order streams, South Ballinlee, Ballinrea, and North Ballinlee. In contrast, the northern section drains southwest via the 4th order Morningstar River and 2nd order Killorath stream. The 2nd order Rathcannon Stream and 1st order Parkroe Stream drain north via the Morningstar River. All streams and rivers mentioned above are located within WDF River Subbasin 'Morningstar_060'.

The watercourses draining the proposed development collectively support flora species such as great willowherb (*Epilobium hirsutum*), fool's watercress (*Apium nodiflorum),* brooklime (*Veronica beccabunga*) and lesser water-parsnip (*Berula erecta*), with some yellow iris (*Iris pseudocourus*) recorded on bankside habitats.

3.1.1 Rathcannon Stream

The Rathcannon Stream originates in Ballinculloo, approximately 1.2 km southwest of the proposed development, and flows northeast for about 2.2 km before reaching the boundary of the proposed development. It continues northward, passing through the proposed development.

Within the proposed development, the Rathcannon Stream is fed by the Raymondstown 1st order stream, which drains a small section at the southwest of the site. Approximately 200 m downstream of the proposed development, it is further fed by the 2nd order Ballinrea stream, and 400 m downstream, by the 1th order South Ballinlee stream, which drains the easterly section of the development.

The Rathcannon Stream eventually drains into the Morningstar River (4th order) within the proposed development.

During the aquatic survey in July 2022, Site 8, located on the Rathcannon Stream, exhibited low flow conditions, with the stream nearly dried out.

Figure 3-1: Cattle grid and cattle access to Rathcannon stream recorded at Site 8 (18/07/2022).

3.1.2 Ballinlee South Stream

The Ballinlee South is a 2nd order stream. It rises within the southern section of the proposed development. It is fed by the 1st order Ballingayrour Stream which drains the southeastern section of the development. The Ballinlee South drains into the 2nd order Ballinrea Stream within the proposed development.

Figure 3-2: Shallow and overgrown channel recorded at Site 7 on the Ballinlee South Stream (18/07/2022).

3.1.3 Ballinrea Stream

The Ballinrea stream originates as a 1st order stream in Tynacocka, near the eastern boundary of the proposed development site. It flows westerly through the site and is joined by the 2nd order Ballinlee South stream, which drains the southern sections of the proposed development. At the confluence with Ballinlee South, the 1st order Ballinrea stream transitions to a 2nd order stream.

Approximately 700 m downstream, the Ballinrea stream is further fed by the 1st order North Ballinlee stream, which drains the southern section of the development site. Ultimately, the Ballinrea stream flows into the 2nd order Rathcannon stream.

Figure 3-3: Dried up channel recorded at Site 6 on the Ballinrea stream (18/07/2022).

3.1.4 North Ballinlee Stream

North Balinlee is a 1st order stream which rises in Ballinlee North at the southern section of the proposed development. It flows northwest before it drains into the 2nd order Ballinrea stream.

3.1.5 South Ballinlee Stream

South Ballinlee is a 1st order stream originating in Ballincurra at the southwestern section of the proposed development. It flows through the western section of the site for an approximate distance of 1 km before draining a further 600 m downstream into the 2nd order Rathcannon stream.

3.1.6 Camas South Stream

Camas South is a 1st order stream arising in the townland of Ballygrennan, approximately 1.4 km upstream to the east of the proposed development. It briefly flows westwards through the site for approximately 250 m. After leaving the site, it flows to the north, draining into the 4th order Morningstar River 2.8 km downstream. The majority of this stream has been drained.

Figure 3-4: Overgrown channel of the Camas South stream recorded at Site 2 (18/07/2022).

3.1.7 Morningstar River

The Morningstar River is a 4th order river, originating in Glenaree, Co. Limerick, approximately 19 km to the southeast of the proposed development. It flows for approximately 31 km before it reaches the proposed development. After reaching the northeast part of the development, it flows to the south for ca. 500 m, where it is fed by the 1st order Parkroe stream, which drains the northern part of the proposed development. It then changes direction and flows to the west for a distance of 900 m before it is joined by the 2nd order Rathcannon stream, which drains the southern section of the proposed development. The Morningstar River flows for a further 1.5 km to the southwest before it leaves the proposed development. It drains into the 5th order River Maigue, 7 km downstream from the proposed development. The lower reaches of the River Maigue are encompassed within part of the Lower River Shannon SAC (002165), approx. 17 km downstream from the confluence with the Morningstar River.

Sites 1, 3, and 5, located on the Morningstar River, were found to be in the best condition among all surveyed sites during the aquatic assessment. However, despite their relatively better state, these sites exhibited evidence of impacts from agricultural practices in the surrounding area, including potential nutrient enrichment and sediment input.

Figure 3-5: Morningstar River at Site 3 (18/07/2022).

3.1.8 Parkroe

Parkroe is a 1^{th} order stream originating in the townland of Camas South within the proposed development. This stream flows northerly for 1.8 km before draining into the Morningstar River. Site 4 is located on this stream. At the time of survey there was no flow in this stream.

Figure 3-6: Overgrown channel recorded at Site 4 on the Parkroe stream (18/07/2022).

3.1.9 Killorath

Killorath stream rises in the townland of Ballylahiff north of the proposed development. It flows southerly towards the proposed development for ca. 2.2 km before it is joined by the 1th order stream Crean. After the confluence with the Crean stream it keeps flowing south as a 2nd order stream, before discharging into the Morningstar River after 1.4 km.

During a sampling at Site 11, a sluice structure was noted nearby.

Figure 3-7: Killorath stream at Site 11 (15/07/2022).

3.2 Aquatic habitats

The physical attributes of watercourses draining the proposed development are the basis of the aquatic ecosystems supported therein. The habitat quality for macroinvertebrates (**Section 3.2.1**) and fish (**Section 3.2.2**) is a function of the watercourse characteristics in the receiving riverine environment. The physical characteristics of survey sites are listed in **Table 3-1**.

The watercourses draining the proposed development site are low gradient streams. Their lotic[8] carrying capacity is limited by certain characteristics including morphological condition, small size, riparian conditions (e.g. overshading) and / or pollution.

The stream substrates recorded comprised mainly of cobble and gravel with significant silt deposits at all sites apart from sites 1, 3, 5 and 9. The subject watercourses are characterised by riffle-glide-pool sequences in reaches of higher gradient, with lower gradient reaches exhibiting more glide-pool sequences. They are generally shallow with a mean summer depth of 5 cm-20 cm, with only four sites exceeding 20 cm. Significant siltation (heavy/moderate) was recorded at all sites, apart from site 1, 3 and 5, which are located on the Morningstar River. All rivers surveyed during the aquatic surveys flow through agricultural areas, so substrate siltation is most likely a result of agricultural practice. The study area lies in lands primarily used for production of milk and beef, and observations of riparian and instream impacts from cattle access and runoff from denuded riparian areas were common during the surveys undertaken. The excessive siltation recorded across the study area was considered

[8] of organisms or habitats inhabiting or situated in rapidly moving fresh water

to reduce the habitat availability and quality to benthic macroinvertebrates and fish alike. Evidence of enrichment in the form of luxuriant macrophytes and/or filamentous algae was also recorded at most locations, the occurrence of these flora dependent on light. Primary instream production in these watercourses is considered strongly influenced by emergent vegetation, which can dominate some reaches of these streams during the growing season. Along with stressors like siltation and eutrophication, this likely limits the biodiversity of these aquatic ecosystems.

Table 3-1: Physical characteristics of the aquatic survey sites

New site No.	1	2	3	4	5	6	7	8	9	10	11
Wetted width (m)	5.5	0.2	5.5	0.5	6.5	0.3	0.8	1	0.25	1.7	2.9
Riffle (%)	15	1	35	0	60	5	0	0	0	5	0
Glide (%)	50	4	30	0	30	5	5	10	10	10	0
Pool (%)	35	95	35	100	10	90	95	90	90	85	100
Instream vegetation cover (%)	25	90	2	80	50	50	10	90	95	0	95
Mean depth (cm)	25	3	25	2	20	1	5	5	3	15	60
Max depth (cm)	55	10	60	5	40	15	10	20	5	40	100
Boulder (%)	15	0	30	5	20	10	0	5	5	5	5
Cobble (%)	20	5	30	5	30	10	5	5	25	5	5

New site No.	1	2	3	4	5	6	7	8	9	10	11
Gravel (%)	40	25	30	15	30	0	0	0	25	5	0
Sand (%)	15	10	5	5	10	0	0	5	10	5	0
Silt (%)	10	60	5	70	10	80	95	85	30	80	90
Shade (%)	5	100	85	85	15	90	100	95	100	100	5
Bank Cover (%)	5	75	50	100	90	65	50	80	100	50	100
Bank erosion (Both Banks, Mild/Severe/High/None)	H	N	M	N	M	S	N	S	M	M	N
Bank height (m)	1.3	2	2.3	2.5	3	10.5	2.2	1	1	3	1.5
Siltation (Clean/Slight/Moderate/Heavy/Excessive)	M	H	M	H	L	H	H	H	H	E	H
Plume (Heavy/Moderate/Slight/None)	H	H	H	H	H	H	H	H	H	H	H
Algae cover(%)	25	0	0	0	10	0	0	0	0	0	1
Main land use*	IAG	IAG	IAG	IAG	IAG	IAG	IAG	IAG	IAG	IAG	IAG

* IAG = improved agricultural grassland

3.2.1 Macroinvertebrate habitats

The physical habitat suitability assessment of the survey sites for macroinvertebrate production is provided in Table 3-2. Based on the physical attributes of the surveyed sites and assessment criteria, the sites are generally rated between marginal and suboptimal. This rating was applied to all survey sites mainly due to the domination of substrates by one size class (rock/cobble) owing to the low gradient of watercourses, suboptimal habitat complexity, coupled with mainly marginal pool quality (<1m deep), bank stability (eroding in some instances) and canopy conditions (heavily shaded). The drain-like watercourses such as the Camas South (Site 2) and Killorath stream (site 10) were rated least suitable for aquatic macroinvertebrates. Habitats of this classification can limit taxa richness as there are fewer ecological niches available, noting that mixed gradient streams are generally suitable for macroinvertebrates with morphologies evolved for fast flows (such as Heptagenid mayflies), as well as those with other life strategies (e.g., burrowing larvae of Ephemeridae mayflies). With increasing size and depth, corresponding to distance downstream from the proposed development site, the stream macroinvertebrate suitability was found to generally increase. The highest habitat score was recorded at Site 5 on the Morningstar River, primarily due to the larger channel size and greater habitat complexity, which provides more suitable conditions for macroinvertebrate production. In contrast, the other surveyed streams exhibited lower habitat scores, largely due to poor substrate composition, reduced flow conditions, and limited habitat diversity.

Habitat suitability also depends on water quality. Impacted conditions (e.g. below 'good' status) will also result in fewer taxa. The synergistic effect of river morphological character (including physical habitat) and stressors (e.g., silt) along with other water quality influences (e.g., nutrient loading) could explain the variation in results at the study sites.

Table 3-2: Physical habitat assessment of the survey sites regards suitability for macroinvertebrate production (adapted from Barbour and Stribling, 1991)

Site	Watercourse	Bottom substrate	Habitat complexity	Pool quality	Bank stability	Bank protection	Canopy	Score	Average score	Overall Assessment[1]
1	Morningstar (River)	15	20	15	15	15	5	85	14.2	Suboptimal
2	Camas South	5	5	5	5	5	5	30	5	Poor
3	Morningstar (River)	15	20	15	15	15	5	85	14.2	Suboptimal
4	Parkroe	10	10	5	15	15	10	55	9.17	Marginal
5	Morningstar (River)	15	20	15	10	15	15	90	15	Suboptimal
6	Ballinrea	5	5	5	15	10	10	50	8.3	Marginal
7	Ballinlee South	5	5	5	10	10	10	45	7.5	Poor
8	Rathcannon	10	10	10	10	5	10	55	9.2	Marginal
9	South Ballinlee	5	10	10	10	10	10	55	9.2	Marginal
10	Rathcannon	5	5	5	15	10	10	50	8.3	Marginal
11	Killorath	5	5	5	5	10	10	40	6.7	Poor

[1] scale: poor (5) - marginal (10) – suboptimal (15) – optimal (20)

3.2.2 Fish habitats

It is considered that the importance of the small streams draining the proposed development site generally increase with distance downstream until their gradient eases, or they merge with other streams to become larger watercourses. This is a universal concept related to stream size and water quantities in parts of catchments near watershed boundaries.

Within the streams surveyed, a relatively small proportion of the fluvial habitat was classified as suitable for salmonid spawning. Such habitats are the transitional areas between pool and riffle where flow accelerates and depth decrease over gravel beds, due to a marked change in hydraulic head over the gravel. Based on the physical character of the sites surveyed, only the Morningstar River offered marginal conditions for salmonids. The other watercourses are deemed too small and lack the physical features required for salmonid reproduction i.e., well aerated clean gravels and/or gravel substrates at the end of pools which can provide spawning areas. Riffles (broken water), instream rocks, irregularities in the stream bed and dappled shade, or combinations thereof, generally provide some nursery habitat in the Morningstar River. This watercourse is considered suboptimal for the early life stages of salmonids and for spawning adult salmonids however, as these features do not commonly occur together. It is noted by Crisp (2000) that small trout may spawn in quite small gravel patches between large stones. Such features are likely of importance to spawning trout in the Morningstar River. The small size of the watercourses near the proposed development are unsuitable for holding large salmonids: the small/shallow pools are not considered sufficiently large for large trout and adult salmon througout the year.

There are some obvious water quality problems associated with siltation and enrichment which reduce the quality of salmonid spawning and nursery habitat however. Salmonids, especially at early life stages require good water quality. Generally, unsatisfactory water quality conditions (See **Section 3.4.2**) are considered to limit reproductive success (decreasing oxygen supply to ova buried in gravels) and early life stage opportunities for salmon and trout. A study by Kelly *et al.* (2007) established that there is a relationship between fish-community composition and Q-values – the abundance of 1+ and older salmon was significantly different between moderate (Q3–4) and good-quality (Q4) sites. **Table 3-3** gives the habitat rating of the watercourses examined with reference to salmonid habitats.

Table 3-3: Salmonid habitat rating at the aquatic survey sites

Site	Watercourse	Spawning		Nursery		Holding		Overall evaluation
		Habitat grade[1]	fluvial cover[2] (≈%)	Habitat grade[1]	fluvial cover[2] (≈%)	Habitat grade[1]	fluvial cover[2] (≈%)	
1	Morningstar (River)	2	60	3	40	3/4	5	Suboptimal
2	Camas South	4	5	4	5	4	15	Poor
3	Morningstar (River)	2	40	3	30	3/4	25	Suboptimal
4	Parkroe	4	5	4	5	4	5	Poor
5	Morningstar (River)	2	65	2	70	3	15	Suboptimal
6	Ballinrea	4	5	4	5	4	5	Poor
7	Ballinlee South	4	5	4	10	4	5	Poor
8	Rathcannon	4	5	4	10	4	10	Poor
9	South Ballinlee	4	5	4	10	4	5	Poor
10	Rathcannon	4	5	4	5	4	5	Poor
11	Killorath	4	5	4	5	4	5	Poor

Following DCAL's advisory leaflet 'The Evaluation of habitat for Salmon and Trout'

[1]*Grade 1 is optimal habitat and habitat quality reduces with increases in Grade (Grade 4 = poor)*

[2] *Fluvial cover relates to river substrate under water and available to fish*

Lampreys have similar habitat requirements for spawning to small trout. There are adequate silt deposits in the watercourses draining the proposed development, a requirement for juvenile lamprey larvae, but as for salmonids, there is poor lamprey spawning habitat. This is considered the limiting factor for lampreys in the study area. Lamprey may occur in the subject watercourses in very low densities and any present are considered brook lamprey (*L. planeri)*. This assertion takes account of the poor swimming ability of lampreys (Reinhardt *et al.* 2009) and distance from the sea.

3.2.2.1 Site 1, 3, 5

The sites are located on the Morningstar River. This watercourse is wide and fast flowing with good sections of gravel and cobble. This watercourse is considered suboptimal for salmonids. Potential salmonid spawning and nursery value was assessed as suboptimal. The holding value was poor due to its smaller size and lack of pool habitats.

Site 3 is the only location where salmonids were recorded alongside with brook lamprey. This reach of the river supported heathy populations of small salmon and trout.

3.2.2.2 Site 2, 4, 6, 7

The surveyed sites are situated on first-order streams, including Camas South, Parkroe, Ballinrea, and Ballinlee South. These streams exhibited poor habitat conditions for salmonid species, primarily due to their small size and significant siltation, largely attributed to intensive agricultural activities in the surrounding area.

During the electrofishing survey, Three-Spined Stickleback (*Gasterosteus aculeatus*) was the only fish species recorded at these sites. This species is known for its high adaptability and tolerance to environmental stressors, including low oxygen levels, organic enrichment, and elevated nutrient loads—conditions often associated with agricultural runoff. Their presence suggests that these streams may be experiencing ecological pressures that limit their viability for more sensitive fish species, such as salmonids.

3.2.2.3 Site 8, 10

Both surveyed sites provide poor suitability for spawning and nursery habitats for salmonids, primarily due to the lack of substrate diversity and the small channel size, which limits available refugia and spawning areas for fish species.

Minnow (*Phoxinus phoxinus*) was the only species recorded during the electrofishing survey, indicating that the stream may support only tolerant fish species capable of withstanding suboptimal environmental conditions.

3.2.2.4 Site 9, 11

The surveyed sites are located on South Ballinlee and Killorath streams. Both streams provide poor habitat quality for salmonids due to significant siltation and the absence of suitable spawning and nursery habitats.

No fish were recorded at either site during the electrofishing survey, which may indicate unfavourable environmental conditions, such as poor water quality and excessive sedimentation. The absence of fish highlights the ecological limitations of these streams, likely exacerbated by surrounding land-use pressures.

3.3 Macroinvertebrate diversity and abundance

3.3.1 Existing information

The Morningstar River supports an array of macroinvertebrate life, including larvae of mayfly (*Ephemera danica, Baetis rhodani, Seratella ignita, Caenis* sp.), caddisfly (*Limnephilus* sp,, Glossosomatidae, Phyrganeidae, Polycentropodidae, Hydropsychidae), molluscs (*Ancylus fluviatilis, Theodoxus fluviatilis, Potamopyrgus antipodarium, Radix balthica*), the dragonfly *Agrion* sp. and the crustacean *Gammarus* sp. Most of these taxa can be expected to occur in the watercourses which drain most of the proposed development site. The macroinvertebrate assemblages in watercourses that drain agricultural lands can be expected to coincide with those that generally occur in the Morningstar_060 subbasin, i.e., pollution tolerant taxa.

According to the NBDC, there are numerous records of white-clawed crayfish *(Austropotamobius pallipes)* within the area, with the most recent record dating back to 2020 indicating white-clawed crayfish c. 6.5rkm downstream of the Development on the Morningstar River between the town of Athlacca and the confluence with the Maigue. However, this species suffered significant population declines due to the crayfish plague outbreak in 2017. Crayfish plague, caused by the water mould *Aphanomyces astaci,* is present in the Maigue catchment as confirmed by National Crayfish Plague Surveillance Programme (NCPSP)[1] in successive sampling years from 2018-2019 and 2020-2021 and updates from the Fish Health Unit at the Marine Institute[2]. The NCPSP confirmed the presence of white clawed crayfish and the crayfish plague in the Morningstar River in 2020 downstream of the proposed Development at Athlacca (Howardstown) bridge. In 2021, at the same sampling site, eDNA sampling for the crayfish plague and white clawed crayfish were both confirmed to be negative. Three crayfish plague mortality events occurred in 2021 in the Shannon Estuary South, one of which was upstream of the proposed Development on the Morningstar River at Ballinahinch Bridge, confirming the continued spread of crayfish plague within the Maigue catchment and the Morningstar River.

3.3.2 Survey results

The results of the macroinvertebrate surveys are presented in **Appendix 3**, where a species list of macroinvertebrates recorded at each survey location has been provided. The bulk of macroinvertebrates recorded belong to pollution sensitivity group C across the survey sites (pollution tolerant) as per Toner *et al,* (2005). Some of the most commonly recorded macroinvertebrates in the study area are shown below. The greatest diversity of macroinvertebrates was recorded at Site 3 on the Morningstar River where 26 taxa were recorded. The reason for this diversity could be attributed to sampling in the combination of vegetative and stony habitats upstream and downstream of the bridge, respectively. The lowest taxa found were at Site 2 (5), Camas South stream and Site 11 (10), Killorath stream. Species diversity is shown in **Table 3-4**.

Table 3-4: Species diversity at the aquatic survey sites.

Site	2	3	4	5	6	7	8	10	11
Species richness	5	26	14	18	12	14	21	12	10

Among the Ephemeropterans (mayflies) recorded during the survey, *Heptagenia sp.* was found only at Sites 3 and 5, while *Ephemera danica* was recorded exclusively at Site 5. These species were the only representatives of Group A (pollution-sensitive group) identified across all surveyed sites, indicating that highly sensitive aquatic macroinvertebrates were scarce in the study area.

More pollution-tolerant mayfly species, including *Baetis rhodani, Alainites muticus*, and *Serratella ignita*, were present at Sites 3, 5, and 10. These species are known for their higher tolerance to organic enrichment and moderate pollution levels, belonging to group C.

No representatives of the Plecoptera (stoneflies) order were recorded during the survey.

The Trichopterans (caddisflies) were a well-represented group in the survey, with two cased (Group B) and three caseless (Group C) species recorded.

Among the cased caddisfly larvae, the Limnephilidae family was the most widespread, present at all sites except Sites 2, 4 and 11. The only other cased caddisfly recorded, *Sericostoma personatum*, was found exclusively at Site 7, indicating a more localized distribution.

Caseless caddisfly larvae, including *Hydropsyche sp., Rhyacophila sp.,* and *Polycentropus sp*., were scarce across surveyed sites. All three species were recorded only at Site 3, while Site 5 yielded only *Rhyacophila sp*.

The Diptera (true flies) were represented across the survey sites by the Simuliidae, Pediciidae, Chironomidae, and Empididae families.

Crustaceans (Crustacea) were among the most abundant macroinvertebrate groups recorded. *Gammarus duebeni* accounted for a significant proportion of the macroinvertebrate community and was present at all sites except Site 6. Similarly, *Asellus aquaticus* was widely recorded, with the exception of Sites 3, 5, and 8.

The Coleoptera (beetles) were also well represented, with six different families recorded: Gyrinidae, Dytiscidae, Hydrophilidae, Elmidae, Helodidae, and Haliplidae.

Mollusc species recorded during the survey included a variety of snails and mussels:

Snails: *Potamopyrgus antipodarum, Theodoxus fluviatilis, Planorbis carinatus, Bithynia tentaculata, Physa fontinalis, Lymnaea peregra,* and *Lymnaea stagnalis*

Mussels: *Pisidium* sp.

Several Hemiptera (true bug) families were also identified, including Veliidae, Mesoveliidae, and Gerridae.

Other recorded taxa included damselfly (Calopterygidae), water mites (order Hydracarina), aquatic earthworms (Lumbricidae and Lumbriculidae), and leeches (Hirudinea), all of which contributed to the overall macroinvertebrate diversity of the study area. See Plate 3.1 and 3.2, for macroinvertebrates caught during the kick sampling in July 2022.


Plate 3.1. Mayfly larvae of *Heptagenia sp*. (top middle to image on left side), *Baetis rhodani* (bottom left on image to the left), *Caenis* sp. (bottom right on image on left side) and *Seratella sp*. (top left on image to left side) from Site 3. Adult diving beetle (Dityscidae) from site 3 (right image)


Plate 3.2. Banded jewelling larvae, *Agrion sp.* (left image). *Asellus aquaticus,* one of the most recorded macroinvertebrate across all sites (right image)

3.4 Water quality

3.4.1 Existing information

3.4.1.1 Biological water quality

The EPA carries out biological monitoring at stations at various locations along the watercourses that drain the proposed development site. The results of these are given hereunder.

The following is the most recent EPA biological assessments[9] for the Morningstar River draining the proposed development, based on surveys in 2023:

[9] http://www.epa.ie/QValue/webusers/PDFS/HA24.pdf?Submit=Get+Results

- Morningstar River: Good ecological conditions were observed at four of the six stations surveyed on the Morningstar river in 2023. Both station 0300 and 0600 declined from good to moderate ecological condition. Siltation and signs of enrichment were observed at every station on this river.[10]

3.4.1.2 Physico-chemical water quality

Nutrient enrichment (excessive inputs of phosphorus and nitrogen) is the main cause of water pollution in Ireland. The Environmental Quality Standards (EQS) for individual chemical parameters define the threshold for achieving 'Good' chemical status. The compliance of river and lake monitoring stations against the physico-chemical EQSs, in particular ortho-phosphate, but also nitrate and ammonia, is usually complimentary to biological assessments at the same monitoring point. Nutrient concentrations were available for the Morningstar River at the bridge 2km downstream of Athlacca (monitoring station code RS24M020800) as part of WFD surface water monitoring. The results of the key parameters are presented in **Appendix 4** and summarised below in **Table 3-5**. The results are discussed by parameter below. The results at these locations are deemed representative of conditions in streams draining the proposed development site, taking account of catchment characteristics and landuse.

Table 3-5: EPA chemistry results for the Morningstar River (monitoring station code RS24M020800) between January 2022 and October 2024

Parameter	Unit	Limit of Detection	Morningstar River		
			N	Mean	Max
Ammonia-Total (as N)	mg/l	0.02	13	0.020	0.039
BOD - 5 days (Total)	mg/l	1	13	0.77	1.9
Dissolved Oxygen	% Saturation	1	13	95.7	115
Dissolved Oxygen	mg/l	0.1	13	10.38	12.6
Nitrate (as N)	mg/l	0.2	5	1.19	2.1
Nitrite (as N)	µg/l	4	5	6.59	10.3
ortho-Phosphate (as P) - unspecified	mg/l	0.01	13	0.084	0.16
Total Hardness (as CaCO3)	mg/l	10	13	266.2	307

3.4.1.2.1 ***Total Ammonia/Ammonium***

Ammonia occurs naturally in rivers arising from the microbiological decomposition of nitrogenous compounds in organic matter. Fish and other aquatic organisms also excrete ammonia (EPA, 2001). Ammonia is naturally present in unpolluted waters in small amounts usually <0.02mg/L as N. Animal slurry, domestic sewage and industrial processes can all contribute to ammonia levels in water bodies. Ammonia may also be discharged directly into water bodies by some industrial processes or as a component of domestic sewage or animal slurry. The decay of organic waste is another factor leading to the addition of ammonia in waters (EPA, 2001).

Total Ammonia mean concentrations were 0.020 mg/l, with maxima of 0.039 mg/l. The maximum values are considered high. In relation to the 'Quality of Salmonid Waters Regulations 1988' this parameter has an EQS of ≤1mg/L NH_4, subject to conforming to the standard for non-ionized ammonia (Flynn, 1988). All samples met this objective.

3.4.1.2.2 ***Biochemical Oxygen Demand (BOD) and Oxygenation***

[10] https://epawebapp.epa.ie/qvalue/webusers/PDFS/HA24.pdf?Submit=Get+Results

BOD serves as an indicator of the presence of organic matter in a watercourse (eutrophication) and is a useful measure of water quality. Mean and maximum BOD results for the Morningstar River were 0.77 mg/l and 1.9 mg/l respectively - indicative of good status.

These results are within the recommended tolerance of 5mg/L O_2 for salmonid species. The results also achieve adherence to the 'Freshwater Fish Directive (78/659/EEC)' guidance of 3mg/L O_2 for salmonid waters and 6mg/L O_2 for cyprinid (fish from carp family) waters (EPA, 2001). During times of heavy rainfall and high river flows the BOD value often increases due to organic matter being washed from land and farmyards (EPA, 2011).

3.4.1.2.3 ***Nitrate/Nitrite***

There are no environmental quality standards for nitrate but average nitrate concentration values less than 4 mg/l NO_3 (0.9mg/l N) and less than 8 mg/l NO_3 (1.8mg/l N) are considered by the EPA to be indicative of high and good quality respectively (EPA, 2017).

The results indicate that the Morningstar River is good quality, in accordance with EPA (2001) guidance, as average values for nitrite were 1.19. Results for nitrite are from between January 2022 and August 2022. They are no results from 2023 and 2024.

3.4.1.2.4 ***Orthophosphate***

This chemical parameter does occur naturally in water bodies from geological sources. Orthophosphate is the most readily available form of the nutrient Phosphorous for plant uptake during photosynthesis and is generally considered to be the limiting nutrient for plant growth in freshwater. Elevated levels of this chemical can have a detrimental effect on aquatic life.

The average values for orthophosphate in the Morningstar River were 0.0084 mg/l, with maximum values of 0.16 mg/l. The mean orthophosphate levels met the 'good' quality status. The maxima indicate severe episodic problems. The main cause for elevated levels is from agricultural runoff from land and farmyards which can contain organic and artificial fertilisers and other effluents (EPA, 2001).

3.4.1.2.5 ***Total Hardness***

The average water hardness of the Morningstar River was 266.2 mg/l. According to the EPA's classification table for water hardness (EPA, 2001), water in the study area is classified as 'Hard' (251 mg/l – 350 mg/l). Harder water can reduce the effect of toxicity of some metals including zinc, copper and lead (EPA, 2001).

3.4.2 Survey results

3.4.2.1 Biological water quality

The biological water quality of the watercourses in the receiving environment is impacted to the degree that only three 'Group A' pollution sensitive taxa were recorded during the baseline aquatic surveys for the proposed development, and at only 2 sites. It is notable also that a major group of macroinvertebrates, the Plecoptera (stoneflies), were not recorded, this group containing mostly pollution sensitive indicators. Another biological metric of water quality, the Salmonidae, were absent from most sites examined, this attributed mostly to habitat suitability but also in part to water quality, noting that these two parameters were inter-related in the small channels draining the site. Biological water quality is largely compromised in the study area. Q-ratings and EPT indices derived from the diversity and relative abundance of the macroinvertebrates at the study sites are given in Table 3-6.

Based on macroinvertebrate assemblages, the EPA scheme and Water Framework Directive (WFD) intercalibration, 'Poor' ecological conditions were recorded at all locations, apart from Site 3 and 5, which were 'Moderate'. Site 9 was unsuitable for Q-rating scheme due to small size/poor habitat however, so this result must be interpreted accordingly.

Based on BMWP scores, biological water quality ratings were mostly 'Poor' (Sites 2, 4, 6, 7, 8, 10 and 11) and 'Moderate' (Sites 3 and 5). Site 3 on the Morningstar River scored highest at 100, with a corresponding category of 'Good', interpreted as 'Clean but slightly impacted'.

The EPT (Ephemeroptera, Plecoptera, Trichoptera) index of water quality across sampling locations varied between 0 (Site 2) to 13.3 (Site 3). Based on the EPT index, macroinvertebrate richness is highly variable and generally indicative of degraded water quality.

Overall, the biological water quality results indicate an unstable aquatic ecosystem in some of the smaller streams within the study area. The most significant factor influencing water quality appears to be soil loss into watercourses, primarily caused by cattle access and the absence of buffer strips adjacent to streams.

As noted by Kelly-Quinn & Reynolds (2020), excess fine sediment can severely impact river invertebrate diversity and abundance by coating and clogging benthic substrates, reducing interstitial habitat, abrading delicate feeding and respiratory structures, and smothering eggs, nymphs, and larvae. Additionally, soil loss from surrounding land introduces excess nutrients—particularly phosphorus—into watercourses. This nutrient enrichment can lead to excessive plant and algal growth, which disrupts the natural functioning of aquatic ecosystems. Such eutrophication can cause shifts in biological communities, reduce oxygen availability, and create an overall deterioration in ecological integrity (EPA, 2018).

Table 3-6: Biological water quality results and interpretations at study sites on watercourses potentially affected by the proposed wind farm

Site	Watercourse	Q-rating	Quality Status	Corresponding WFD Status	BMWP Score	BMWP Category	BMWP Interpretation	EPT
2	Camas South	Q2-3	Moderately Polluted	Poor	15	Poor	Polluted or impacted	0
3	Morningstar (River)	Q3-4	Slightly Polluted	Moderate	100	Good	Clean but slightly impacted	13.3
4	Parkroe	Q3	Moderately Polluted	Poor	60	Moderate	Moderately impacted	10
5	Morningstar (River)	Q3-4	Slightly Polluted	Moderate	95	Good	Clean but slightly impacted	12
6	Ballinrea	Q3	Moderately Polluted	Poor	51	Moderate	Moderately impacted	5.7
7	Ballinlee South	Q3	Moderately Polluted	Poor	70	Good	Clean but slightly impacted	7.9
8	Rathcannon	Q3	Moderately Polluted	Poor	96	Good	Clean but slightly impacted	6
9*	South Ballinlee	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10	Rathcannon	Q3	Moderately Polluted	Poor	52	Moderate	Moderately impacted	3.5
11	Killorath	Q2-3	Moderately Polluted	Poor	40	Poor	Polluted or impacted	0

*unsuitable for Q-rating scheme due to small size/poor habitat

3.4.2.2 Physico-chemical water quality

Laboratory results from the aquatic site samples are summarized in **Table 3-7**, with key findings outlined below. pH levels were alkaline across all sites. Nitrite concentrations were below 1.8 mg/l N at only three sites (Site 4, Site 8, and Site 9), indicating good water quality. However, most sites exceeded this threshold, with the highest recorded value at Site 7 (9.06 mg/l N) on the Ballinle South Stream. Conductivity levels were high, consistent with watercourses draining limestone-based soils. Water hardness was also elevated across the study area, with all sites exceeding 300 mg/l CaCO3, classifying them as 'very hard water' (>300 mg/l CaCO3). For a full analysis of all tested parameters, refer to **Appendix 4**.

Table 3-7: Summary of key water quality parameters from samples taken at aquatic sites

Site	Watercourse	pH	Temperature (°C)	Conductivity (µS/cm)	Total hardness (mg/L CaCO3)	Nitrate (mg/l N)
1	Morningstar (River)	8.3	16.4	481	325	2.32
2	Camas South	8.2	16.5	514	346	1.99
3	Morningstar (River)	8.3	16.3	480	342	2.45
4	Parkroe	8.1	16.4	493	339	0.84
5	Morningstar (River)	8.4	16.5	480	336	2.37
6	Ballinrea	8.4	16.5	524	364	4.13
7	Ballinlee South	8.3	16.6	564	402	9.06
8	Rathcannon	8.3	16.4	514	359	1.07
9	South Ballinlee	8.2	16.5	523	333	1.73
10	Rathcannon	8.3	16.5	536	361	4.34
11	Killorath	8.0	16.6	643	447	5.3

3.5 Fish

3.5.1 Existing information

The proposed development is located in the 10km grid squares R53 and R63. The distribution and range of protected fish in the 10km grid squares containing the Ballinlee proposed development site are illustrated in **Table 3-8**. This is based on Article 17 (2013 - 2018) Assessments in NPWS (2019) and includes the three lamprey species. The proposed development is also located in the Maigue_SC_030 subcatchment.

Salmon *Salmo salar* was once common in the Morningstar River and River Maigue but faces many obstacles and problems both at sea and in freshwater. Arterial drainage has interfered with the fishery value of the River Maigue. The River Maigue supports populations of Salmon and experiences a notable run of spring salmon from mid-March to mid-May, followed by a grilse run from early June to the end of July[11]. Whilst the Morningstar River contributes to the River Maigue, which supports salmon populations, it is predicted that some juvenile salmon may be present in the river. This has been confirmed by the capture of young salmon during the proposed development site survey conducted in July 2022. Salmon are protected under both European (Habitats Directive,

[11] https://www.limerick.ie/discover/eat-see-do/sports-recreation/activities/fishing-angling/river-maigue-game-angling

92/43/EEC) and Irish legislation (Fisheries consolidation Act, 1959). Atlantic salmon occur in almost every suitable river system in Ireland (Kennedy & Fitzmaurice, 1971). Populations are found in rivers with access to the sea, as salmon are anadromous, migrating between freshwater and marine environments. Juvenile salmon, known as parr, inhabit clean, well-oxygenated streams and rivers before migrating to the ocean as smolts. Adult salmon return to their natal rivers to spawn, contributing to populations in many Irish river systems.

Atlantic salmon are specifically protected under the EU Habitats Directive (Annex II and V), recognizing their ecological importance and the need for conservation. In Ireland, salmon fisheries are regulated by national legislation and bye-laws governing closed seasons, angling methods, size limits, bag limits, and quotas. Additional conservation measures, such as catch-and-release policies and fishery district regulations, are implemented to protect declining stocks.

During the Inland Fisheries Ireland fish counter programme of the River Maigue for Summary Fish Counter Report (2023), 445x Spring salmon, 552x Grillse and 31x Late summer salmon were recorded. Inland Fisheries used two types of fish counters. The Logie resistivity counter is the most versatile and robust option, capable of operating in two configurations: within a fiberglass tube or on a crump weir. Inland Fisheries Ireland has integrated camera software with these resistivity counters, allowing for video verification of each fish as it is counted. The second type of counter is the VAKI Riverwatcher, an optical counter that utilizes infrared scanners. It is specifically designed for locations where fish must pass through a narrow opening. This system is highly effective in areas with fish passes, ladders, or trapping facilities[12].

There is over 2.4 million m^2 of river habitat in the Maigue catchment (2,437,307 m^2 given in McGinnity *et al.,* 2003).

Table 3-8: Distribution and range of aquatic Annex II listed habitats and species in the 10km grid squares R24 and R34 containing the proposed development

Annex habitat/species	Code	R53		R63		Likely reason for distribution in the 10km grid squares
		CD*	CR*	CD[1]	CR[1]	
Floating river vegetation	3260	Yes	Yes	Yes	Yes	The extent of this habitat has not been mapped and the area is based on the distribution of rivers. There are no particularly important watercourses draining the PDS with respect to 3260
Sea lamprey	1095	No	No	No	No	n/a
River lamprey	1099	No	No	No	No	n/a
Brook lamprey	1096	Yes	Yes	Yes	Yes	Common species likely to occur in most fluvial habitats with suitable spawning and nursery habitats
Atlantic salmon	1106	Yes	Yes	Yes	Yes	No Salmon recorded within either R53 and R63 10km grid square on NBDC website. According to Maigue River Trust, Salmon was found in Morningstar during the electro fishing survey in 2013[13]
White-clawed crayfish	1092	Yes	Yes	Yes	Yes	White-clawed crayfish was once found in Morningstar River, latest EPA surveys in 2023 did not detect this species.

**CD = Current distribution, CR = Current range*

Brook lamprey and Sea lamprey are listed in Appendix II, while river lamprey is listed in both Appendices II and V of the Habitats Directive (92/43/EEC). All three species are listed in Appendix III[14] of the Bern Convention. The

[12] [Managing fish counters | Inland Fisheries Ireland]
[13] https://maigueriverstrust.ie/wp-content/uploads/2019/06/Fish-stocks-Maigue-final.pdf
[14] Annex III Berne Convention: Protected fauna species.

brook lamprey is the smallest of the three lamprey species native to Ireland and it is the only one of the three species that is non-parasitic and spends all its life in freshwater (Maitland & Campbell 1992). The river lamprey is larger in size than the brook lamprey, while the sea lamprey is the largest of the Irish lampreys; both of these species exhibit an anadromous[15] life cycle. Brook lamprey occur within the study area of the proposed development, but only in low densities, given that only one individual was recorded during the July 2022 survey.

In McGinnity *et al.* (2003), which classifies Irish rivers in terms of salmonid habitats:

- The Morningstar River and River Maigue are indicated as 'Producers of Salmon/Sea trout'. Also, lower reaches of Killorath and Rathcannon are indicated as 'Producers of Salmon/Sea trout'[16].
- With the remaining watercourses in this subcatchment indicated as 'Not considered a significant producer of Salmonids'.

Sea trout are the migratory form of brown trout. Sea trout > 40cm fork-length are classified as salmon in terms of legislation and are covered under salmon regulations; commercial and rod harvest of salmon is permitted where stocks are in surplus (exceeding a system-specific Conservation Limit) and the fisheries are very strictly controlled. During the Inland Fisheries Ireland fish counter programme of the River Maigue for Summary Fish Counter Report (2023) 63x sea trout were recorded. The 1st order streams draining the proposed development are deemed too small to be of importance to trout, and such watercourses are not shown in McGinnity *et al.* (2003).

Brown trout occur in almost every rivulet, brook, stream, river and lake in Ireland (Kennedy & Fitzmaurice, 1971). Populations occur in the upper reaches of estuaries (slob trout) and anadromous (sea trout) populations occur in many river systems all around the coast. Eel occur in almost every rivulet, brook, stream, river and lake in Ireland to which they can gain access (Kennedy & Fitzmaurice, 1971).

Brown trout are not specifically listed for protection by EU directives. In Ireland, brown trout fisheries are regulated by national legislation and bye laws governing closed seasons, angling methods, size limits, bag limits, etc. Angling clubs may also have their own regulations.

3.5.2 Survey results

Brown trout, salmon, brook lamprey, minnow, stoat loach and three-spined stickleback were recorded during the electrical fishing investigations of watercourses draining the proposed development site. A total of 139x fish were recorded: minnow (N=69), salmon (N=34), three spined stickleback (N=28); brown trout (N=6), lamprey species (N=2) and stone loach (N=1). No fish were recorded at Site 9 and 11. This was related to habitat suitability, which was poor in terms of providing cover for fish. **Table 3-9** gives length descriptive statistics for all fish species captured. **Table 3-10** gives Catch Per Unit Effort (CPUE) indices for trout and salmon captured. All electrical fishing data is presented in **Appendix 5**. **Figure 3-8** illustrates fish records at the aquatic survey sites.

Table 3-9: Length descriptive statistics for fish species captured during the 2022 electrofishing survey of watercourses draining the proposed development

Site	Species	N	Mean	Min	Max	St. dev.
2	Three-spined stickleback	5	3.38	2.8	3.7	0.4
3	Salmon	34	9.7	6.1	13.9	3.5
	Brown tout	6	11.1	8.5	23.7	3.7
	Lamprey sp.	2	12	12	12	2.9
	Minnow	2	8.2	4.4	4.8	3.6

[15] Anadromous fish spend most of their adult lives in salt water and migrate to freshwater rivers and lakes to reproduce.
[16] https://opendata-ifigeo.hub.arcgis.com/apps/980ad001886443e0ac4f5420e045acac/explore

	Stone loach	1	7.6	7.6	7.6	n/a
4	Three-spined stickleback	8	3.6	2.8	4.5	0.5
6	Three-spined stickleback	8	3.6	2.7	4.6	0.5
7	Three-spined stickleback	7	3.3	2.7	3.6	0.3
8	Minnow	17	4.0	2.9	4.7	0.6
9	No fish detected	-	-	-	-	-
10	Minnow	50	4.3	2.5	6.8	0.8
11	No fish detected	-	-	-	-	-

3.5.2.1 Atlantic Salmon

Atlantic salmon (*Salmo salar*) were recorded only at Site 3, where they were the most frequently caught fish species. This indicates that the Morningstar River provides suitable habitat for juvenile salmon. It is reasonable to presume that further downstream, closer to the confluence with the River Maigue, additional young salmon may be present due to improved habitat availability and connectivity to the larger river system.

A total of 34 juvenile salmon were captured during the survey, with lengths ranging from 6.1 cm to 13.9 cm and an average length of 9.7 cm. The presence of exclusively young salmon suggests that the surveyed section serves as a nursery area, providing essential conditions for juvenile development before migration downstream.

Table 3-10: Catch Per Unit Effort (CPUE) indices for salmonids captured during the 2022 electrofishing surveys of watercourses draining the proposed development

Site	Area fished (m^2)	Time fished (minutes)	Brown trout			Atlantic Salmon		
			N	CPUE		N	CPUE	
				fish/m^2	fish/min		fish/m^2	fish/min
2	9	10	0	0	0	0	0	0
3	110	10	6	0.05	0.6	34	0.31	3.4
4	21	10	0	0	0	0	0	0
6	15	10	0	0	0	0	0	0
7	34.4	10	0	0	0	0	0	0
8	38	10	0	0	0	0	0	0
9	8.5	10	0	0	0	0	0	0
10	51	10	0	0	0	0	0	0
11	58	10	0	0	0	0	0	0

3.5.2.2 Brown trout

Brown trout were recorded only at Site 3 on the Morningstar River, just outside of the boundary of the proposed development site. It is possible that small numbers of trout occur in the Morningstar River adjacent to the proposed development site and in downstream areas, this more likely with distance downstream. The trout recorded at Site 3 were mostly juvenile fish, with one exception of an adult. The trout captured ranged in length from 8.5 cm to 23.7 cm. These fish had a mean length of 11.8 cm.

3.5.2.3 Three spined stickleback

Three spined stickleback were the most widespread species recorded, occurring at most locations surveyed. A total of twenty-eight three-spined spined stickleback were captured and ranged in length from 2.7 cm to 4.6 cm.

Three-spined stickleback is one of the most widely distributed fish in the British Isles (Maitland and Campbell, 1992). According to Byrne *et al.* (2011), it is commonly recorded in fish surveys in rivers, lakes and transitional waters in all parts of the country. The stickleback appears to be a relatively pollution tolerant species and a good coloniser of rivers recovering from chronic historical pollution (Pottinger *et al.* 2002). Stickleback likely occurs in the larger drainage ditches within the proposed development site.

3.5.2.4 Lamprey species

Two unidentified lamprey species were caught at Site 3 during the 1m square specifically electro fished for lamprey species. Both individuals were 12 cm long. It was hard to identify if individuals were brook lamprey or river lamprey.

Brook lamprey (*Lampetra planeri*) occur in many suitable freshwater systems across Ireland (Kennedy & Fitzmaurice, 1971). Populations are found in clean, well-oxygenated rivers and streams with sandy or silty substrates, where their larvae, known as ammocoetes, burrow and filter-feed for several years before metamorphosing into adults. Unlike other lamprey species, brook lamprey do not migrate to the sea, remaining in freshwater throughout their life cycle. Adults do not feed after metamorphosis and die shortly after spawning in shallow, gravelly areas of rivers and streams.

Brook lamprey are specifically protected under the EU Habitats Directive (Annex II), recognizing their ecological significance and the importance of conserving their populations. In Ireland, their habitats are safeguarded through various conservation measures, including water quality management and habitat protection initiatives. Their presence in a river system is often considered an indicator of good ecological health due to their sensitivity to pollution and habitat degradation.

River lamprey (*Lampetra fluviatilis*) occur in many suitable freshwater systems across Ireland (Kennedy & Fitzmaurice, 1971). They inhabit clean, well-oxygenated rivers and estuaries with suitable sandy or silty substrates, where their larvae, known as ammocoetes, burrow and filter-feed for several years before metamorphosing into juveniles. Unlike brook lamprey, river lamprey are anadromous, migrating to the sea after metamorphosis, where they grow and feed parasitically on fish before returning to freshwater to spawn. Spawning occurs in shallow, gravelly areas of rivers and streams, and adults die shortly after reproduction.

River lamprey are specifically protected under the EU Habitats Directive (Annex II), highlighting their ecological significance and the necessity of conservation efforts. As they require unpolluted, well-connected river systems for their life cycle, their presence in a watercourse is often regarded as an indicator of good ecological status.

3.5.2.5 Minnow

Minnow was the most recorded fish species across all the sites. Sixty-nine minnow were caught ranging in size from 2.5 cm to 6.8 cm with mean length of 5.4 cm.

Minnow (*Phoxinus phoxinus*) occurs in many freshwater systems across Ireland (Kennedy & Fitzmaurice, 1971). They are commonly found in rivers, streams, and lakes with clean, well-oxygenated water and a mix of gravel and sandy substrates. Minnows are highly adaptable and can tolerate a range of environmental conditions, including slow and fast-flowing waters. They primarily feed on small invertebrates, algae, and organic detritus, playing an important role in freshwater ecosystems as both prey for larger fish and consumers of aquatic organisms. They are not native to Ireland, but they are considered benign as they have no significant impact on native species or ecosystem[17]

Minnow is not specifically protected under EU directives, as they are widespread and abundant throughout their range.

---

[17] https://www.fisheriesireland.ie/species/minnow-phoxinus-phoxinus

3.5.2.6 Stone Loach

Only one individual of this species was caught at Site 3 during the electro fishing survey in July 2022.

Stone loach (*Barbatula barbatula*) is a small, bottom-dwelling freshwater fish found in rivers and streams across Ireland. It prefers clean, well-oxygenated waters with gravelly or sandy substrates, where it can use its elongated body to navigate and burrow among the stones. This nocturnal species is highly adaptable, tolerating moderate levels of siltation and varying flow conditions. Stone loach primarily feed on aquatic invertebrates such as insect larvae, small crustaceans, and mollusks. Stone loach is not specifically protected under EU directives.

3.5.2.7 Red List Status

All fifteen native species of freshwater fish were assessed in Byrne *et al.* (2011) using the latest IUCN categories. The red list status of the fish recorded during the current assessment are provided in Table 3-11 below. The classification of the European eel as Critically Endangered, is a reflection of its significant decline in Ireland and the Europe-wide decline in eel populations.

Table 3-11: Red list status of the fish recorded during the current assessment (adapted from Byrne et al. 2011)

Species	Irish Red List status	Legal status	Rationale for assessment
Atlantic Salmon	Vulnerable	EU Habitats Directive [92/43/EEC] Annex II and Annex V. Fisheries Acts 1959 to 2006	Previously assessed as Internationally Important. Significant declines have been observed since the 1970s, largely driven by reduced marine survival attributed to climate effects (Friedland et al. 2009) justify the species assessment as Vulnerable. However, the species remains widespread in all major river systems on the island. Good penetration by adult fish and widespread populations of juvenile fish at satisfactory levels.
Trout	Least concern	Fisheries Acts 1959 to 2006	Previously assessed as not threatened. There are serious concerns about the declines in sea trout stocks, particularly in the mid-west. Nonetheless, trout remain widespread in all major river and lake systems on the island, at satisfactory levels in terms of population structure, for the water in question, and of stock density, justifying a conservation assessment of 'least concern'.
Brook Lamprey	Least concern	EU Habitats Directive [92/43/EEC] Annex II.	Previously assessed as Indeterminate, but there has been extensive survey work since then. Sampling since 2003, on a catchment-wide basis, has indicated presence of this species in a series of designated SACs in the Republic. Additional catchment-wide surveys undertaken in period 2004 – 2010 has confirmed a widespread distribution in channels in the Republic (IFI unpublished data) and in Northern Ireland (Goodwin et al., 2009). This species is therefore listed as least concern.
Three-spined stickleback	least concern	Fisheries Acts 1959 to 2006	Previously assessed as least concern and still considered of least concern as it is widely distributed in fishery surveys in rivers of all sizes and in lakes and transitional waters around the coast.

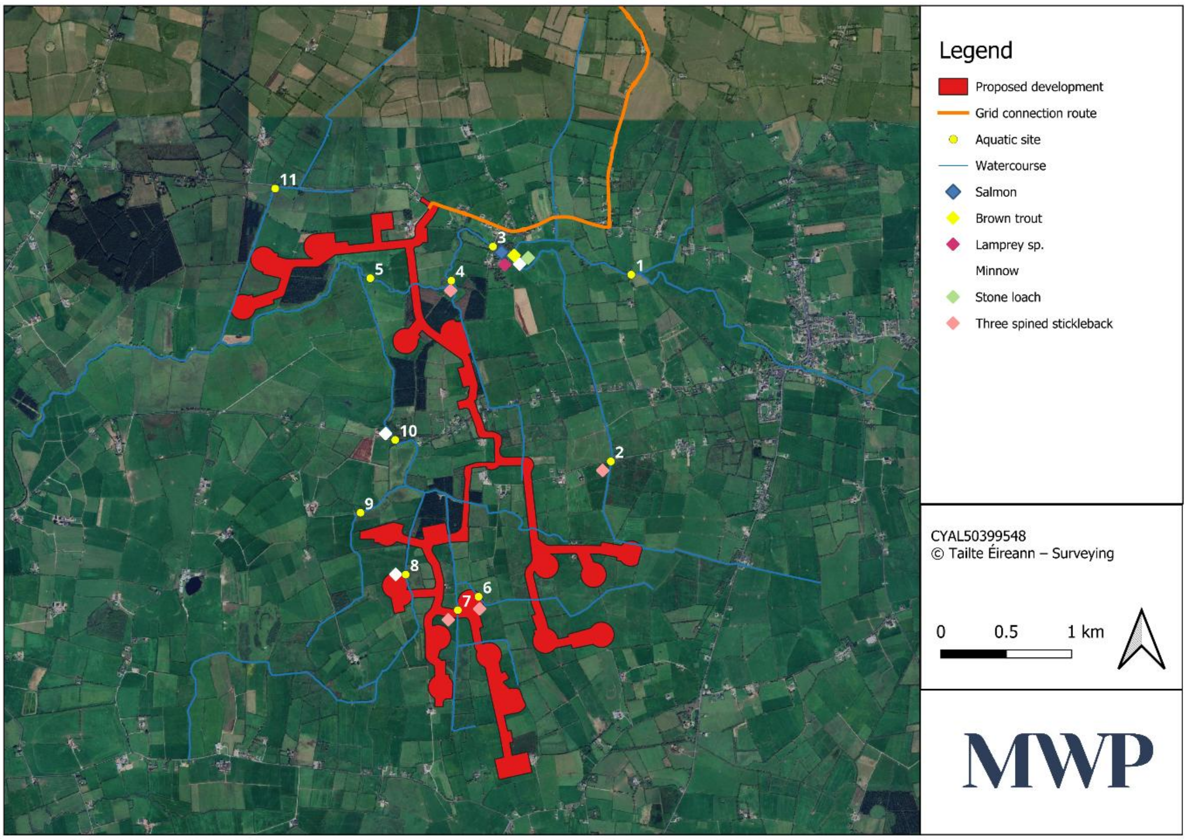

Figure 3-8: Fish records at the electrical fishing survey sites

3.6 Amphibians

3.6.1 Existing information

Common frog (*Rana temporaria*) is the only amphibian species recorded in the past in the 10 km grid squares R53 and R63 overlapping the proposed development site.

3.6.2 Survey results

The proposed development site has some habitat suitable for frog. The drainage ditches and some 1st order streams at higher reaches at the proposed development site could provide spawning habitat (see **Figure 3-9**). No frog spawn was identified during the ecological survey undertaken in the study area on 2nd February 2023.

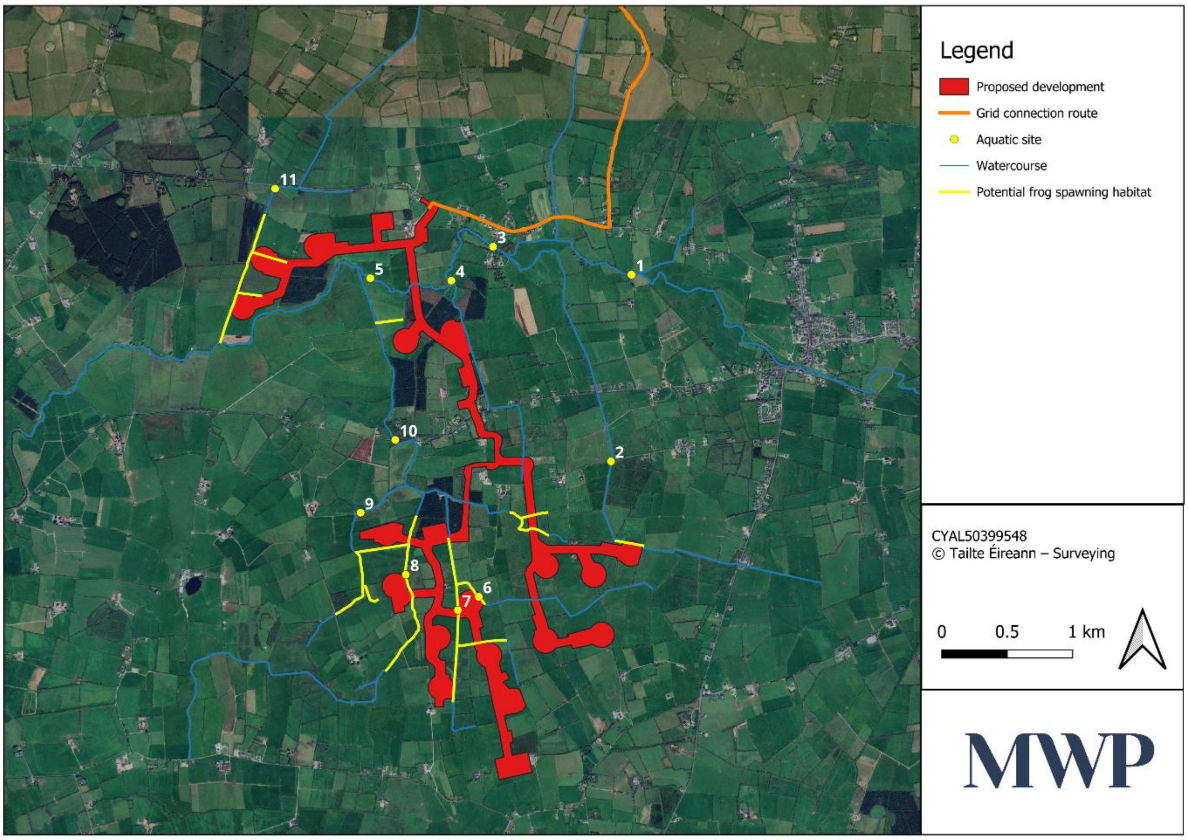

Figure 3-9: Potential frog spawning habitat within the proposed development site

Frogs can be expected to occur in the streams within the proposed development site also, as they will sometimes use streams during summer-time when flows are low. Streams such as South Ballinlee, Rathcannon, Ballinlee South, North Ballinlee, Killorath and Parkroe are generally sluggish as they flow through the proposed development site and could be used by frogs during the summer.

Figure 3-10: Example of a drain which comprises potential frog spawning habitat within the proposed development site

The wet grassland habitats are considered important for froglets and adult feeding (See Figure 3-11).

Figure 3-11: Potential feeding frog habitat

4. Ecological pressures

4.1 Water quality

The proposed development overlaps with sub catchment: Maigue_SC_030 (Code 24_17). An aassessment for this sub catchment has been produced as part of the national characterisation programme undertaken for the second cycle of Water Framework Directive River basin management planning. Significant pressures have been identified for waterbodies that are At Risk of not meeting their water quality objectives under the Water Framework Directive. While there are a multitude of pressures in every waterbody, the significant pressures are those pressures which need to be addressed in order to improve water quality. Many of our waterbodies have multiple significant pressures. A robust scientific assessment process has been carried out to determine which pressures are the significant pressures. This has incorporated over 140 datasets, a suite of modelling tools, and local knowledge from field and enforcement staff from the Local Authorities, Inland Fisheries Ireland and EPA.

4.1.1 Maigue_SC_030

The Morningstar River and its tributaries Killorath, Rathcannon, Parkroe, Camas South alongside with Ballinlee South, Ballinrea, South Ballinlee, North Ballinlee draining the proposed development site are found in the Maigue_SC_030 subcatchment. The following is taken from this WFD subcatchment assessment[18]: *Phosphate*

[18] https://catchments.ie/wp-content/files/subcatchmentassessments/24_5%20Shanagolden[Stream]_SC_010%20Subcatchment%20Assessment%20WFD%20Cycle%202.pdf

enrichment a significant issue in Maigue_040 with the baseline concentration at Poor status and exceedances of the EQS for Good in the annual average concentrations for 2014 and 2015. The likely significant pressure is agriculture as the wastewater treatment plant in the river subbasin has tertiary phosphate removal in place. It should also be noted that the Maigue_040 is downstream of the Charleville Stream in another subcatchment where there have been pollution issues from industry which may also be causing an issue. There is limited chemistry data on the Morningstar River within this subcatchment but the Morningstar_050 has Moderate ecological status for 2013-2015 which is likely driven by land drainage on agricultural lands and also diffuse urban run-off. While status improved to Good in the Morningstar_060, it has been Moderate in the past and the baseline concentration of phosphate exceeded the EQS for Good, as did the annual average concentrations for 2014 and 2015. The likely drivers of this are agricultural activities as well as septic tanks and issues with inadequate percolation.

A review of the EPA online mapping system was carried out to determine what ongoing emissions occur in the study area, namely Section 4 discharges, EPA integrated pollution control (IPC) and industrial emissions (IE) licensed facilities, urban waste-water treatment plants and extractive industries. Section 4 discharges (under the Water Pollution Acts) are Local Authority Licensed discharges of trade effluent into waters. Mapped emissions to watercourses and activities that may be impacting water quality in the study area are shown in Figure 4-1. These may be negatively affecting water quality in the Morningstar River and additionally the Maigue River.

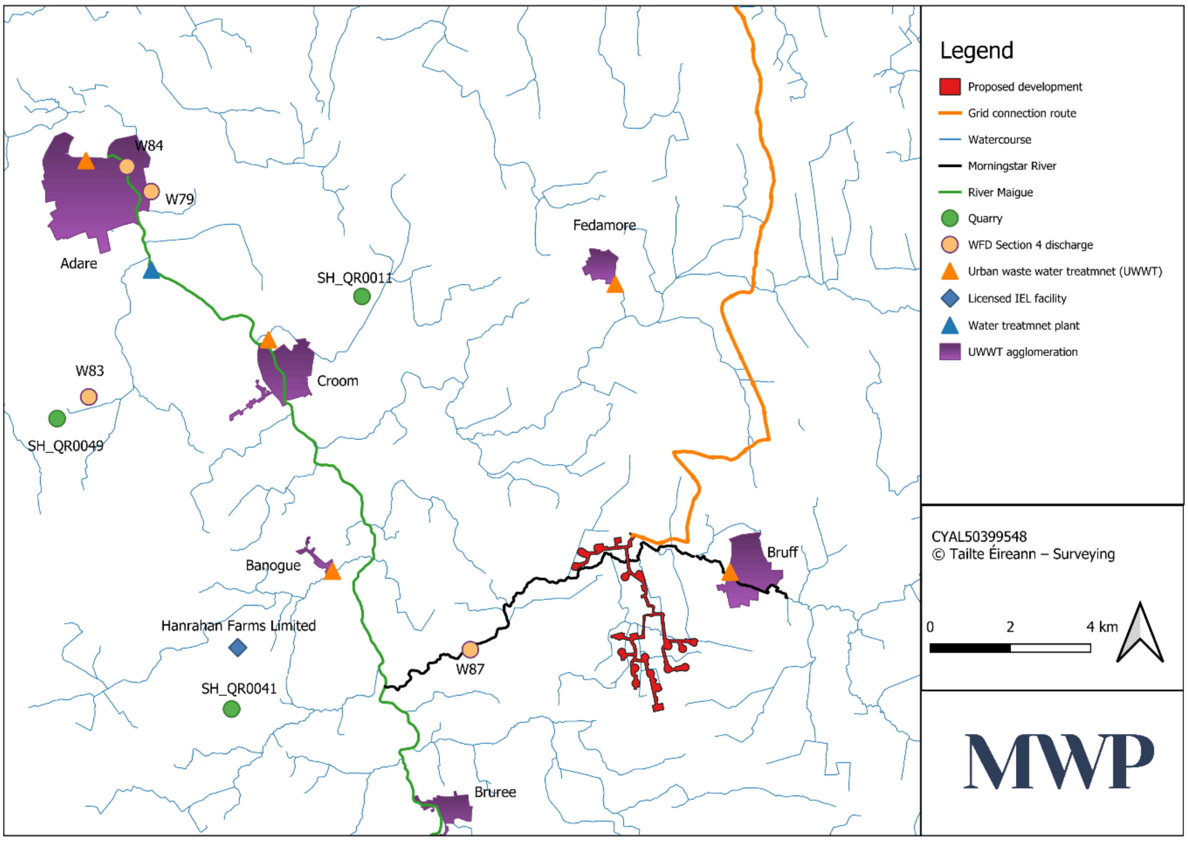

Figure 4-1: Activities potentially impacting water quality in the study area

4.2 Hydromorphology

Sub-catchment assessments for the study area highlight hydromorphological impacts, including sedimentation, siltation pollution, and physical modifications to the aquatic environment. Key hydromorphological pressures include channelization, embankments, barriers, culverts, land drainage, overgrazing, and bank erosion.

4.2.1 Maigue_SC_030

The Morningstar River faces significant pressures from agriculture, urban runoff, and hydromorphological alterations. These issues were evident during field investigations in 2022 and are well-documented through local knowledge of the study area. Many surveyed streams have been historically channelized, reducing their natural flow variability and habitat complexity. Additionally, agricultural activities exert substantial pressure, with nutrient leaching and direct cattle access contributing to water quality degradation. As a result, excessive siltation and sedimentation are prevalent, negatively impacting aquatic habitats and biodiversity. These pressures not only reduce the suitability of the river for sensitive species such as salmonids and macroinvertebrates but also contribute to wider ecosystem imbalances. Implementing buffer zones, improving riparian vegetation, and restricting livestock access to waterways could help mitigate these impacts and enhance the ecological integrity of the Morningstar River.

Plate 4.1: Cattle access to the Rathcannon stream at Site 8 (left) and example of sedimentation at Site 4 (right)

4.3 Climate change

A new study reveals the migration route of salmon at sea and raises concerns about effects of climate change[19]. The study found that salmon released further south tended to cover longer migration distances, with a straight-line distance tracked as far as 2,400 km for one salmon tagged from the River Suir in Ireland. Overall, populations closest in proximity tended to converge in their oceanic feeding area but taken together the salmon populations exploit a very large part of the ocean. Given that salmon from different geographic locations feed in distinct areas at sea, they experience different temperature regimes. For example, Irish salmon experienced much warmer temperatures, ranging from 5 to 16°C, than Norwegian and Danish salmon which experienced temperatures ranging from 0 to 11°C. These differences not only contribute to variation in growth and survival across populations, but also are likely to affect Atlantic salmon populations differently with changing climate. Southernmost populations, like those of Ireland, are more at risk than northernmost populations as migration distances are likely to become longer, or more variable, thereby decreasing feeding time, with important consequences for the marine survival and productivity of different populations. Taken together, the findings suggest that a common marine factor responsible for the decline in Atlantic salmon is unlikely. Importantly, this means conservation efforts should be focused locally, such as during the freshwater phase.

[19] https://doi.org/10.1038/s41598-021-91137-y

5. Conclusion

5.1 Fish

Salmonid spawning and nursery habitat quality varies across the surveyed sites. The smaller streams and drainage ditches within the site provide limited habitat and are only capable of supporting pollution-tolerant species such as three-spined stickleback and minnow. In contrast, the Morningstar River offers more suitable conditions, supporting brown trout (both adult and juvenile) and juvenile salmon, indicating the presence of viable spawning and nursery habitat. However, none of the surveyed streams provide suitable holding areas for adult salmon.

A range of fish species, including Atlantic salmon, brook lamprey, brown trout, minnow, stone loach, and three-spined stickleback, were recorded during the 2022 surveys, though suitable habitat was primarily found in the Morningstar River. Due to the absence of appropriate habitat, migratory lampreys (sea and river lamprey) are unlikely to occur in the affected reaches. Juvenile salmon are expected to be present in the Morningstar River and further downstream in the River Maigue, where the Morningstar discharges. While the Morningstar River provides deeper refuge areas suitable for trout, the wider and deeper channel of the River Maigue may offer better conditions for adult salmon.

As pointed out by Crisp (2000), inert suspended solids can have a variety of effects upon salmonid fishes. They may have indirect effects through reduction of light input and, when they settle out in slower flows, they may occlude gravel interstices and reduce the amount of hiding places for small fish and/or their invertebrate prey. More directly, they may abrade or clog delicate membranes (e.g., fish gills) and they may cause skin irritation and abrasions, which may facilitate various secondary infections (Crisp, 2000). Obvious water quality problems in the study area reduce the salmonid habitat value of all watercourses and silt is identified as one of the main problems.

5.2 Macroinvertebrates and Water Quality

In terms of aquatic macroinvertebrate habitat, the streams draining the proposed development site were classified as poor to suboptimal. The recorded macroinvertebrate species were predominantly common and largely pollution tolerant. Overall, macroinvertebrate communities across the study area exhibited reduced diversity, which is likely linked to the degraded fluvial conditions and limited habitat suitability. Many of the surveyed streams have been physically altered due to anthropogenic influences, particularly agricultural activities and stream crossings. The loss of riparian vegetation and increased sedimentation from agricultural practices are key factors contributing to habitat degradation in these waterways.

Biological water quality was unsatisfactory (Moderate status) across the study area, consistent with historical EPA findings. Substrate siltation could explain the reduced biological diversity and subsequent biological water quality recorded in the study area. In a detailed study carried out by Davis *et al.* (2018), sediment, phosphorus and nitrogen were manipulated simultaneously. Davis *et al.* (2018) concluded that sediment was the most pervasive stressor particularly at high cover levels. Problems in watercourses arise from smothering of coarse patches of sediment with fine particles that ingress into the coarse sediment and deplete oxygen levels by reducing through-flow within the sediment (Walsh *et al.,* 2012)[20]. The negative impacts of high and persistent sediment loads affect invertebrate assemblages and abundances, with Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa exhibiting the greatest negative response to increased sediment[21].

[20] https://www.epa.ie/pubs/reports/water/rivers/EPA_River_Sediment_Studies.pdf
[21] https://www.salmon-trout.org/wp-content/uploads/2017/09/STC-The-impact-of-excess-fine-sediment-on-invertebrates-and-fish-in-riverine-systems.pdf

It is clear that land management and associated activities were having an adverse effect on water quality in the streams within the proposed development site. Based on the results of the current surveys, it is concluded that the main water quality problems in the study are consistent with those documented by the EPA i.e., agricultural and domestic wate-water.

5.3 Amphibians

It is considered that the proposed development site is used by breeding and foraging frog.

6. Recommendations

It is imperative that the proposed development does not cause further surface water quality deterioration in watercourses where water quality is already unsatisfactory. A conclusion of a Davis *et al.* (2018) study was that improving river ecological quality requires improved management of sediment inputs, so sediment control will be a key driver of mitigation to protect water quality.

Incorrect practices in land use, and improper management during construction projects can lead to excessive runoff of silt, nutrients and organic matter in times of heavy rainfall. A Surface Water Management Plan (SWMP), has been produced for the proposed development. The SWMP details method statement(s) for protecting water quality in the watercourses affected. The SWMP will be distributed and discussed with all parties involved in construction (including any sub-contractors) to protect aquatic conservation interests within the study area. Silt control will be a primary concern during construction stage, as silt has been identified a sediment source for downstream areas. The SWMP sets out measures to avoid siltation, erosion, surface water run-off and accidental pollution events which all have the potential to adversely affect water quality within the site during the construction phase.

It is recommended that the following measures be implemented on site during design and construction:

- Any new development at watercourse crossings (upgrading/new tracks) will need to consider fish passage.
- Existing tracks should be used insofar as possible.
- Infrastructure should be placed on areas away from watercourses and on ground with low gradients insofar as possible.
- Any works involving stream crossings should maintain or improve faunal connectivity upstream and downstream of works.
- Ponds should be constructed as part of the SWMP to attenuate water draining denuded areas during construction.

The proposed development will be constructed in cognisance of the following guidelines:

- 'Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes' (NRA, 2008)
- 'River Crossings and Migratory Fish: Design Guidance' (Scottish Executive, 2000)
- 'Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters' (IFI, 2016)
- 'Control of water pollution from construction sites – Guidance for consultants and contractors' (Masters-Williams *et al*. 2001)

- 'Control of water pollution from linear construction projects' (Murnane *et al.* 2006).

The following preliminary measures are advised to mitigate habitat loss and promote aquatic biodiversity at the proposed Ballinlee wind farm site. Securing the areas outlined below and agreements for land management would assist biodiversity.

6.1 Hedgerow replacement

Hedgerows are important in checking overland flow of water and with such attenuation can reduce silt and nutrient loss to surface water features. There will be loss of this linear habitat at various locations during construction stage. Where such habitat loss will occur, there will be resultant potential erosion and increased overland flow. Hedgerow continuity will be maintained through planting, to bridge gaps created by construction. Double hedgerows will be created along access tracks within wooded areas. Hedgerow planting will include the following native species: alder Alnus glutinosa, blackthorn Prunus spinosa, holly Ilex aquifolium, bramble Rubus fruticosus, hazel Corylus avellana, dog-rose Rosa canina, spindle Euonymus europaeus and hawthorn Crataegus monogynaNative species including whitethorn, hazel and holly will be planted along the infrastructure boundaries to bridge the gaps in hedgerows created. Areas for hedgerow laying will be marked out using wire or twine (area of c. 1.2 m in width). Planting will be performed in double staggered rows, with c. 33 cm between the rows and the same between each plant.

6.2 Watercourse buffering

Livestock grazing within the proposed development site currently allows animals direct access to watercourses at multiple locations. This access has resulted in significant damage to both instream and riparian habitats due to riverbed disturbance, defecation, poaching, and associated bank erosion. These impacts are likely degrading aquatic habitat quality and negatively affecting water quality, primarily through increased siltation. To mitigate these effects, it is recommended that fencing be installed along watercourses to restrict livestock access.

A minimum riparian setback of 2 m is proposed along all EPA-registered streams within and adjacent to the development site. This setback will establish a continuous, undisturbed buffer zone of natural vegetation to protect water quality and aquatic ecosystems by intercepting sediment and nutrient runoff from both current land-use practices and the proposed development. By maintaining an effective riparian buffer, the connection between potential pollution sources and receiving watercourses will be disrupted, reducing contamination risks.

Additionally, cattle drinkers should be installed in grazing fields to provide an alternative water source, thereby eliminating the need for livestock to enter the streams. There is a range of products available that can utilise stream water for this purpose, from pasture pumps[22] to troughs fitted with pumps connected to solar panels.

6.3 Protection of existing wet grassland

Locally important wet grassland habitats will be protected going forward at operation stage. Wet grassland which will not be lost as part of the proposed development will be fenced off to prevent cattle entry and associated poaching, such habitats being important to a range of aquatic macroinvertebrates, wetland birds and amphibians.

[22] https://www.odonovaneng.ie/product/pasture-pump-suckler-side-bowl/?gclid=Cj0KCQjw8uOWBhDXARIsAOxKJ2HOnMI1zC-M7F6JAPx2_MnNO7r30xyfKmvihciHYPzchWC69mI579caAh6LEALw_wcB

Within the site, these areas are currently prone to damage by cattle access. The fenced off area will not be managed so that ecological features can develop e.g., encroachment of scrub from boundaries will be allowed to grow and there should be no cutting of vegetation.

6.4 Drain management

To protect aquatic biodiversity, it is recommended that no further maintenance of drainage ditches, identified as having suitable spawning habitat (Figure 3-9, Section 3.6.2), be carried out during the operational stage. Routine maintenance activities can negatively impact breeding frogs by causing habitat destruction and degradation. Preserving these ditches in their natural state will help maintain essential spawning and foraging habitats for amphibians and other aquatic species.

6.5 Ponds

Where conditions allow, silt ponds constructed for water quality protection associated with proposed development infrastructure will be retained post construction to allow colonisation by local aquatic flora and fauna. The decision to retain ponds would be dependent on factors including location, stability and whether they retain water or not. The ECoW and site engineer would decide which ponds to retain. These ponds would act as wetland niches during operation stage and beyond. Silt ponds retained post construction can be expected to act as wetland areas for aquatic and terrestrial macroinvertebrates, amphibians and birds, and a drinking water source for fauna. Physical variation/heterogeneity is a key influence in biodiversity richness. Therefore, sinuosity in pond outline/plan is preferable to linearity, so pond borders/banks and stone filter beds should be of varied shape/angle according to each specific silt pond location, where local topography would dictate design. Wetland habitat creation guidance in Gilbert and Anderson (1998) would be followed.

7. References

Anonymous (2004) *Margaritifera margaritifera*: Stage 1 and Stage 2 survey guidelines. Irish Wildlife Manuals No. 12. National Parks and Wildlife Service, Dublin.

Bauer, G. (1988). Threats to the freshwater pearl mussel *Margaritifera margaritfera* L. in central Europe. Biological Conservation, 45, 239–253.

Butcher R.W. (1946) Studies in the ecology of rivers VI: The algal growth in certain highly calcareous streams. *Journal of Ecology* **33**, 268 - 283

Byrne, A., Moorkens, E.A., Anderson, R., Killeen, I.J. & Regan, E.C. (2009) Ireland Red List No. 2 – Non-Marine Molluscs. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Crisp TJ (2000). Trout and Salmon. Ecology, Conservation and Rehabilitation. Blackwell Science, Oxford. 212pp.

CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine. Institute of Ecology and Environmental Management, Winchester

Davis, S. J., Ó hUallacháin, D., Mellander, P., Kelly, A., Matthaei, C. D., Piggott, J. J. and Kelly-Quinn, M. (2018) Multiple-stressor effects of sediment, phosphorus and nitrogen on stream macroinvertebrate communities. Science of the Total Environment 637–638 (2018) 577–587.

Department of Agriculture for Northern Ireland (1995) Advisory Leaflet No. 1 'The Evaluation of habitat for Salmon and Trout' Department of Agriculture for Northern Ireland Fisheries Division. EU Salmonid Enhancement Programme.

Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (2017) Margaritifera Sensitive Areas Map. NPWS GIS files relevant to the distribution of freshwater pearl mussel (*Margaritifera margaritifera*) and Nore freshwater pearl mussel (*Margaritifera durrovensis*) in Ireland.

DoEHLG (2009) The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009. S.I. No. 296 of 2009.

EPA (2013) Integrated Water Quality Report 2012 Monaghan & Louth. EPA Regional Inspectorate Monaghan, The Glen, Monaghan.

EA (2003) River Habitat Survey in Britain and Ireland: Field Survey Guidance Manual. River Habitat Survey Manual: 2003 version, Environment Agency, 136 pp

EPA (2001) Parameters of Water Quality – Interpretation and Standards. Environmental Protection Agency, Ireland.

European Communities Environmental Objectives (Surface waters) Regulations. Statutory Instrument No. 272 of 2009.

Elliott, J. M., Humpesch, U. H. & Macan, T.T. (1988) Larvae of the British Ephemeroptera – a key with ecological notes. Freshwater Biological Association, Scientific Publication No. 49.

Feeley, H.B., Baars, J-R., Kelly-Quinn, M. & Nelson, B. (2020) Ireland Red List No. 13: Stoneflies (Plecoptera). National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland.

Foster, G. N., Nelson, B. H. & O Connor, Á. (2009) Ireland Red List No. 1 – Water beetles. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Gilbert, O. L. & Anderson, P.A. (1998) Habitat Creation and Repair. Oxford University Press.

Gledhill, T., D.W. Sutcliffe & W.D. Williams (1993) British Freshwater Crustacea Malacostraca: a Key with Ecological Notes 1993, 176pp.

Hastie LC, Boon PJ & Young MR (2000). Physical microhabitat requirements of freshwater pearl mussel *Margaritifera margaritifera* (L.). *Hydrobiologia* 429 59–71.

Hendry K & Cragg-Hine D (2003). Ecology of the Atlantic Salmon. Conserving Natura 2000 Rivers Ecology Series No. 7. English Nature, Peterborough.

Hartley, A.M., House, W.A. Callow, M.E. and Leadbeater B.S.C (1997) Coprecipitation of phosphate with calcite in the presence of photosynthesizing green algae. *Water Research* **31,** 2261-2268.

Hennigan, H., Feely, H.B. and Kelly-Quinn, M. (2016) Should rare river types be given special consideration under the WFD. Biology and Environment. Proceedings of the royal Irish Academy Val 116B, No. 3 (2016), pp, 167-177 (11 pages). Royal Irish Academy.

IFI (2016) Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus Co. Dublin. IFI/2016/1-4298.

IFI (2010) IFI Biosecurity Protocol for Field Survey Work. Inland Fisheries Ireland. , 3044 Lake Drive, Citywest Business Campus Co. Dublin

Kennedy, M. & Fitzmaurice, P. (1971) Growth and food of brown trout Salmo trutta (L.) in Irish waters. *Proceedings of the Royal Irish Academy* 71 B(18), 269-352.

Kelly-Quinn, M. & Regan, E.C. (2012) Ireland Red List No. 7: Mayflies (Ephemeroptera). National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Kelly-Quinn, M. and Reynolds, J. D. (eds.) (2020) *Ireland's Rivers*. University College Dublin Press, Dublin.

Lenat, D.R. (1988) Water quality assessment using a qualitative collection method for benthic macroinvertebrates. J.N. Am. Benthological Soc. 7: 222-233.

Macan T.T. (1994) A Key to the British Fresh- and Brackish-Water Gastropods, with Notes on their Ecology Fourth edition, 1977 (reprinted 1994), 46pp.

Maitland, P. S. & Campbell, R. N. (1992) Freshwater Fishes of the British Isles. Harper Collins Publishers. Somerset, UK.

Maitland PS (2003) Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

Maitland, P. (2004) Key to British Freshwater Fish with notes on their ecology and distribution. Freshwater Biological Association Scientific Publication No. 62. Freshwater Biological Association, Amblreside.

Masters-Williams, H., Heap, A., Kitts, H., Greenshaw, L., davis, S., Fisher, P., Hendrie, M., Owens, D. (2001) Control of water pollution from construction sites. Guidance for consultants and contractors. DETR/CIRIA. London.

Murnane, E., Heap, A., Swain A. (2006) Control of water pollution from linear construction projects. Technical guidance (C648). 234pp. CIRIA, UK.

NRA (2005) Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes. National Roads Authority.

NRA (2009) Ecological Surveying Techniques for Protected Flora and Fauna during the Planning of National Road Schemes. National Roads Authority.

Natural England (2014). *Bats and onshore wind turbines: Interim guidance.* Natural England Technical Note TIN051. Third Edition, Mar. 2014. Peterborough: Natural England. Available at www.naturalengland.org.uk.

Pedley, M. (1992) Freshwater (phytohem) reefs: the role of biofilms and their bearing on marine reef cementation. Cemetery Geology **79,** 255 – 274.

Pentecost, A (2005) Travertine. Berlin, Springer.

Pitois, F., Jigorel, A. and Bertru, G (2003). Development of cyanobacterial buildup and evolution of riverbed morphology in the chalk stream Eaulne, Upper Normandy France. Biodiversity and Conservation **12,** 621-636.

Pottinger, T. G., Carrick T. R., and Yeomans, W. E. (2002) The three-spined stickleback as an environmental sentinel: effects of stressors on whole-body physiological indices. Journal of Fish Biology **61**(1): 207 – 229.

Rabenil, C.F., Doisy, K.E. and Zweig, L.D. (2005) Stream invertebrate community functional responses to deposited sediment Journal of Aquatic Sciences. 67(4):395-402.

Reice, S.R. (1974) Environmental patchiness and the breakdown of leaf litter in a woodland stream. Ecology 55 1271 – 1282.

Reinhardt, U.G., Binder, T., and McDonald, D.G. (2009) Ability of adult sea lamprey to climb inclined surfaces. In: Biology, Management and Conservation of lampreys in North America (Eds: Brown, L.R., Chase, S.D., Mesa, M.G., Beamish, R.J., and Moyle P.B.). American Fisheries Society Symposium, 27: p71-115. Bethesda, Maryland.

Ruff, H. and Maier, G. (2000) Calcium carbonate deposits reduce predation pressure on *Gammarus fusarum* from salamander larvae. *Freshwater Biology* **43**, 99-105.

Savage A.A. (1989) Adults of the British Aquatic Hemiptera Heteroptera: a Key with Ecological Notes1989, 173pp.

Scottish Natural Heritage (SNH) (2019). *Bats and Onshore Wind Turbines: Survey, Assessment and Mitigation (Version January 2019)*. Prepared jointly by Scottish Natural Heritage, Natural England, Natural Resources Wales, Renewable UK, Scottish Power Renewables, Ecotricity Ltd, the University of Exeter and the Bat Conservation Trust (BCT).

Scottish Executive (2000) River Crossings and Migratory Fish: Design Guidance. A Consultation Paper. April 2000. Available at

http://www.gov.scot/Topics/marine/science/Publications/publicationslatest/rivercrossings

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

Skinner, A., Young, M. and Hastie, L. (2003) Ecology of the Freshwater Pearl Mussel. Conserving Natura 2000 Rivers Ecology Series No. 2 English Nature, Peterborough.

Toner, P., Bowman, K., Clabby, K., Lucey, J., McGarrigle, M, Concannon, C., Clenaghan, C., Cunningham, P., Delaney, J., O'Boyle, S., MaCarthaigh, M., Craig, M., and Quinn, R. (2005) Water Quality in Ireland 2001-2003. Environmental Protection Agency, Wexford.

Walsh, N., Neill, M., and Lucey, J (2012) River sediment studies in relation to juvenile pearl mussels and salmonids. Aquatic Environment, Office of Environmental Assessment Environmental Protection Agency, Seville Lodge, Callan Road, Kilkenny, Ireland.

Wallace, I.D., B. Wallace & G.N. Philipson (2003) Keys to the Case-bearing Caddis Larvae of Britain.

Appendix 1

Macroinvertebrate Physical Habitat Suitability

MWP

Table A1.1: Physical habitat assessment of streams for their suitability for macroinvertebrate production (adapted from Barbour and Stribling, 1991)

	Optimal	Suboptimal	Marginal	Poor
Score	20	15	10	5
Bottom substrate	More than 60% of bottom is gravel, cobble, and boulders. Even mix of substratum size classes.	30-60% of bottom is cobble or boulder substrata. Substrate may be dominated by one size class.	10-30% of substrata consists of large materials. Silt or sand accounts for 70-90% of bottom.	Substrate dominated by silt and sand. Gravel, cobble and larger substrate sizes <10%.
Habitat complexity	A variety of types and sizes of material form a diverse habitat.	Structural types or sizes of material are less than optimum but adequate cover still provided.	Habitat dominated by only one or two structural components. Amount of cover is limited.	Monotonous habitat with little diversity. Silt and sand dominate and reduce habitat diversity and complexity.
Pool quality	25% of the pools are as wide or wider than the mean stream width and area >1m deep.	<5% of the pools are >1m deep and wider than the mean stream width.	<1% of the pools are >1m deep and wider than the mean stream width. Pools present may be very deep or very shallow. Variety of pools or quality is fair.	Majority of pools are small and shallow. Pools may be absent.
Bank stability	Little evidence of past bank failure and little potential for future mass wasting into channel.	Infrequent or very small slides. Low future potential of slides.	Mass wasting moderate in frequency and size. Raw spots eroded during high floods.	Frequent or large slides. Banks unstable and contributing sediment to the stream.
Bank protection	Over 80% of streambank surfaces are covered by vegetation, boulders, bedrock, or other stable materials.	50-80% of the streambanks covered with vegetation, cobble, or larger material.	25-50% of the streambank is covered by vegetation.	<25% of the streambank is covered by vegetation or stable materials.
Canopy	Vegetation of various heights provides a mix of shade and filtering light to water surface.	Discontinuous vegetation provides areas of shade alternating with areas of full exposure. Or filtering shade occurs <6h/day.	Shading is complete and dense. Or filtering shade occurs <3h/day.	Water surface is exposed to full sun nearly all day long.

Appendix 2

Biotic Indices

Table A2.1: Intercalibration of EPA Q-rating system with Water Framework Directive status based on macroinvertebrates

Q Value*	WFD Status	WFD Intercalibration Common Metric Value[23]	Pollution Status	Condition**	Ecological description
Q5, Q4-5	High	0.92	Unpolluted	Satisfactory	No or only minor difference from reference condition. Normal community structure, sensitive species present. Ecological processes functioning normally.
Q4	Good	0.853	Unpolluted	Satisfactory	Slight difference from reference condition. Slight change in community structure. Fewer sensitive species present, but increase in species richness and productivity. Ecological processes functioning normally.
Q3-4	Moderate	0.764	Slightly polluted	Unsatisfactory	Moderate difference from reference condition. Moderate change in community structure and loss of some niche species. Some ecological processes altered. Reduced resilience and ability to absorb external shocks.
Q3, Q2-3	Poor	0.627	Moderately polluted	Unsatisfactory	Major difference from reference condition. Significant change in community structure. Significant loss of niche species. Food chains and biogeochemical pathways significantly altered. Limited ability to absorb external shocks
Q2, Q1-2, Q1	Bad	0.42	Seriously polluted	Unsatisfactory	Severe difference from reference condition. Severe change in community structure. Severe loss of niche species and ecological functioning. Food chains collapse and biogeochemical pathways breakdown. Water body incapable of supporting most aquatic life.

** These Values are based primarily on the relative proportions of pollution sensitive to tolerant macroinvertebrates (the young stages of insects primarily but also snails, worms, shrimps etc.) resident at a river site.*
*** "Condition" refers to the likelihood of interference with beneficial or potential beneficial uses.*

[23]From:https://www.epa.ie/pubs/reports/water/other/wfd/EPA_water_WFD_monitoring_programme_main_report.pdf

Table A2.2: Q-value for use in eroding (i.e. riffle-glide) river stretches

EPA Biological Assessment of Water Quality in Rivers and Streams*

Biotic Indices (Q Values) and typical associated macroinvertebrate community structure

WFD Status Groups	Families	High Q5	High Q4-5	Good Q4	Moderate Q3-4	Poor Q3	Poor Q2-3	Bad Q2	Bad Q1-2	Bad Q1
Group A Plecoptera Ephemeroptera Lamellibranchiata	All except Leuctridae Heptageniidae Siphlonuridae *Ephemera danica* *Ameletus inopinatus* *Margaritifera margaritifera*	**At least 3 taxa well represented i.e., common to dominant.** Expect 5 or more Group A taxa outside of June – Sept period	**At least 2 taxa well represented i.e., common to dominant.** Expect >2 Group A taxa outside of June-Sept period	**At least 1 taxon in reasonable numbers**	**At least 1 taxon Few - Common**	**Absent**	**Absent**	**Absent**	**Absent**	**Absent**
Group B Plecoptera Ephemeroptera Trichoptera Odonata Hemiptera	Leuctridae Baetidae (excl *B. rhodani* agg.) Leptophlebidae All Cased Trichoptera Odonata Aphelocheiridae	**Few to Numerous**	**Few to Numerous**	**Few to Numerous**	**Few/Absent to Numerous**	**Few/Absent**	**Absent**	**Absent**	**Absent**	**Absent**
Group C Ephemeroptera	*Baetis rhodani/Baetis atlanticus*	Few to Dominant	Few to Dominant	Numerous to Dominant	Numerous to Excessive	Numerous to Excessive	Few to Common	Absent	Absent	Absent
Trichoptera Hemiptera Coleoptera Hydracarina Diptera	Ephemerellidae Caenidae All Uncased Trichoptera All excl Aphelocheridae All All All (excl. *Chironomus* & *Eristalis*)	**Few to Numerous** Group C taxa can represent over 70% of total abundance with good diversity and no single taxa dominant	**Few to Numerous** Group C taxa can represent over 70% of total abundance with good diversity and no single taxa dominant	**Common to Numerous (Never Excessive)**	**Common to Excessive (usually Dominant or Excessive as a group)** Diversity can be reduced with a few taxa dominant	**Dominant to Excessive** Diversity reduced with a few taxa dominant	**Few to Common** Diversity reduced with a few taxa	**Absent**	**Absent**	**Absent**
	Simuliidae	Few	Few to common	Few to Numerous	Common to Dominant/Excessive	Common to Excessive	Few to Common	Absent	Absent	Absent
Crustacea	All (excl. Asellidae & *Crangonyx* spp.)									
	Gammarus c.f. duebeni	Few to common	Few to common	Common to Dominant	Common to Excessive	Common to Excessive	Few to Common	Absent	Absent	Absent
Gastropoda Lamellibranchiata Hirudinea Platyhelminthes Oligochaeta	All (excl. *Radix peregra, Physella*) *Anodonta* sp. *Piscicola* sp. All Lumbriculidae, Lumbricidae	**Ephemeroptera, Trichoptera may be well represented Others few or absent.**	**Ephemeroptera, Trichoptera may be well represented Others few or absent.**							
Group D Crustacea Megaloptera Gastropoda Lamellibranchiata Hirudinea Oligochaeta	Asellidae, *Crangonyx* Sialidae *Radix peregra, Physella* *Sphaeriidae,* All excl. *Piscicola* Naididae, Enchytraeidae	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few/Absent to Common**	**Few/Absent to Common**	**Dominant to Excessive**	**Dominant to Excessive**	**Few to common**	**Few or Absent**
Group E Oligochaeta Diptera	Tubificidae, Chironomus, Eristalis spp.	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few to Common**	**Few/Absent to Common**	**Common to Numerous**	**Dominant**

* This scheme is not intended for assessment of conditions in stagnant waters or where substratum is mud, bedrock or sand. It should be borne in mind that faunal composition is affected by such factors as ground water input, calcification, drainage, canalisation, culverting, marked shading and seasonal factors. Note: **The occurrence/abundance of groups in above table refers to some but not necessarily all the constituents of the group. Single specimens may be ignored.**

Few (<5%), Common (6-20%), Numerous (21-50%), Dominant (51-74%), Excessive (>75%)

Table A2.3: BMWP Scores, categories and interpretation

BMWP score	Category	Interpretation
0-10	Very poor	Heavily polluted
11-40	Poor	Polluted or impacted
41-70	Moderate	Moderately impacted
71-100	Good	Clean but slightly impacted
>100	Very good	Unpolluted, unimpacted

Table A2.4: Revised BMWP scoring system

Name	Family	Original BMWP Score	Revised BMWP Score	Habitat Specific Scores		
				Riffles	Riffle/Pools	Pools
Flatworms	Planariidae	5	4.2	4.5	4.1	3.7
	Dendrocoelidae	5	3.1	2.3	4.1	3.1
Snails	Neritidae	6	7.5	6.7	8.1	9.3
	Viviparidae	6	6.3	2.1	4.7	7.1
	Valvatidae	3	2.8	2.5	2.5	3.2
	Hydrobiidae	3	3.9	4.1	3.9	3.7
	Lymnaeidae	3	3	3.2	3.1	2.8
	Physidae	3	1.8	0.9	1.5	2.8
	Planorbidae	3	2.9	2.6	2.9	3.1
Limpets and Mussels	Ancylidae	6	5.6	5.5	5.5	6.2
	Unionidae	6	5.2	4.7	4.8	5.5
	Sphaeriidae	3	3.6	3.7	3.7	3.4
Worms	Oligochaeta	1	3.5	3.9	3.2	2.5
Leeches	Piscicolidae	4	5	4.5	5.4	5.2
	Glossiphoniidae	3	3.1	3	3.3	2.9
	Hirudididae	3	0	0.3	-0.3	
	Erpobdellidae	3	2.8	2.8	2.8	2.6
Crustaceans	Asellidae	3	2.1	1.5	2.4	2.7
	Corophiidae	6	6.1	5.4	5.1	6.5
	Gammaridae	6	4.5	4.7	4.3	4.3
	Astacidae	8	9	8.8	9	11.2
Mayflies	Siphlonuridae	10	11	11		
	Baetidae	4	5.3	5.5	4.8	5.1
	Heptageniidae	10	9.8	9.7	10.7	13
	Leptophlebiidae	10	8.9	8.7	8.9	9.9
	Ephemerellidae	10	7.7	7.6	8.1	9.3
	Potamanthidae	10	7.6	7.6		
	Ephemeridae	10	9.3	9	9.2	11
	Caenidae	7	7.1	7.2	7.3	6.4
Stoneflies	Taeniopterygidae	10	10.8	10.7	12.1	
	Nemouridae	7	9.1	9.2	8.5	8.8
	Leuctridae	10	9.9	9.8	10.4	11.2
	Capniidae	10	10	10.1		
	Perlodidae	10	10.7	10.8	10.7	10.9
	Perlidae	10	12.5	12.5	12.2	
	Chloroperlidae	10	12.4	12.5	12.1	
Damselflies	Platycnemidae	6	5.1	3.6	5.4	5.7
	Coenagriidae	6	3.5	2.6	3.3	3.8
	Lestidae	8	5.4			5.4
	Calopterygidae	8	6.4	6	6.1	7.6
Dragonflies	Gomphidae	8				
	Cordulegasteridae	8	8.6	9.5	6.5	7.6
	Aeshnidae	8	6.1	7	6.9	5.7
	Corduliidae	8				

Name	Family	Original BMWP Score	Revised BMWP Score	Habitat Specific Scores		
				Riffles	Riffle/Pools	Pools
	Libellulidae	8	5			5
Bugs	Mesoveliidae *	5	4.7	4.9	4	5.1
	Hydrometridae	5	5.3	5	6.2	4.9
	Gerridae	5	4.7	4.5	5	4.7
	Nepidae	5	4.3	4.1	4.2	4.5
	Naucoridae	5	4.3			4.3
	Aphelocheiridae	10	8.9	8.4	9.5	11.7
	Notonectidae	5	3.8	1.8	3.4	4.4
	Pleidae	5	3.9			3.9
	Corixidae	5	3.7	3.6	3.5	3.9
Beetles	Haliplidae	5	4	3.7	4.2	4.3
	Hygrobiidae	5	2.6	5.6	-0.8	2.6
	Dytiscidae	5	4.8	5.2	4.3	4.2
	Gyrinidae	5	7.8	8.1	7.4	6.8
	Hydrophilidae	5	5.1	5.5	4.5	3.9
	Clambidae	5				
	Scirtidae	5	6.5	6.9	6.2	5.8
	Dryopidae	5	6.5	6.5		
	Elmidae	5	6.4	6.5	6.1	6.5
	Chrysomelidae *	5	4.2	4.9	1.1	4.1
	Curculionidae *	5	4	4.7	3.1	2.9
Alderflies	Sialidae	4	4.5	4.7	4.7	4.3
Caddisflies	Rhyacophilidae	7	8.3	8.2	8.6	9.6
	Philopotamidae	8	10.6	10.7	9.8	
	Polycentropidae	7	8.6	8.6	8.4	8.7
	Psychomyiidae	8	6.9	6.4	7.4	8
	Hydropsychidae	5	6.6	6.6	6.5	7.2
	Hydroptilidae	6	6.7	6.7	6.8	6.5
	Phryganeidae	10	7	6.6	5.4	8
	Limnephilidae	7	6.9	7.1	6.5	6.6
	Molannidae	10	8.9	7.8	8.1	10
	Beraeidae	10	9	8.3	7.8	10
	Odontoceridae	10	10.9	10.8	11.4	11.7
	Leptoceridae	10	7.8	7.8	7.7	8.1
	Goeridae	10	9.9	9.8	9.6	12.4
	Lepidostomatidae	10	10.4	10.3	10.7	11.6
	Brachycentridae	10	9.4	9.3	9.7	11
	Sericostomatidae	10	9.2	9.1	9.3	10.3
True flies	Tipulidae	5	5.5	5.6	5	5.1
	Chironomidae	2	3.7	4.1	3.4	2.8
	Simuliidae	5	5.8	5.9	5.1	5.5

Appendix 3

Macroinvertebrate species lists

Table A3. 1: Macroinvertebrates recorded during biological sampling on watercourses draining the proposed development during summer 2022.

Taxa	Pollution sensitivity group	Site									
		2	3	4	5	6	7	8	9	10	11
MAYFLIES (Uniramia, Ephemeroptera)											
Yellow may dun *Heptagenia sp*	A	-	F	-	F	-	-	-	-	-	-
The green/grey drake mayfly *Ephemera danica*	A	-	-	-	F	-	-	-	-	-	-
Yellow evening dun *Seratella sp*	C	-	C	-	C	-	-	-	-	-	-
Large dark olive *Baetis rhodani*	C	-	F	-	C	-	-	-	-	F	-
Alaintes muticus	C	-	F	-	-	-	-	-	-	-	-
CASED CADDIS FLIES (Tricoptera)											
Northern caddisflies (Limnephilidae)	B	-	F	F	C	F	C	F	-	F	-
Limnephilus sp.	B	-	-	-	F	-	P	F	-	-	-
Black caperer *Sericostoma personatum*	B	-	-	-	-	-	F	-	-	-	-
CASELESS CADDIS FLIES (Trichoptera)											
Hydropsye sp.	C	-	F	-	-	-	-	-	-	-	-
The sandfly *Rhyacophila* sp.	C	-	P	-	P	-	-	-	-	-	-
Polycentropus sp.	C	-	F	-	-	-	-	-	-	-	-
DAMSELFLIES (Odonata, Zygoptera)											
Jewelwings/Demoiselles (Calopterygidae)	B	-	-	-	-	-	-	P	-	-	-
Banded jewelwing *Agrion sp.*	B	-	P	-	-	-	-	-	-	-	-
TRUE FLIES (Diptera)											
Blackfly (Simulidae)	C	-	-	-	-	-	F	-	-	-	-
Simulium sp.	C	-	F	-	C	-	-	-	-	-	-
Pediciidae											
Dicranota sp.	C	-	-	-	-	-	P	-	-	-	-
Family Chironomidae											
Bloodworm *Chironomous sp*.	E	F	-	P	-	-	-	P	-	-	-
Green chironomid	C	-	-	F	-	-	-	-	-	-	-
Empididae											
Clinocera sp.	C	-	F	-	-	-	-	-	-	F	-
Dixidae	C	-	-	-	-	P	P	-	-	-	-
BEETLES (Coleoptera)											
Haliplus sp.	C	-	-	-	-	-	-	-	-	-	F
Common whirligig beetle *Gyrinus substriatus*	C	-	-	P	P	-	-	F	-	-	-
Diving beetles (Dytiscidae)	C	-	F	-	-	P	-	-	-	-	-

Taxa	Pollution sensitivity group	Site									
		2	3	4	5	6	7	8	9	10	11
Sub family Colymbetinae	C	-	-	P	-	-	-	P	-	-	-
Agabus	C	-	-	-	-	-	-	P	-	-	-
Water scavenger beetles (Hydrophilidae)	C	-	P	-	-	F	-	F	-	-	-
Crawling water beetle (Haliplidae)	C	-	P	P	C	-	-	F	-	-	-
Riffle Beetle (Elmidae)											
Elmis aenea	C	-	-	-	F	-	F	-	-	F	-
Marsh beetles (Helodidae)	C	-	-	-	-	-	P	F	-	-	-
SNAILS (Mollusca, Gastropoda)											
Family Lymnaeidae											
Wandering snail *Lymnaea peregra*	D	-	-	-	-	F	-	C	-	C	-
Great pond snail *Lymnaea stagnalis*	C	-	-	-	-	-	-	-	-	-	F
Common Bithynia *Bithynia tentaculata*	C	-	-	-	P	-	-	P	-	-	F
Jenkin's spire shell *Potamopyrgus antipodarium*	C	-	D	-	N	-	C	-	-	C	-
Family Physidae											
Bladder Snail *Physa fontinalis*	D	-	P	-	-	F	P	C	-	-	F
Family Neritidae											
The Nerite *Theodoxus fluviatilis*	C	-	F	-	C	-	-	-	-	F	-
Family Ancylidae											
Planorbis carinatus	C	-	-	-	-	-	-	P	-	-	N
Planorbis sp.	C	-	-	-	-	-	-	P	-	-	-
MUSSELS (Mollucsa, Bivalva)											
Pisidium sp.	D	-	F	-	-	F	-	-	-	-	F
CRUSTACEANS (Crustacea)											
Amphipods (Amphipoda, Gammaridae)											
Freshwater shrimp *Gammarus duebeni*	C	N	F	P	N	F	C	F	-	C	F
Isopods, Asellidae											
Asellus aquaticus	D	D	-	N	-	C	-	C	-	N	F
LEECHES (Hirudinae)											
Erpobdellidae											
Erpobdella sp.	D	-	P	-	P	-	-	-	-	-	-
Helobdella sp.	D	-	-	-	-	-	-	P	-	-	-
Piscicolidae	C	-	-	P	-	-	-	-	-	-	-
Piscicola geometra	C	-	-	F	-	-	-	-	-	-	-
Glossiphonidae											
Glossiphonia complanata	D	-	P	P	-	-	-	-	-	F	-

Taxa	Pollution sensitivity group	Site									
		2	3	4	5	6	7	8	9	10	11
BUGS (Hemiptera)											
Broad shouldered water striders (Veliidae)											
Velia sp.	C	F	-	P	-	C	-	-	-	-	-
Microvelia	C	-	-	-	-	-	-	-	-	F	-
Mesovelidae	C	-	F	C	-	C	C	-	-	-	-
Broad shouldered water skaters (Gerridae)											
Gerris sp.	C	-	F	-	F	-	-	P	-	-	F
SPIDERS (Crustacea, Arachnida)											
Water mite (Order Hydrachnidae)	C	-	C	F	-	C	C	C	-	C	-
SEGMENTED WORMS (Annelida, Clitellata)											
Aquatic earthworm (Lumbriculidae)	D	-	P	-	-	-	-	-	-	-	-
Aquatic earthworm (Lumbricidae)	D	-	-	-	-	-	-	-	-	F	-
Tubificidae	E	P	P	-	F	-	-	-	-	-	-
Dugesia	E	-	-	-	-	-	F	P	-	-	-

Few (<5%), Common (6-20%), Numerous (21-50%), Dominant (51-74%), Excessive (>75%)

Appendix 4

Chemistry results

Table A4.1: Chemistry results for Br 2km downstream Athlacca (station code RRS24M020800) in the Morningstar_060 waterbody.(EPA maps, 2025)

Sample Date	Parameter	Parameter Unit	Result	Limit of Detection	Report Result
30/10/2024	Ammonia-Total (as N)	mg/l	0.031	0.02	0.031
30/07/2024	Ammonia-Total (as N)	mg/l	0.022	0.02	0.022
05/06/2024	Ammonia-Total (as N)	mg/l	-	0.02	0.01
20/03/2024	Ammonia-Total (as N)	mg/l	0.039	0.02	0.039
24/10/2023	Ammonia-Total (as N)	mg/l	0.035	0.02	0.035
18/07/2023	Ammonia-Total (as N)	mg/l	0.023	0.02	0.023
26/06/2023	Ammonia-Total (as N)	mg/l	-	0.02	0.01
28/03/2023	Ammonia-Total (as N)	mg/l	-	0.02	0.01
23/11/2022	Ammonia-Total (as N)	mg/l	0.03	0.02	0.03
22/08/2022	Ammonia-Total (as N)	mg/l	-	0.02	0.01
18/05/2022	Ammonia-Total (as N)	mg/l	-	0.02	0.01
14/03/2022	Ammonia-Total (as N)	mg/l	0.028	0.02	0.028
17/01/2022	Ammonia-Total (as N)	mg/l	-	0.02	0.01
30/10/2024	BOD - 5 days (Total)	mg/l	-	1	0.5
30/07/2024	BOD - 5 days (Total)	mg/l	-	1	0.5
05/06/2024	BOD - 5 days (Total)	mg/l	1	1	1
20/03/2024	BOD - 5 days (Total)	mg/l	1.5	1	1.5
24/10/2023	BOD - 5 days (Total)	mg/l	1.9	1	1.9
18/07/2023	BOD - 5 days (Total)	mg/l	-	1	0.5
26/06/2023	BOD - 5 days (Total)	mg/l	-	1	0.5
28/03/2023	BOD - 5 days (Total)	mg/l	-	1	0.5
23/11/2022	BOD - 5 days (Total)	mg/l	1.2	1	1.2
22/08/2022	BOD - 5 days (Total)	mg/l	-	1	0.5
14/03/2022	BOD - 5 days (Total)	mg/l	-	1	0.5
17/01/2022	BOD - 5 days (Total)	mg/l	-	1	0.5
19/07/2021	BOD - 5 days (Total)	mg/l	-	1	0.5
30/10/2024	Dissolved Oxygen	% Saturation	93	1	93
30/07/2024	Dissolved Oxygen	% Saturation	115	1	115
05/06/2024	Dissolved Oxygen	% Saturation	100	1	100
20/03/2024	Dissolved Oxygen	% Saturation	97	1	97
24/10/2023	Dissolved Oxygen	% Saturation	82	1	82
18/07/2023	Dissolved Oxygen	% Saturation	81	1	81
26/06/2023	Dissolved Oxygen	% Saturation	107	1	107
28/03/2023	Dissolved Oxygen	% Saturation	97	1	97
23/11/2022	Dissolved Oxygen	% Saturation	79	1	79
22/08/2022	Dissolved Oxygen	% Saturation	94	1	94
18/05/2022	Dissolved Oxygen	% Saturation	105	1	105

Sample Date	Parameter	Parameter Unit	Result	Limit of Detection	Report Result
14/03/2022	Dissolved Oxygen	% Saturation	96	1	96
17/01/2022	Dissolved Oxygen	% Saturation	98	1	98
30/10/2024	Dissolved Oxygen	mg/l	10.2	0.1	10.2
30/07/2024	Dissolved Oxygen	mg/l	11.3	0.1	11.3
05/06/2024	Dissolved Oxygen	mg/l	10.3	0.1	10.3
20/03/2024	Dissolved Oxygen	mg/l	11.1	0.1	11.1
24/10/2023	Dissolved Oxygen	mg/l	8.8	0.1	8.8
18/07/2023	Dissolved Oxygen	mg/l	8.2	0.1	8.2
26/06/2023	Dissolved Oxygen	mg/l	10.3	0.1	10.3
28/03/2023	Dissolved Oxygen	mg/l	11.1	0.1	11.1
23/11/2022	Dissolved Oxygen	mg/l	9.1	0.1	9.1
22/08/2022	Dissolved Oxygen	mg/l	9.2	0.1	9.2
18/05/2022	Dissolved Oxygen	mg/l	11	0.1	11
14/03/2022	Dissolved Oxygen	mg/l	11.7	0.1	11.7
17/01/2022	Dissolved Oxygen	mg/l	12.6	0.1	12.6
23/11/2022	Nitrate (as N)	mg/l	1.1	0.2	1.1
22/08/2022	Nitrate (as N)	mg/l	0.54	0.2	0.54
18/05/2022	Nitrate (as N)	mg/l	0.5	0.2	0.5
14/03/2022	Nitrate (as N)	mg/l	1.7	0.2	1.7
17/01/2022	Nitrate (as N)	mg/l	2.1	0.2	2.1
23/11/2022	Nitrite (as N)	µg/l	10.3	4	10.3
22/08/2022	Nitrite (as N)	µg/l	-	4	2
18/05/2022	Nitrite (as N)	µg/l	5.65	4	5.65
14/03/2022	Nitrite (as N)	µg/l	6.92	4	6.92
17/01/2022	Nitrite (as N)	µg/l	8.1	4	8.1
30/10/2024	ortho-Phosphate (as P)	mg/l	0.084	0.01	0.084
30/07/2024	ortho-Phosphate (as P)	mg/l	0.067	0.01	0.067
05/06/2024	ortho-Phosphate (as P)	mg/l	0.018	0.01	0.018
20/03/2024	ortho-Phosphate (as P)	mg/l	0.076	0.01	0.076
24/10/2023	ortho-Phosphate (as P)	mg/l	0.16	0.01	0.16
18/07/2023	ortho-Phosphate (as P)	mg/l	0.11	0.01	0.11
26/06/2023	ortho-Phosphate (as P)	mg/l	0.15	0.01	0.15
28/03/2023	ortho-Phosphate (as P)	mg/l	0.043	0.01	0.043
23/11/2022	ortho-Phosphate (as P)	mg/l	0.099	0.01	0.099
22/08/2022	ortho-Phosphate (as P)	mg/l	0.14	0.01	0.14
18/05/2022	ortho-Phosphate (as P)	mg/l	0.024	0.01	0.024
14/03/2022	ortho-Phosphate (as P)	mg/l	0.062	0.01	0.062
17/01/2022	ortho-Phosphate (as P)	mg/l	0.066	0.01	0.066
30/10/2024	Total Hardness (as CaCO3)	mg/l	296	10	296
30/07/2024	Total Hardness (as CaCO3)	mg/l	271	10	271
05/06/2024	Total Hardness (as CaCO3)	mg/l	251	10	251

Sample Date	Parameter	Parameter Unit	Result	Limit of Detection	Report Result
20/03/2024	Total Hardness (as CaCO3)	mg/l	270	10	270
24/10/2023	Total Hardness (as CaCO3)	mg/l	180	10	180
18/07/2023	Total Hardness (as CaCO3)	mg/l	245	10	245
26/06/2023	Total Hardness (as CaCO3)	mg/l	271	10	271
28/03/2023	Total Hardness (as CaCO3)	mg/l	307	10	307
23/11/2022	Total Hardness (as CaCO3)	mg/l	214	10	214
22/08/2022	Total Hardness (as CaCO3)	mg/l	295	10	295
18/05/2022	Total Hardness (as CaCO3)	mg/l	253	10	253
14/03/2022	Total Hardness (as CaCO3)	mg/l	263	10	263
17/01/2022	Total Hardness (as CaCO3)	mg/l	345	10	345

Table A4.2: Chemistry results from water samples taken at aquatic sites from streams draining the proposed development site (MWP, January 2025)

Sample Date	Stream (Aquatic site)	Parameter	Parameter unit	LOQ	Result
06/02/2025	Morningstar River (Site 1)	Hydrogen Ion (pH)	pH	4.0	8.3
06/02/2025	Morningstar River (Site 1)	Temperature	°C	-	16.4
06/02/2025	Morningstar River (Site 1)	Conductivity	µS/cm @ 20 °C	14.7	481.0
06/02/2025	Morningstar River (Site 1)	Biological Oxygen Demand (BOD)	mg/l	1.0	<1.0
06/02/2025	Morningstar River (Site 1)	Suspended Solids	mg/l	2	6
06/02/2025	Morningstar River (Site 1)	Total Ammonia	mg/l N	0.02	0.06
06/02/2025	Morningstar River (Site 1)	Nitrate (calculated)	mg/L NO3	0.25	2.32
06/02/2025	Morningstar River (Site 1)	Nitrite	mg/L NO2	0.005	0.007
06/02/2025	Morningstar River (Site 1)	Orthophosphate	mg/L P	0.01	0.05
06/02/2025	Morningstar River (Site 1)	Total Hardness	mg/L CaCO3	5	325
06/02/2025	Morningstar River (Site 1)	Chemical Oxygen Demand (COD)	mg/L	10	<10
06/02/2025	Morningstar River (Site 1)	Total Phosphorus	mg/L P	0.04	0.06
06/02/2025	Morningstar River (Site 1)	Total Organic Carbon (TOC)	mg/L	0.5	4.6
06/02/2025	Morningstar River (Site 1)	Total Dissolved Solids (TDS)	mg/L	5	274
06/02/2025	Camas South (Site 2)	Hydrogen Ion (pH)	pH	4.0	8.2
06/02/2025	Camas South (Site 2)	Temperature	°C	-	16.5
06/02/2025	Camas South (Site 2)	Conductivity	µS/cm @ 20 °C	14.7	514.0
06/02/2025	Camas South (Site 2)	Biological Oxygen Demand (BOD)	mg/l	1.0	<1.0
06/02/2025	Camas South (Site 2)	Suspended Solids	mg/l	2	<4
06/02/2025	Camas South (Site 2)	Total Ammonia	mg/l N	0.02	0.03
06/02/2025	Camas South (Site 2)	Nitrate (calculated)	mg/L NO3	0.25	1.99
06/02/2025	Camas South (Site 2)	Nitrite	mg/L NO2	0.005	0.010
06/02/2025	Camas South (Site 2)	Orthophosphate	mg/L P	0.01	0.05

Sample Date	Stream (Aquatic site)	Parameter	Parameter unit	LOQ	Result
06/02/2025	Camas South (Site 2)	Total Hardness	mg/L CaCO3	5	346
06/02/2025	Camas South (Site 2)	Chemical Oxygen Demand (COD)	mg/L	10	<10
06/02/2025	Camas South (Site 2)	Total Phosphorus	mg/L P	0.04	0.04
06/02/2025	Camas South (Site 2)	Total Organic Carbon (TOC)	mg/L	0.5	3.9
06/02/2025	Camas South (Site 2)	Total Dissolved Solids (TDS)	mg/L	5	294
06/02/2025	Morningstar River (Site 3)	Hydrogen Ion (pH)	pH	4.0	8.3
06/02/2025	Morningstar River (Site 3)	Temperature	°C	-	16.3
06/02/2025	Morningstar River (Site 3)	Conductivity	µS/cm @ 20 °C	14.7	480.0
06/02/2025	Morningstar River (Site 3)	Biological Oxygen Demand (BOD)	mg/l	1.0	<1.0
06/02/2025	Morningstar River (Site 3)	Suspended Solids	mg/l	2	16
06/02/2025	Morningstar River (Site 3)	Total Ammonia	mg/l N	0.02	<0.02
06/02/2025	Morningstar River (Site 3)	Nitrate (calculated)	mg/L NO3	0.25	2.45
06/02/2025	Morningstar River (Site 3)	Nitrite	mg/L NO2	0.005	0.007
06/02/2025	Morningstar River (Site 3)	Orthophosphate	mg/L P	0.01	0.07
06/02/2025	Morningstar River (Site 3)	Total Hardness	mg/L CaCO3	5	342
06/02/2025	Morningstar River (Site 3)	Chemical Oxygen Demand (COD)	mg/L	10	19
06/02/2025	Morningstar River (Site 3)	Total Phosphorus	mg/L P	0.04	0.10
06/02/2025	Morningstar River (Site 3)	Total Organic Carbon (TOC)	mg/L	0.5	4.6
06/02/2025	Morningstar River (Site 3)	Total Dissolved Solids (TDS)	mg/L	5	272
06/02/2025	Parkroe (Site 4)	Hydrogen Ion (pH)	pH	4.0	8.1
06/02/2025	Parkroe (Site 4)	Temperature	°C	-	16.4
06/02/2025	Parkroe (Site 4)	Conductivity	µS/cm @ 20 °C	14.7	493.0
06/02/2025	Parkroe (Site 4)	Biological Oxygen Demand (BOD)	mg/l	1.0	4.8
06/02/2025	Parkroe (Site 4)	Suspended Solids	mg/l	2	11
06/02/2025	Parkroe (Site 4)	Total Ammonia	mg/l N	0.02	0.04
06/02/2025	Parkroe (Site 4)	Nitrate (calculated)	mg/L NO3	0.25	0.84
06/02/2025	Parkroe (Site 4)	Nitrite	mg/L NO2	0.005	0.009
06/02/2025	Parkroe (Site 4)	Orthophosphate	mg/L P	0.01	0.05
06/02/2025	Parkroe (Site 4)	Total Hardness	mg/L CaCO3	5	339
06/02/2025	Parkroe (Site 4)	Chemical Oxygen Demand (COD)	mg/L	10	32
06/02/2025	Parkroe (Site 4)	Total Phosphorus	mg/L P	0.04	8.10
06/02/2025	Parkroe (Site 4)	Total Organic Carbon (TOC)	mg/L	0.5	6.5
06/02/2025	Parkroe (Site 4)	Total Dissolved Solids (TDS)	mg/L	5	280
06/02/2025	Morningstar River (Site 5)	Hydrogen Ion (pH)	pH	4.0	8.4
06/02/2025	Morningstar River (Site 5)	Temperature	°C	-	16.5
06/02/2025	Morningstar River (Site 5)	Conductivity	µS/cm @ 20 °C	14.7	480.0

Sample Date	Stream (Aquatic site)	Parameter	Parameter unit	LOQ	Result
06/02/2025	Morningstar River (Site 5)	Biological Oxygen Demand (BOD)	mg/l	1.0	<1.0
06/02/2025	Morningstar River (Site 5)	Suspended Solids	mg/l	2	6
06/02/2025	Morningstar River (Site 5)	Total Ammonia	mg/l N	0.02	0.03
06/02/2025	Morningstar River (Site 5)	Nitrate (calculated)	mg/L NO3	0.25	2.37
06/02/2025	Morningstar River (Site 5)	Nitrite	mg/L NO2	0.005	0.008
06/02/2025	Morningstar River (Site 5)	Orthophosphate	mg/L P	0.01	0.05
06/02/2025	Morningstar River (Site 5)	Total Hardness	mg/L CaCO3	5	336
06/02/2025	Morningstar River (Site 5)	Chemical Oxygen Demand (COD)	mg/L	10	<10
06/02/2025	Morningstar River (Site 5)	Total Phosphorus	mg/L P	0.04	0.07
06/02/2025	Morningstar River (Site 5)	Total Organic Carbon (TOC)	mg/L	0.5	4.5
06/02/2025	Morningstar River (Site 5)	Total Dissolved Solids (TDS)	mg/L	5	275
06/02/2025	Ballinrea (Site 6)	Hydrogen Ion (pH)	pH	4.0	8.4
06/02/2025	Ballinrea (Site 6)	Temperature	°C	-	16.5
06/02/2025	Ballinrea (Site 6)	Conductivity	µS/cm @ 20 °C	14.7	524.0
06/02/2025	Ballinrea (Site 6)	Biological Oxygen Demand (BOD)	mg/l	1.0	1.2
06/02/2025	Ballinrea (Site 6)	Suspended Solids	mg/l	2	<4
06/02/2025	Ballinrea (Site 6)	Total Ammonia	mg/l N	0.02	0.05
06/02/2025	Ballinrea (Site 6)	Nitrate (calculated)	mg/L NO3	0.25	4.13
06/02/2025	Ballinrea (Site 6)	Nitrite	mg/L NO2	0.005	<0.005
06/02/2025	Ballinrea (Site 6)	Orthophosphate	mg/L P	0.01	0.10
06/02/2025	Ballinrea (Site 6)	Total Hardness	mg/L CaCO3	5	364
06/02/2025	Ballinrea (Site 6)	Chemical Oxygen Demand (COD)	mg/L	10	<10
06/02/2025	Ballinrea (Site 6)	Total Phosphorus	mg/L P	0.04	0.14
06/02/2025	Ballinrea (Site 6)	Total Organic Carbon (TOC)	mg/L	0.5	4.2
06/02/2025	Ballinrea (Site 6)	Total Dissolved Solids (TDS)	mg/L	5	300
06/02/2025	Ballinlee South (Site 7)	Hydrogen Ion (pH)	pH	4.0	8.3
06/02/2025	Ballinlee South (Site 7)	Temperature	°C	-	16.6
06/02/2025	Ballinlee South (Site 7)	Conductivity	µS/cm @ 20 °C	14.7	564.0
06/02/2025	Ballinlee South (Site 7)	Biological Oxygen Demand (BOD)	mg/l	1.0	<1.0
06/02/2025	Ballinlee South (Site 7)	Suspended Solids	mg/l	2	5
06/02/2025	Ballinlee South (Site 7)	Total Ammonia	mg/l N	0.02	0.03
06/02/2025	Ballinlee South (Site 7)	Nitrate (calculated)	mg/L NO3	0.25	9.06
06/02/2025	Ballinlee South (Site 7)	Nitrite	mg/L NO2	0.005	0.007
06/02/2025	Ballinlee South (Site 7)	Orthophosphate	mg/L P	0.01	0.04
06/02/2025	Ballinlee South (Site 7)	Total Hardness	mg/L CaCO3	5	402
06/02/2025	Ballinlee South (Site 7)	Chemical Oxygen Demand (COD)	mg/L	10	<10

Sample Date	Stream (Aquatic site)	Parameter	Parameter unit	LOQ	Result
06/02/2025	Ballinlee South (Site 7)	Total Phosphorus	mg/L P	0.04	0.06
06/02/2025	Ballinlee South (Site 7)	Total Organic Carbon (TOC)	mg/L	0.5	3.3
06/02/2025	Ballinlee South (Site 7)	Total Dissolved Solids (TDS)	mg/L	5	325
06/02/2025	Rathcannon (Site 8)	Hydrogen Ion (pH)	pH	4.0	8.3
06/02/2025	Rathcannon (Site 8)	Temperature	°C	-	16.4
06/02/2025	Rathcannon (Site 8)	Conductivity	µS/cm @ 20 °C	14.7	514.0
06/02/2025	Rathcannon (Site 8)	Biological Oxygen Demand (BOD)	mg/l	1.0	1.3
06/02/2025	Rathcannon (Site 8)	Suspended Solids	mg/l	2	<2
06/02/2025	Rathcannon (Site 8)	Total Ammonia	mg/l N	0.02	0.02
06/02/2025	Rathcannon (Site 8)	Nitrate (calculated)	mg/L NO3	0.25	1.07
06/02/2025	Rathcannon (Site 8)	Nitrite	mg/L NO2	0.005	0.013
06/02/2025	Rathcannon (Site 8)	Orthophosphate	mg/L P	0.01	0.05
06/02/2025	Rathcannon (Site 8)	Total Hardness	mg/L CaCO3	5	359
06/02/2025	Rathcannon (Site 8)	Chemical Oxygen Demand (COD)	mg/L	10	<10
06/02/2025	Rathcannon (Site 8)	Total Phosphorus	mg/L P	0.04	0.08
06/02/2025	Rathcannon (Site 8)	Total Organic Carbon (TOC)	mg/L	0.5	5.5
06/02/2025	Rathcannon (Site 8)	Total Dissolved Solids (TDS)	mg/L	5	296
06/02/2025	South Ballinlee (Site 9)	Hydrogen Ion (pH)	pH	4.0	8.2
06/02/2025	South Ballinlee (Site 9)	Temperature	°C	-	16.5
06/02/2025	South Ballinlee (Site 9)	Conductivity	µS/cm @ 20 °C	14.7	523.0
06/02/2025	South Ballinlee (Site 9)	Biological Oxygen Demand (BOD)	mg/l	1.0	1.5
06/02/2025	South Ballinlee (Site 9)	Suspended Solids	mg/l	2	4
06/02/2025	South Ballinlee (Site 9)	Total Ammonia	mg/l N	0.02	0.05
06/02/2025	South Ballinlee (Site 9)	Nitrate (calculated)	mg/L NO3	0.25	1.73
06/02/2025	South Ballinlee (Site 9)	Nitrite	mg/L NO2	0.005	0.006
06/02/2025	South Ballinlee (Site 9)	Orthophosphate	mg/L P	0.01	0.05
06/02/2025	South Ballinlee (Site 9)	Total Hardness	mg/L CaCO3	5	333
06/02/2025	South Ballinlee (Site 9)	Chemical Oxygen Demand (COD)	mg/L	10	13
06/02/2025	South Ballinlee (Site 9)	Total Phosphorus	mg/L P	0.04	0.07
06/02/2025	South Ballinlee (Site 9)	Total Organic Carbon (TOC)	mg/L	0.5	6.5
06/02/2025	South Ballinlee (Site 9)	Total Dissolved Solids (TDS)	mg/L	5	301
06/02/2025	Rathcannon (Site 10)	Hydrogen Ion (pH)	pH	4.0	8.3
06/02/2025	Rathcannon (Site 10)	Temperature	°C	-	16.5
06/02/2025	Rathcannon (Site 10)	Conductivity	µS/cm @ 20 °C	14.7	536.0
06/02/2025	Rathcannon (Site 10)	Biological Oxygen Demand (BOD)	mg/l	1.0	<1.0
06/02/2025	Rathcannon (Site 10)	Suspended Solids	mg/l	2	<4

Sample Date	Stream (Aquatic site)	Parameter	Parameter unit	LOQ	Result
06/02/2025	Rathcannon (Site 10)	Total Ammonia	mg/l N	0.02	0.04
06/02/2025	Rathcannon (Site 10)	Nitrate (calculated)	mg/L NO3	0.25	4.34
06/02/2025	Rathcannon (Site 10)	Nitrite	mg/L NO2	0.005	0.008
06/02/2025	Rathcannon (Site 10)	Orthophosphate	mg/L P	0.01	0.06
06/02/2025	Rathcannon (Site 10)	Total Hardness	mg/L CaCO3	5	361
06/02/2025	Rathcannon (Site 10)	Chemical Oxygen Demand (COD)	mg/L	10	12
06/02/2025	Rathcannon (Site 10)	Total Phosphorus	mg/L P	0.04	0.009
06/02/2025	Rathcannon (Site 10)	Total Organic Carbon (TOC)	mg/L	0.5	5.7
06/02/2025	Rathcannon (Site 10)	Total Dissolved Solids (TDS)	mg/L	5	305
06/02/2025	Killorath (Site 11)	Hydrogen Ion (pH)	pH	4.0	8.0
06/02/2025	Killorath (Site 11)	Temperature	°C	-	16.6
06/02/2025	Killorath (Site 11)	Conductivity	µS/cm @ 20 °C	14.7	643.0
06/02/2025	Killorath (Site 11)	Biological Oxygen Demand (BOD)	mg/l	1.0	1.1
06/02/2025	Killorath (Site 11)	Suspended Solids	mg/l	2	<4
06/02/2025	Killorath (Site 11)	Total Ammonia	mg/l N	0.02	0.03
06/02/2025	Killorath (Site 11)	Nitrate (calculated)	mg/L NO3	0.25	5.13
06/02/2025	Killorath (Site 11)	Nitrite	mg/L NO2	0.005	0.011
06/02/2025	Killorath (Site 11)	Orthophosphate	mg/L P	0.01	0.04
06/02/2025	Killorath (Site 11)	Total Hardness	mg/L CaCO3	5	447
06/02/2025	Killorath (Site 11)	Chemical Oxygen Demand (COD)	mg/L	10	33
06/02/2025	Killorath (Site 11)	Total Phosphorus	mg/L P	0.04	0.05
06/02/2025	Killorath (Site 11)	Total Organic Carbon (TOC)	mg/L	0.5	12.1
06/02/2025	Killorath (Site 11)	Total Dissolved Solids (TDS)	mg/L	5	372

Appendix 5

Fish results

Table A5.1: All fish species caught during the electro fishing surveys at streams draining the proposed development in July 2022.

River name	Aquatic site	Species ID	Common name	Latin name	Length (cm)
Camas South	Site 2	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.3
Camas South	Site 2	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	2.8
Camas South	Site 2	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.7
Camas South	Site 2	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.5
Camas South	Site 2	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.6
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	13.8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	12.2
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	11.6
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	11.4
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	11.9
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	13.9
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	11
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	12.5
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	12
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	11.5
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	11.6
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	12
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	10.8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	12.3
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	8.2
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	8.3
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.3
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	8.8

River name	Aquatic site	Species ID	Common name	Latin name	Length (cm)
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	7.4
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.4
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	9
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	7.4
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	7.3
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	7.8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.8
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	7.3
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.6
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.4
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.4
Morningstar (River)	Site 3	SAL	Salmon	*Salmo salar*	6.1
Morningstar (River)	Site 3	BTW	Brown trout	*Salmo trutta*	15.3
Morningstar (River)	Site 3	BTW	Brown trout	*Salmo trutta*	8.7
Morningstar (River)	Site 3	BTW	Brown trout	*Salmo trutta*	8.9
Morningstar (River)	Site 3	BTW	Brown trout	*Salmo trutta*	15
Morningstar (River)	Site 3	BTW	Brown trout	*Salmo trutta*	23.7
Morningstar (River)	Site 3	BTW	Brown trout	*Salmo trutta*	8.5
Morningstar (River)	Site 3	LAS	Lamprey sp.	*Lampetra sp.*	12
Morningstar (River)	Site 3	LAS	Lamprey sp.	*Lampetra sp*	12
Morningstar (River)	Site 3	FTL	Stone loach	*Barbatula barbatula*	7.6
Morningstar (River)	Site 3	FMW	Minnow	*Phoxinus phoxinus*	4.4
Morningstar (River)	Site 3	FMW	Minnow	*Phoxinus phoxinus*	4.8
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.5

River name	Aquatic site	Species ID	Common name	Latin name	Length (cm)
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.7
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	4.5
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	2.8
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.6
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.5
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.4
Parkroe	Site 4	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.5
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.6
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.6
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	4.6
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	2.7
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.7
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.4
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.5
Ballinrea	Site 6	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.4
Ballinlee South	Site 7	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.4
Ballinlee South	Site 7	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.6
Ballinlee South	Site 7	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.2
Ballinlee South	Site 7	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	2.7
Ballinlee South	Site 7	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.6
Ballinlee South	Site 7	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.4
Ballinlee South	Site 7	TSS	Three-spined stickleback	*Gasterosteus aculeatus*	3.5
Rathcannon	Site 8	FMW	Minnow	*Phoxinus phoxinus*	4.7
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	4.7
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	4.6
Rathcannon	Site 8	FMW	Minnow	*Phoxinus phoxinus*	4.7
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	3.9
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	3.3
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	3.8
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	4.8

River name	Aquatic site	Species ID	Common name	Latin name	Length (cm)
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	3.7
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	3.6
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	3.6
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	4.4
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	3.3
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	4.5
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	4.6
Rathcannon	Site 8	FMW	Minnow	*Phoxinus Phoxinus*	2.9
Rathcannon	Site 8	FMW	Minnow	*Phoxinus phoxinus*	3.1
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	5.3
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	6.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	5.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.5
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.4
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.2
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.3
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.9
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	5
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	5.5
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	5.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	5.3
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.1
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.5
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.2
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	5.2
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	4.4
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.3
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.3
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.9
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.7
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	4.2

River name	Aquatic site	Species ID	Common name	Latin name	Length (cm)
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	4.5
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.6
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.2
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.9
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.7
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.5
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.7
Rathcannon	Site 10	FMW	Minnow	*Phoxinus phoxinus*	4.3
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.4
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.4
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	4.7
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	2.8
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	3.2
Rathcannon	Site 10	FMW	Minnow	*Phoxinus Phoxinus*	2.5